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Community profiling of water sources and uses in a rural setting in Northwest Province, South Africa



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A research report submitted to the School of Public Health, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Science in Medicine (Exposure Science)

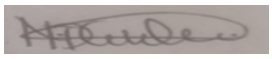
August 2024

Declaration

I (Xulu, Nqobile Thabisile) with student ID number (2260932) declare that this research study titled "*Community profiling of water sources and uses in a rural setting in, Northwest Province, South Africa*" is my own work, unaided work undertaken under the supervision of both Doctor Daniel Mmereki and Professor Nisha Naicker. It is being submitted in partial fulfilment for the degree of Master of Science in Medicine (Exposure Science) at the School of Public Health, University of the Witwatersrand, Johannesburg. The author designed the study, conducted data collection, as well as data analysis and write-up of this research report. As per the plagiarism policy, a plagiarism declaration form is signed and attached as Appendix A.

Full Name of Student: Nqobile Thabisile Xulu

Student Number: 2260932

Signature:  Date: 05 August 2024

Dedication

This project is dedicated to almighty God whom I thank for providing me with the strength to persevere during the most difficult stages of the research project. My parents and siblings (Miss Siphokuhle Sibongile Mngadi, Mr. Muzikawuchithwa Xulu, and Ayanda Xulu) for being my support system, and my family for being my inspiration (Mr. Tebogo Makaleng, Reabetswe Links and Lumnene Xulu).

Abstract

Background

Access to sustainable and potable water remains a constitutional right for all citizens regardless of their demographic, level of educational, or socioeconomic status. Rural communities are vulnerable to inadequate water supply and lack access to potable water, increasing their vulnerability to waterborne diseases and a lack of personal and environmental hygiene. The majority of residents in rural communities often resort to alternative water sources. Those water sources are often susceptible to contamination. The water contamination has been attributed to a lack of norms and monitoring plans aimed at protecting and preserving the quality of these water sources. Many studies have focused on identifying factors that influence water demand in urban and semi-urban areas to improve water resource planning and development. However, there have been limited studies focused on water use patterns and water profiling in rural areas, particularly where water is sourced from surface sources.

Purpose

The purpose of the study was to describe the socio-economic characteristics, water sources, water uses, and consumption patterns in Ganyesa village, Northwest Province.

Methods

A quantitative cross-sectional study design was employed to profile water sources and uses in a rural setting in the Northwest. A total of 175 households were randomly selected to participate in the study. A semi-structured questionnaire comprising of Section A: Household socio-economic data, Section B: Water sources, and Section C: Water consumption. Furthermore, water consumption daily activity diaries were used to collect information on water activity usage for seven (7) days.

Results

A total of 175 participants aged 18 to 65 years were included in this study. Most of the participants were females (78.28%, n = 137), and males accounted for (21.72%, n = 38). The majority of the study participants (37.17%, n = 65) were between the ages of 41 to 50 years, and the majority (58.5%) had a secondary education.

Participants use different water sources, such as communal taps, boreholes, bottled water, rainwater, water tankers, and rainwater, to meet their daily water needs. The water needs included activities such as bathing, cooking, and outdoor activities. Most of the participants (78,29%, n = 137) depend on communal taps as their primary water supply, followed by boreholes (19.4%, n = 34), and a small group of participants used both boreholes and communal taps (2.22%, n = 4). Participants used variety of alternative water sources to meet their daily water needs during water shortage from their primary water sources. Boreholes were the most used alternative water source (65,71% n=115), communal tap (20%, n=35), borehole and water tanker (7,43%, n=13), borehole and rainwater (2,86%, n=5), borehole and communal tap (2,29%, n=4).

The average daily water consumption of one to three occupants was estimated to be 26.62 L/day per person. The average water consumption of males and females was estimated to be 29.6 L/day and 25 L/day, respectively. Several socio-demographic covariates were independently associated with water consumption. In terms of income, i.e., those earning R 5001-R 10000 per month had a statistically significant negative association with water consumption ($p = 0.01$), with a coefficient of -8.00. Similarly, the distance to the source of water was significant ($p < 0.001$), with a negative coefficient of -5.82, suggesting that as the distance from the water source increases, the average water consumption at the household level decreases.

Gender disparity in water consumption was observed, male participants had a statistically significant reduction in water usage compared to their female counterparts ($p = 0.02$), with a coefficient of -3.84.

Conclusion

The study hypothesized that residents residing in rural settings use various water sources improved or unimproved to meet their water daily needs. Therefore, the hypothesis of this study is confirmed, meaning that rural dwellers of (Ganyesa) use both improved and unimproved water sources. Residents use both communal taps and boreholes as their primary water sources. The most used alternative source is borehole, indicating water unsustainability by Kagisano Molopo Local municipality. The alternative water sources used by residents are unimproved and unmonitored as per SANS 241. Groundwater was acknowledged as a remedy to water shortage. To prevent contamination to this groundwater sources the sustainability and preservation of this resource, effective management strategies and policies must be

implemented. From the study, a conclusion can be made that most of the community members utilized communal taps for both indoor and outdoor activities. It was also found that water consumption at the household level is affected by various sociodemographic factors including household income, sex and distance to water source, the type of water source and number of occupants. This study provides scientific evidence that would help policy and decision makers to take these factors into consideration when addressing water scarcity and improving service delivery challenges to rural communities.

Keywords: water, household, accessible, potable, sufficient

Acknowledgements

I would like to appreciate and thank Dr. Ruth Segomosti Mompati District Municipality for financial support in this study. I want to express my heartfelt gratitude and highest respect to my supervisors (Dr Daniel Mmereki and Professor Nisha Naicker), who made this work possible by guiding and advising me through all the stages of writing my research report. I will forever be grateful to Dr Daniel Mmereki for his contribution and support during this journey; you had more faith in me than I believed in my capacity to ever begin, let alone to complete a study.

I would also want to thank Professor Nisha Naicker, who jumped on board at the last minute but whose attention to detail saw the study reach new heights. I want to express my heartfelt gratitude to Tlou le Tau Tribal for taking the time to listen and allowing me to perform the study in the area, which helped me finish my research. Thank you to my fieldworkers for ensuring that the data obtained is accurate and meets the study objectives. My participants' time and contributions were not in vain. Your expertise has been documented and preserved for the future.

I thank you and value your input in this regard. I would also like to thank the community service department at Kagisano Molopo Fire Station for their unwavering support and for transporting me to relevant stakeholders during a time of need. To the Mngadi family, thank you for babysitting my son and for your unending support in ensuring that I complete my studies. I would also like to thank my fiancée (Tebogo Mokaleng), for believing in me and driving me to Johannesburg for my classes. Thank you, Lumnene Xulu, for being my daily dose of inspiration. I would also like to thank my friends for checking on me and encouraging me during this journey.

Table of Contents

Declaration II

Dedication..... III

Abstract IV

Acknowledgements..... VII

Table of Contents VIII

List of Figures XI

List of Tables XII

List of abbreviations..... XIII

Glossary XIV

Chapter 1: INTRODUCTION..... 1

1.1 Background..... 1

1.2 Literature review 3

1.2.1 Water sources..... 3

1.2.1.2 Dams and rivers..... 6

1.2.2 Water pollution..... 7

1.2.3 Water access in South Africa 8

1.2.4 Water use at the household level. 10

1.2.4.1 Factors affecting water consumption. 11

1.2.4.2 Average daily water used at the household level..... 12

1.2.5 Water consumption amongst gender and age..... 13

1.2.6 Water scarcity 14

1.2.7 Water security..... 14

1.2.8 Policies for water management..... 15

1.2.9 Human health effects of unsafe and inappropriate sanitation 16

1.3 Problem statement..... 19

1.3.1 Justification 20

1.4 Study Aim 20

1.5 Objectives 21

CHAPTER 2: METHODOLOGY 22

2.1 Research design 22

2.2 METHODS AND MATERIALS 23

2.2.1 Description of the study area 23

2.2.2 Target Population 24

2.2.3 Sampling 25

2.3 Data collection 25

2.3.1 Research instruments 25

2.3.2 Data collection procedure 26

2.3.3 Questionnaires 27

2.3.4 Filling in daily activities 27

2.3.5 Piloting of the study 28

2.4 Data processing and analysis 28

2.5 Quality control 29

2.6 Ethical Consideration 29

CHAPTER 3: RESULTS 30

3.1 Sociodemographic information of the study participants 30

3.2 Description of water sources used in Ganyesa Village 31

3.3 Water consumption by the number of occupants in a household in Ganyesa Village. 33

3.4 Water consumption by sex 39

3.5 Water consumption by age 39

3.6 Household income and water consumption 40

CHAPTER 4: DISCUSSION 43

4.1 Sociodemographic information of the study participants 43

4.2 Water sources used in Ganyesa Village 44

4.3. Containers used for fetching water by households. 45

4.4. Water consumption patterns and lifestyle 45

4.5 Water consumption by sex and age 46

4.6 Water consumption comparison with minimum water use baseline. 47

4.7 Water consumption by distance and frequency 47

4.8 Summary 48

4.9 Limitations of the study 48

CHAPTER 5: SUMMARY AND CONCLUSION 50

5.1 Summary 50

5.2 Future research avenues 50

5.3 Conclusion and significance 51

5.4 Recommendations 51

REFERENCES 53

Appendix A: Plagiarism declaration form 60

Appendix B: Research ethics clearance certificate 61

Data capturing sheet Questionnaires. 65

List of Figures

Figure1: A geographical map of the study area (Created using ArcMap GIS version 10.8) .....**ERROR! BOOKMARK NOT DEFINED.**

Figure 2: A point plot of the average distance traveled to fetch water and the average water consumption (L/day).....**ERROR! BOOKMARK NOT DEFINED.**

Figure 3: Participant's answers on the state of water service delivery in Ganyesa village .....**ERROR! BOOKMARK NOT DEFINED.**

Figure 4: Water collection in Ganyesa village, (a) methods used to collect water, (b) person responsible for collecting water, (c) how frequently water is collected in a week, (d) the size of containers used to collect water. .....**ERROR! BOOKMARK NOT DEFINED.**

Figure 5: Amount of money spent on water per month (a), containers used to store collected water (b), measures taken by Ganyesa respondents to make water safer for consumption (c), types of toilets system used in Ganyesa village (d).....**ERROR! BOOKMARK NOT DEFINED.**

Figure 6**:** Sources of water and containers used to collect, (b) donkey cart and 25 L containers used for water collection, (b) community borehole, (c) buckets used for water collection, (d) communal taps and containers used for water collection, (e) wheelbarrow and containers used for water collection, (f) 20 L buckets used for water collection. (Source: Author 2022).....**ERROR! BOOKMARK NOT DEFINED.**

List of Tables

Table 1: List of water policies in South Africa and their description ..... **ERROR! BOOKMARK NOT DEFINED.**

Table 2: Categories of water sanitation and hygiene-related diseases . **ERROR! BOOKMARK NOT DEFINED.**

Table 3: Sociodemographic information of the study participants ..... **ERROR! BOOKMARK NOT DEFINED.**

Table 4: Primary and alternative water sources used. .....**ERROR! BOOKMARK NOT DEFINED.**

Table 5: Primary and alternative water used for drinking and bathing.. **ERROR! BOOKMARK NOT DEFINED.**

Table 6: Primary and alternative water sources used for house chores and outdoor activities .....**ERROR! BOOKMARK NOT DEFINED.**

Table 7: Water consumption (L/day) based on the number of occupants in a dwelling. .....**ERROR! BOOKMARK NOT DEFINED.**

Table 8: One-way analysis of variance comparing water consumption by the number of occupants in households.....**ERROR! BOOKMARK NOT DEFINED.**

Table 9: Comparison of water consumption of water by sex.....**ERROR! BOOKMARK NOT DEFINED.**

Table 10: Water consumption within age groups .....**ERROR! BOOKMARK NOT DEFINED.**

Table 11: One-way analysis of variance comparing the water consumption by age....**ERROR! BOOKMARK NOT DEFINED.**

Table 12: Comparison of household income and average water consumption (L/day) .....**ERROR! BOOKMARK NOT DEFINED.**

Table 13: One-way analysis of variance comparing the water consumption by household income.....**ERROR! BOOKMARK NOT DEFINED.**

Table 14: One-way analysis of variance comparing the water consumption by household income…….41

Table 15: Linear regression models for the relationship between water consumption and socio-demographic factors (N=175)…….42

Table 16: Multivariate linear regression model for the association between water consumption and socio-demographic covariates (N=175)……43

List of abbreviations

DEAT:	Department of Environmental Affairs and Tourism
Dr. RSDM	Dr. Ruth Segomosti District Municipality
DWA:	Department of Water and Sanitation
DWAF:	Department of Water & Environmental Affairs
DWS:	Department of Water & Sanitation
EPA:	Environmental Protection Agency
HICs:	High-income countries
IDP:	Integrated Development Plan
KMLM	Kagisano Molopo Local Municipality
LMICs:	Low-middle-income countries
MCM:	Million Cubic Meters
MDGs:	Millennium Development Goal
Mg/m^3:	Milligram per cubic metre
NEMA:	National Environmental Management Act
NWA:	National Water Act
SA:	South Africa
SABS:	South African Bureau Standards
SADWAF:	South Africa Department of Water Affairs and Forestry
SANS 241:	South Africa National Standard: drinking water specification
SDGs:	Sustainable Development Goal
SSA:	Sub-Saharan Africa
WASH	Water Sanitation and Hygeine
WHO:	World Health Organisation
WSA:	Water Services Authorities

WSP:	Water Service Provider
LCDP	Liter per Capita Per Day

Glossary

Accessibility: The effort, expressed in terms of total time for collection (including waiting) and/or distance, that a person must expend to obtain water

Adequate water: is a legal source of water that reliably meets the water quantity and quality requirements as per WHO stipulation of minimum 20 to 50 maximum 5 to 100 liters per person per 24 hours.

Affordability: The amount that households can routinely pay for water within their available resources without causing hardship

Alternative water source: is water supplied by sustainable sources that can be used to help during the offset of the primary water sources.

Availability: The presence of water at a water source that can be collected when needed, but water may not be continuously available

Groundwater: is the water found underground in the cracks and spaces in soil, sand, and rock for example borehole.

Heavy metals: Naturally occurring elements that have a high atomic weight and a density of at least 5 times greater than that of water.

Household: A household refers to a group of individuals who live together in a shared dwelling and share resources, such as a home, food, and utilities. Households can be composed of family members, such as parents and children, or non-related individuals who co-reside and share resources.

Improved water sources: Are those that have the potential to deliver safe water by nature of their design and construction. This source should be characterised by three criteria: (i) it should be accessible on-premises (ii) water should be available when needed (iii) the water supplied should be free from contamination.

Loadshedding: According to Eskom, is a controlled process that prevent the collapse of the power system country wide. When there is insufficient power station

capacity to supply the demand (load) from all the customers, the electricity system becomes unbalanced

Primary water source: includes water supplied by city, or municipality. Sources such as ground water, harvested rain, and/or surface water may be used. The cost and quality are typically high since much of the water is for residential use and drinking water and is treated.

Reliability: The presence of water at a water source at expected or known times (usually every day), but water may not be continuously available.

Surface water: is water on the surface of continents, such as in rivers, lakes or wetlands.

Sustainable development goals: Global goals for fair and sustainable health at every level: from the planetary biosphere to the local community. The aim is to end poverty, protect the planet and ensure that all people enjoy peace and prosperity, now and in the future.

Unimproved water sources: Unprotected dug well, unprotected spring, river, dam, lake, pond, stream, canal, and irrigation canal.

Water consumption: is the portion of water use that is not returned to the original water source after being withdrawn.

Water contamination: The introduction of pollutants in water such as microbiological, pesticides and chemicals that cause water not to be safe and not healthy for people and animals to drink.

Water use: The total amount of water withdrawn from its source to be used for different activities such as industrial, agricultural, and domestic use.

World Health Organization: It is responsible for providing leadership on global health matters.

Aggressive water: is soft and acidic water that can corrode plumbing, pipes, and appliances. This kind of water usually contains an inordinate amount of carbon dioxide deposits. The reason it is labeled as “aggressive” is due to its high propensity to strike surfaces that possess metals such as copper and iron, or calcium.

CHAPTER 1: INTRODUCTION

This chapter begins with an overview of the global and local water status, then discusses the challenges that rural areas face in terms of water service delivery. The consequences of unsustainable water provision such as water scarcity, and environmental and health outcomes, problem statement, research questions, literature review, and significance of the study are provided in this chapter. The study's problem statement and justification are given, and the chapter concludes with the aim, hypothesis, and objectives of the study.

1.1 Background

Low-middle-income countries (LMICs), such as South Africa (SA) are experiencing numerous challenges related to population growth, lack of clean potable water, and mismanagement of solid and liquid waste (Arouna and Dabbert, 2010; Oageng and Mmopelwa, 2014; Omarova et al., 2019). Adequate water supply is essential in the public health domain on both global and local scales as it improves standards of living for people such as disease prevention, physical health, protection of the environment and better educational outcomes (Arouna and Dabbert, 2010; Oageng and Mmopelwa, 2014; Omarova et al., 2019). In the year 2000, approximately 189 countries, including SA, signed an agreement of adherence to the Millennium Development Goals (MDGs) to halve the number of people without access to clean potable water and basic sanitation by the year 2015 (Statistics South Africa, 2015; Ford, L. et al., 2017). However, these goals have not been achieved particularly in Sub-Saharan Africa (SSA).

In 2017, reports revealed that more than 2.2 billion persons lacked access to clean and tested potable water globally (UNICEF, 2017). In the SSA region, nearly 42% of the population still lacks access to clean water (Eberhard, 2019). In SA, more than 5 million people still lack access to a reliable supply of clean drinking water, particularly in rural settings (Hove et al., 2019 & Omarova, A. et al., 2019). However, considerable progress has been made in recent years due to work on the Millennium Development Goals and Sustainable Development Goals. It is important to note that, although there is notable progress in the global domain of water accessibility rural dwellers especially in SSA still struggle to access portable water for their daily water needs such as bathing and cooking (Armah, et al.,2018 & Steele, et al., 2012).

Access to water, sanitation, and hygiene (WASH) is vital for community health and socio-economic development. Low-middle income countries and South Africa with no exception continues to experience inadequate and inequitable portable water supply and sanitation, specifically in remote rural areas and small towns (Abrams et al., 2021). These areas continue to face challenges in service delivery such as poor water provision and loadshedding. According to the World Health Organization (WHO), individuals require approximately 50 to 100 L of water per day to meet their daily needs, which include drinking, personal sanitation, clothes washing, food preparation, and personal and household hygiene (WHO, 2015).

Nounkeu et al., 2022 reported that over two-thirds of the population in rural areas of SSA must leave their homes to collect water from distant water sources (Graham, Hirai and Kim, 2016; Foster et al., 2018). The issue of time spent collecting water has largely been overlooked and not thoroughly examined and explored under Millennium Development Goals (MDGs). Consequently, there is a growing concern that individuals who fetch water from distant sources may experience health consequences associated with musculoskeletal disorders, such as spinal pain or other joint problems (Foster et al., 2018; Geere and Hunter, 2020).

Women and children, who are primarily responsible for fetching water, are particularly at high risk to these above-mentioned disorders (Cooper-Vince et al., 2017). High levels of open defecation lead to deteriorating environments and contributes to contamination of water bodies. During open defecation individuals defaecate in the fields, bushes, and bodies of water or other open spaces. This highly contaminated water bodies and environment with E-coli and other pathogens (Okullo et al., 2017). Studies have demonstrated that collecting water from distant unprotected water sources such wells increase the risk of faecal contamination, leading to waterborne diseases (Luvhimbi et al., 2022). Consequently, rural dwellers and the poorest individuals in society continue to be susceptible.

Scholars have acknowledged that South Africa's water provision and accessibility are unsustainable (Luvhimbi et al., 2022 & Sibiya and Gumbo, 2013). Studies have highlighted the growing concerns regarding quality at the household level (Sibiya and Gumbo, 2013). These studies have shown that most rural areas in South Africa are experiencing the challenges of accessing water services due to their inability to afford the costs associated with municipal services such as water (Luvhimbi et al.,

2022). Understanding the broader health impacts of sub-optimal water access is crucial for the appropriate and sustainable development of water resources. The provision of potable, safe, and sustainable water from protected sources is considered a constitutional right for all citizens, irrespective of their demographics, level of education, or socioeconomic status (Akpor et al., 2011).

1.2 Literature review

1.2.1 Water sources

Water sources refer to water that is available for human beings' ingestion (Radwan et al., 2016 & Loubser et al., 2021). Sources of water are categorized into two: improved and unimproved sources. Improved water sources are defined as those that are likely to be protected from outside contamination and faecal matter, this includes household connections, public standpipes, boreholes, protected dug wells, protected springs, and rainwater (Clasen et al., 2015). Unimproved water sources refer to those sources that are highly exposed to contaminations such as faecal, leachates, and heavy metals this includes unprotected dug wells, unprotected springs, rivers, dams, lakes, ponds, streams, canals, and irrigation canals (WHO, 2013 & Bain et al., 2014).

In the rural settlements, people use various sources of water due to unsustainable water supply systems from the municipal water connection, households use any source that has water available to meet their daily water needs (Omarova et al., 2019). Only 2.6% of the overall water volume on Earth is fresh, and about 0.3% is found as groundwater and surface water, which can be useful for human consumption (Lui et al., 2019). The remaining percentage of freshwater is frozen in glaciers and polar ice caps (Loubser, Chimbanga, and Jacobs, 2021). Numerous studies have confirmed the decreased in availability of potable water globally (Gain, Giupponi, and Wada, 2016). According to (Liu et al., 2017a), population expansion and water demands put a burden on water resources. Groundwater plays an essential part in the African region, as the main source used by individuals to meet their daily water needs (Armah et al., 2018; Alidadi, et al., 2019; Verlicchi and Grillini, 2019, 2020 & Obeta, 2018).

Above 40% of the African population utilize groundwater as their primary source of drinking water, particularly in northern and southern African countries. In SA, existing water resources comprise 77% surface water, 9% of groundwater, and 14%

of water return to surface or groundwater after use (Department of Water and Sanitation RSA, 2016). Research also found that shortages of water in SSA are also responsible for the consumption of polluted surface water by people from local communities (Murei et al., 2022). Small scale farmers have felt the burden of water scarcity in production. Given the high price of alternative portable water sources such as boreholes, the majority of farmers in SSA use wastewater to irrigates their crops (Liu et al., 2017; Viljoen, 2018). In addition, the presence of biological and chemical contamination in plants can be transferred to human through oral ingestion. In effect, the consumption of polluted food items is identified as a factor responsible for health risks such as foodborne disease outbreaks (Rather et al., 2017; Bintsis, 2017).

1.2.1.1 Groundwater

Failure of the municipalities in LMICs, including SA, to supply adequate, potable, and sustainable water has triggered the use of alternative water sources such as groundwater (Tarrass and Benjelloun, 2012; Loubser et al., 2021). About 2.5 billion of the global population depend on groundwater to meet their daily water needs. In the African region, groundwater is a major source of drinking water (Okello et al., 2015). This reflects the importance of groundwater as a water scarcity solution, thus far government authorities have not yet fully acknowledged the importance of groundwater in mitigating water scarcity both on a global and national scale (Li et al., 2018). In South African groundwater sources supply about 15% of the total volume of water consumed nationally (Department of Water Affairs, 2002). In addition, over 280 cities and towns are either solely or partially dependent on groundwater (Van Tonder, 1999; Maitre et al., 2019).

Previous studies have highlighted the increase in groundwater use from nearly 684 MCM in 1950 to 1 770 m. m^3 in 2004 (Braune and Xu 2008; Nhamoe et al.,2019). At international level, groundwater accounts for about 26% of renewable freshwater resources, mainly of which is utilized for irrigation, yet there is a literature gap about the extent of groundwater availability (Elbeih, 2015; Pimentel et al., 2004; Siebert et al., 2010). About 64% of the groundwater pump-out is used for agricultural purposes such as irrigation (Srivastavaa et al., 2009 & Knuppe, 2011). Domestic and industrial sectors i.e., mining consume about 8% of groundwater (Knuppe, 2011). Besides the little knowledge on groundwater quantity, Bronkhorst et al., 2017 identifies that 13% of the country's freshwater resources come from groundwater of which 59% is

utilized in irrigation, 13% in domestic water supply, 13% in mining, 6% in livestock and 9% for other uses (Bronkhorst et al., 2017).

In addition, groundwater resource plays a vital role in socio-economic and environmental systems, particularly where water resources are under the greatest pressure (Molobela, 2011). The literature review has indicated that a total of 235 000 MCM/a of water is stored underground, and that is between 10 000 MCM/a, and 16 000 m. m^3/a are available for use in an average rainfall year, and 7 000 MCM/a in a drought year (Department of Water Affairs and Forestry, 2004 & Knuppe, 2011). This also highlights the importance of groundwater as a water scarcity solution.

In a water scarce country like South Africa, groundwater management has become topical due to its importance in water supply (Braune and Xu, 2008; Donnenfeld et al., 2018; Münch and Conrad, 2007). In the South African context, industries such as mines discharge harmful and toxic chemicals to nearby rivers and dams. Where human activities are executed, chemicals or wastes may be released to the environment, either intentionally or accidentally, and has the potential to pollute ground water. The contaminants impact on the groundwater depends mostly on their properties such as physical, chemical, and biological. A contaminant that has been released into the environment may move within an aquifer in the same manner that ground water moves (Environmental Protection Agency,2000; Akhtar et al.,2021). This imposes threats on the groundwater water table and the quality of water (Department of Water & Sanitation, 2016). In addition, the lack of policy enforcement on groundwater sources continues to exacerbate human exposure through contaminants (infectious and chemicals).

Commercial mining has been around for decades and makes a significant contribution to employment. The extraction of minerals and metals from the Earth, such as manganese, gold, and copper, and the subsequent refining of gold, have contributed to the continent's richness and economy. Furthermore, mining causes numerous environmental issues and obstacles, including contamination and competition for surface and groundwater. Water contamination from mining activities is caused by the discharge of effluents containing harmful compounds like cyanide and other organic chemicals used in mineral ore processing. These compounds may combine to produce effluent with high acid levels, which can seep into subsurface water or flow into the environment (surface water bodies). It is worth noting that lack of charges or fines for illegal mining will continue to pose a threat to water resources and the ecosystem (Arouna and Dabbert, 2010; Obeta, 2018).

1.2.1.2 Dams and rivers

Africa has 17 rivers regarded as blue water sources with drainage basin areas larger than 100 000 km^2 and more than 160 lakes larger than 27 km^2, with the majority located in the equatorial region and the East African Highlands within the Rift Valley (Yuman et al., 2017). Blue water sources refer to the liquid water in streams, rivers, wetlands, lakes, and aquifers that can be extracted for human use, such as irrigation and domestic use (Loewenson et al., 2020). Moreover, about 60% of the large dams in Africa are situated in SA and Zimbabwe (Masindi and Duncker, 2016).

SA is highly reliant on storage reservoirs to maintain a reliable water supply in dry seasons. SA has more than 500 large dams, of which 50 have a storage capacity exceeding 100 million m^3, which are used for irrigation and urban and industrial water supply (Coetzee et al., 2016; Department of Water and Sanitation RSA, 2016). It is important to note that the water from dams and rivers are mostly polluted by to heavy metals, fertilizers, pesticides, human sewage, detergents, and cattle excrement (Parmalee and Aschner, 2016). These water sources contain heavy metals usually present in trace amounts but many of them are toxic even at very low concentrations. Excessive chemicals such as phosphate have been observed to cause blue or green algae and water hyacinth growth, especially in dams (Briffa et al., 2020b).

1.2.1.3 Rainwater

Rainwater can be used to increase the groundwater table, through rechargeable excess water to the ground. The study conducted in Ethiopia reported that rainwater can be used to substitute tap water, where the communities experience water shortages. Mukaromah (2003) and Thomas (2015) stated that rainwater can be used if surface water is unavailable, groundwater is polluted, and pipe supply is unaffordable. With variable climate conditions and unsustainable municipal water accessibility, rainwater harvesting can help to reduce the effects of rising water scarcity.

Rainwater harvesting remains one of the alternatives for susceptible communities in rural areas of LMICs to meet the domestic water demand by collecting roof water from rain. The harvested water from rain must go through a series of capture, storage, and treatment steps before it is drinkable (Ertop et al., 2023). Due to the harvesting process of water, treatment is essential to remove contaminants, such as pathogens, organic material, dust particles, and metals, that may mix with

rainwater from the air, roof surface, or other pathways (Capehart et al., 2021). Usage of rainwater is an easy-to-use water source and cost-effective (installation of the harvesting and cleaning system) with high potential, and it is reasonable to mainstream rainwater harvesting in integrated water resources management (An et al., 2021).

1.2.2 Water pollution

Water pollution refers to the addition of contaminations to the water bodies to such an extent that the water cannot be used for a specific activity (Mitiku, 2019). Webster 2010 defines pollution as the presence of excessive amounts of a pollutant in water in such a way that it is no longer suitable for use. The addition of contaminants in the water body may result in undesirable changes in chemical and physical properties, this may affect the ecosystem as it depends on water for sustainability (Schweitzer et al., 2018). Introduction of water contamination of water sources may be due to many different natural and anthropogenic activities such as geochemical processes, flooding, the release of untreated wastewater, industrial effluents, manure spreading on soil, acid mine drainage, and infiltration of water from polluted sites (Verlicchi and Grillini, 2019). Sources of water pollution are classified in two categories a point source or a non-source. Point source pollution is the result of the direct addition of contaminants in the water body for example effluent discharges from sewage treatment works and landfill sites.

A nonpoint source occurs when there is runoff of pollutants into a waterway for example leaching into surface water and groundwater of contaminants from roads, and manures (Agrawal et al., 2010). Water pollution is a major cause of health concern in global and local states and water-related diseases, it the leading cause of disease and death globally for both young and older people. Waterborne pathogens cause diseases in humans through two major exposure pathways: drinking water and recreational waters. Agricultural and industrial pollution sources have added chemicals and toxins to water, such as arsenic and nitrates. When arsenic levels in drinking water are generally much higher, long-term consumption of arsenic-contaminated water has been associated with circulatory system problems as well as an increased risk of cancer, liver, and prostate cancer (Chimphamba & Phiri, 2014).

Water pollution in LMICs is an ongoing problem that needs serious interventions. Agricultural activities are identified as the major cause of water pollution. A report from the Environment Protection Agency (EPA), found that greater than 50% of the

water pollution of streams and rivers occurs due to leaching and mixing of chemicals from the agriculture practice. The groundwater contamination is mainly from various sources, including agricultural activities, storage tank leakage, industrial waste, sewer, and septic leakage, leaching from landfills, and mining (Stefanakis et al., 2015). The water contaminants from mining processes are a result of effluent discharge, which contains toxic chemicals such as cyanide and other organic chemicals (Duncan, 2020). The tailings are dispersed into the environment by wind, rainwater runoff, and surface water flow (Hemson, 2016).

Hanses, 2015 and Kinna, 2016 stated that, during rainy days water percolates through mine tailings, and sulfur-bearing pyrite reacts with water and air to form sulfuric acid and ferrous sulfate. The acid effluent further dissolves into the ground or surface water bodies and soils in the area (Belle et al., 2021). During the windy days, dust is blown and particulate matter containing contaminants from mining tailings over long distances, which eventually settle on soil, water bodies, and plant leaves within the vicinity of the mining tailings (Castillo et al., 2013; Stovern et al., 2016).

The increase in illegal mining in Low Middle-Income Countries and SA has posed a threat to water quality in nearby communities, mainly that depend on such water bodies for drinking water and other domestic purposes (Duncan, 2020). The authorities in LMICs fail to hold mines accountable for pollution of these water bodies. This further exposes the authorities in LMICs, who have insufficient policies and poor water and health management surveillance.

1.2.3 Water access in South Africa

The South African government has made considerable progress in providing water services, including both piped water and improved sanitation, to those who were previously deprived of such essential services during the apartheid era (Hamson, 2015). Access to improved water sources in SA has increased between the period 1990–2015, from 66% to 81% of the rural communities. SA has achieved one of the Millennium Development Goals (MDGs) to halve the number of people without access to clean potable water and basic sanitation by 2015 (Statistics South Africa, 2015). In SSA, 42% of people are without a basic water supply, and 72% are without basic sanitation with most of the affected population located in rural areas (Fair, 1995; Obeta, 2018; Armah et al., 2018).

Most SSA countries did not meet the MDG target but progressed during the MDG period, with 42% of its current population gaining access to improved drinking water since 1990 (Armah et al., 2018). It is important to note that regardless of the agreement on adherence to the Sustainable Development Goals (SDGs), to ensure accessibility and supportable supervision of water and sanitation for all by 2030, based on research on the pace of provision of these basics, billions of people will lack access to these basic services in 2030 unless progress quadruples. Demand for water is rising owing to rapid population growth, urbanisation, and increasing water needs from agriculture, industry, and the energy sector (Un et al., 2021). In the South African context, given the current trends such as unsustainable water provision and a high percentage of people without access to water, achieving this SDG is not practicable. The percentage of people without water has increased drastically over recent years (Kijne 2013; Pahlow, 2015). Due to the severe water crisis that has led to water insecurity and inequalities in access to water, the government had to regulate the water sector Department of Water and Sanitation (Pollard et al., 2014).

The National Development Plan (NDP) has been developed to ensure all citizens have access to clean running water in their homes by 2030 (RSA, 2015). The responsibility of adequate provision and equitable supply in SA remains assigned to the district and local municipalities (Loubser et al., 2021). According to the Household Survey 2022, about 82,4% of families in SA have access to potable water. In recent years, progress has been uneven across the country due to various factors. In LMICs and SA with no exception, there are continuous significant inequalities between rural and urban areas and between rich and poor. The water supply is unstable due to water interruptions in both urban and rural settlements (An et al., 2021). Inadequate water supply, low water quality, acid mine drainage, incompetent engineering personnel, and poor maintenance of water supply infrastructure affect water supply and quality (Loubser et al., 2021).

SA is losing over 1.5 billion m^3 of water each year due to broken pipes and infrastructure that have been used for a long time and have exceeded their lifespan (Masindi and Duncker, 2016). Kwazulu-Natal, particularly Durban, reported about 8% of water lost in 2013 due to theft by 40 000 illegal domestic connections and tampering with meters. In 2016, the number of illegal domestic connections

increased to as many as 45 000 in the eThekwini area (Ngcobo, 2021). A gap in empirical evidence on household-level factors that systematically and jointly influence access to improved water and sanitation services and consequently, beyond geopolitical boundaries has been identified. The incomplete understanding of how to incorporate initiatives at the household level into a wider planning and support framework in SSA has been identified as a looming gap (Armah et al., 2021; Ngcobo, 2021).

1.2.4 Water use at the household level.

Understanding household water consumption patterns is essential for provision and developing water-related policies, particularly policies that aim to manage water scarcity and understands the water demand in the household level. As a result, household water consumption patterns continue to gain attention in the literature, across the world. End-uses in the household include the shower, washing machine, toilet, dishwasher, taps and garden irrigation (Nguyen et al.). According to WHO, domestic water refers to water used for all household daily activities including consumption, bathing, and food preparation (WHO, 1993; 2002; Crouch et al., 2021a). Residential water consumption could fundamentally be classified as either indoor use or outdoor use.

Water is a basic need for everyday activities that are required for various activities, and it plays a crucial role in various daily activities. It is essential for drinking, cooking, and maintaining hygiene, including washing hands, preparing food, and bathing at the household level. In some instances, water used for hygiene practices may also have religious significance. Additionally, beyond mere survival, water is necessary for sustaining a desired lifestyle (Thompson et al., 2012). This implies that the requirements regarding the adequacy of water apply across all water use activities and not solely to the consumption of water. Studies have shown that water consumption on outdoor activities it higher than indoor activities. The location of the household also plays a significant role in water consumption level, household located in suburbs tend to use more water as compared to household located in the rural settlements.

According to the data of the United Nations Statistics Division on water consumption in major countries around the world, the total water consumption in the world is about 4 trillion cubic meters, of which domestic water accounts for about 10% (Due et al.,

2022). A study conducted by Hussien et al. (2016) investigated water use pattern in the household level among of 407 households in Duhok City, Kurdistan. Per-capita water consumption was found to be 241, 272 and 290 l/c/d for low- medium- and high-income houses, respectively. The amounts used varied somewhat according to the quality and proximity of the water supply and the size and wealth of households, but in almost all villages in Bushbuckridge the average use for these purposes was close to or below the minimum 'basic needs' figure of 25 l per capita per day (Castresana, 2020). Water consumption in South Africa averages 237 Litres/person/day (L/c/d), a figure higher than the world average of 173 L/c/d (Ngobeni & Breitenbach, 2021). A study by Booysen et al. (2019) found that households water consumption in Cape Town average daily water use is about 260 litres.

The World Water Development (2018) has reported that approximately half of the world's population lives in an area with one month's water shortage every year, the rural communities have frequently experienced the water shortage. Water scarcity is foreseen to be exacerbated by 2050 given the situation is not changing. Water scarcity is the lack of water demand and access to accomplish all the water uses by all sectors (Falkenmark et al., 1989; Alcamo et al., 2000; Vörösmarty et al., 2015).

1.2.4.1 Factors affecting water consumption.

Water scarcity has become a major constraint to socio-economic development, human health, food security, and natural ecosystems (Liu et al.,2017; Hedden and Cilliers, 2014). Various factors have influenced water scarcity which include but are not limited: to disputes over scarce water resources, poor service delivery in terms of water distribution, wastage of existing resources, and environmental changes (Donnenfeld et al., 2018). Literature has shown that water consumption at the household level varies given the socioeconomic status of each household. Studies have reported a significant relationship between two variables household income and water consumption. Households with a high income consume more quantity of water about 200–300 L/day/person, while low-income households consume 40 L/day/person (Ramulongo, Nethengwe, and Musyoki, 2017). The LMICs and rural areas because people cannot buy water due to unemployment and most people who live below the poverty line will feel the water scarcity burden (Yue et al., 2008; Thomas et al., 2020)

In Africa, populations living in vulnerable situations get about 20 L of water a day which is the same quantity of water used for having a shower for 1.5 minutes (Nagabhatla et al., 2019). This is a violation of human rights and the WHO's guidelines for water accessibility. Another example of limits includes affordability, the high costs of water may force households to use higher quantities of water from unimproved water sources.

Domestic water use is affected by accessibility, continuity, reliability, and price (Kayster et al., 2013; Njoku et al., 2022). Internal and external factors such as season, infrastructure, household size, and water source location have been observed to affect household water consumption. A study was conducted by WHO (2020) to determine the minimum amount of water needed to meet basic health-related needs. Individuals who use about 20 LCPD of water per day for personal and household chores are insufficiently equipped to meet basic hygiene needs and are prone to high risk for health concerns, while 50 LCPD and 100 LCPD of water use are at low risk for health concerns. In addition, where demands for water for hygiene are increased for example, due to increased frequency of handwashing in response to outbreaks of disease – 20 L/day is likely to be insufficient; often, running water from a tap is necessary to support sufficient handwashing (Howard et al., 2020).

The consumption of water and the location of sources plays a significant role, individuals who collect water from a communal facility use an average of 20 LCPD. The individuals with a single tap in their households used an average of 50 LCDP. Where there are multiple taps available in a household an average of water greater than 100 LCDP was determined. Where water supplies are not continuous and reliable, households will likely use less water than shown, particularly if they have inadequate coping strategies such as storage.

1.2.4.2 Average daily water used at the household level

A study was conducted to explore water consumption per capita in the City of Cape Town within 57 communities in nine different municipalities using treated bulk water. The researcher found that an average of 20 L/per capita is used (Du Plessis, 2007). This finding highlights the literature gap between urban settlements and rural settlements. Study by (Du Plessis, 2007) profiled water use patterns and water consumption in domestic activities laundry uses more water at 53% followed by

bathing at 25% per day. A study by Viljoen (2015) conducted in Cape Town on residential water consumption trends found that laundry was the highest water use activity in the informal settlement followed by bathing with 55.82%, and 47.5%. In middle to high-income settlements laundry consumed less water, 46.51% and bathing consumed a high quantity of water 62.86%. In addition, a study carried out in 2015 showed that the average South African suburban family of four (4) uses 300 liters per person per day (Mata et al., 2016).

Households without basic access are unlikely to use the minimum quantity of water necessary for consumption. Ensuring that these households have reliable access to a basic water supply, preferably intermediate access or higher, is a priority. Ensuring that everyone has at least an intermediate level of access is consistent with meeting SDG Target 6.1 and should be a priority for national policy in all countries. Further health improvements may occur in households attaining optimal access to water – for example, associated with increased use of water for hygiene because of ease of use, and the ability to use more water for gardening and productive purposes, leading to an increase in household nutrition and income.

1.2.5 Water consumption amongst gender and age

General household-gendered water uses and management in LMICs, particularly in rural settlements have remained relatively under-researched. Several studies on water use and consumption amongst sex and age are conducted in developed countries. Such limitations have led to inaccurate statistics on water use at the household level amongst genders. In a report by the U.S Geological Survey (2015) where water consumption was explored amongst sexes, a female uses 273.07 L/day, a male uses 164 L/day, a child uses 161.21 L/day, and a retired person uses 401.38 L/day. The study was conducted in developed countries hence, it does not apply to LMICs countries. Females are usually responsible for different activities, including domestic household activities, productivity (agriculture), and caregiving for children and the elderly compared to males hence, they use a high quantity of water.

Sustainable water cannot be separated from access to sanitation and good hygiene, including menstrual health management. Women and girls are responsible for most of the water-fetching burden (Sorenson et al., 2011; Kayser et al., 2019). The collection of water over long distances for prolonged periods has, consequently, influenced the high dropouts of children in LMIC schools. Consequently, this practice

has robbed many women of the chance to receive an education and the opportunity to hold down a job as they eventually become regular water carriers for the family (WHO and UNICEF, 2010; Mercy Corps, 2014). Of concern, women are at high risk of exposure to transmission and contraction of diseases, due to the responsibility of provision of water in the household (WHO, 2011).

1.2.6 Water scarcity

The agricultural sector uses more water than other sectors. Mancosu et al., (2015) confirmed that the agriculture sector uses the largest water quantity: approximately 70% of the total water consumption globally. In LMICs domestic water use accounts for 7% of the total water use (Hinrichsen et al., 1997; Khokhar, 2017). With the constant growth of population and changes in water consumption patterns that have increased the water demand, water sources can no longer cater to water supply which has resulted in water scarcity (Okello, 2015). Consequently, these two factors: limited supply and growing demand have resulted in water scarcity/crisis.

The World Water Development (2018) has reported that approximately half of the world's population lives in an area with one month's water shortage every year, the rural communities have frequently experienced the water shortage. Water scarcity is the lack of water demand and access to accomplish all the water uses by all sectors (Falkenmark et al., 1989; Alcamo et al., 2000; Vörösmarty et al., 2015).

1.2.7 Water security

Water security is the abundance of good and valuable water for health, livelihood, ecosystems, and production, without endangering the lives of the people and reducing minimal risk (Grey & Sadoff, 2007; Apraku et al., 2023). This definition emphasises two key points; (1) enough water is available for the sustainability and the well-being of the society, (2) the society is protected from all negative impacts of the water cycle like droughts, and floods, to mention a few. Water management is important and has a major control on the socio-economic development of each country (Ojo, 2019). Adequate measures and proper policies must be laid down to manage water resources, as this will assist the government in achieving water security (DWS, 2014). It will also serve as a basic factor for economic development. Water can be a source of life, livelihood, and prosperity, while at the same time a cause of death, devastation, and poverty, as seen in droughts, floods, landslides,

epidemics, and erosion (Grey & Sadoff, 2007; Department of Water and Sanitation, 2021). Hence, there is a need to promote the prolific potable water and try to reduce its vicious impact on society.

1.2.8 Policies for water management

The integrated Development Plan is five-year plan for service delivery, the current five-year IDP Plan for 2021 to 2025 of Dr. Ruth Segomosti District Municipality (RSDM) was adopted in the previous year's IDP and SDGs goals (IDP, 2021). The major focus of this draft is to ensure communities get basic service delivery and sustainability of water resources. To achieve this vision, the priority is to provide new infrastructures and good maintenance of existing ones (water, sanitation, roads, electricity, and stormwater). The health policy to achieve universal health coverage and reduce the global burden of diseases needs to ensure that targets and indicators go beyond healthcare services and address underlying determinants of health including progressive improvements in access to safe drinking water, sanitation, and hygiene services (Ralo et al., 2014). Adequate quantities of safe water at home are essential for human consumption.

The Constitution of SA stipulates that "everyone has a right to have access to water" (Section 27(1). This document binds the three spheres of government national, provincial, and local to deliver adequate water supply to its citizens regardless of demographics, level of education, and socioeconomic status (Akpor et al., 2011; Adom & Simatele, 2021).There are two core legislative frameworks for transformation in this sector: the National Water Act (Act 36 of 1998) and the Water Services Act (Act 108 of 1997). The Department of Water Affairs uses these acts for the implementation of water policies as it is the main custodian of water resources. The water policies are as follows:

Table 1: List of water policies in South Africa and their description

Policies	Description
Water Service Policy (White paper) 1994	The objective of this policy is to address the backlog of water accessibility post-1994
Public policy on water access	The context of South African water policy can be traced back to historical, political, and economic (Movik, 2014). Before 1994, the Land Act of 1913 gave 85% of white people the right to land use, leaving black people to cohabit in remote areas, as it is illegal to reside in reserved communities.

National Water Policy	The target of this policy is to develop an integrated water resource management approach (IWMRM) on catchment basin and national water resources strategy that will promote governing of river basin within a water management area in a holistic and integrated manner (Act No. 36 of 1998). In 2004 DWAF developed guidelines on groundwater resources that correspond with the IWRM system.

Source: Department of Water Affairs and Forestry (1994).

Based on **Table 1**, water quality monitoring and management in SA remains an ongoing crisis in the presence of the acts and policies in place. The gap between stakeholders in working together to enforce the regulations and bring awareness has been highlighted (Riemann et al., 2014). According to Odiyo et al., (2012), the lack of human capacity (Environmental Health Practitioners) and inadequate finances have hindered the municipalities' implementation of water quality monitoring. The sampled water sources are being limited in numbers and only municipal water sources are sampled this excludes any unimproved water sources such as boreholes. The backlog in issuing groundwater licenses means that water use is taking place without proper regulation and no sampling is taking place as most are treated as private water sources (Pietersen et al., 2011). Consequently, this will exacerbate human exposure as water from private sources does not meet the prescribed National Drinking Water Standards (SANS 241 Drinking Water Specification).

1.2.9 Human health effects of unsafe and inappropriate sanitation

Globally, exposure to water contaminated with microbiological pollutants remains the largest cause of water-related morbidity and mortality (Bezuidenhout et al., 2002; Villanueva et al., 2014). Epidemiological studies have documented a lack of handwashing and ingestion of water contaminated with faecal material to be the main exposure pathway to acute microbial diseases such as trachoma, cholera, diarrhea, typhoid, and amebiasis (Villanueva et al., 2014; Azmuda et al., 2019). Inadequate mismanaged water and sanitation services exposed individuals to preventable health risks. Waterborne diseases are viral, bacterial, and parasitic diseases that use water as a common means of transmission through the oral route of entry (USAID, 2003; Overgaard et al., 2021).

Water-related diseases are classified into six categories waterborne, water-based, water-related, excreta-related, water collection and storage, and toxin-related.

Table 2: Categories of water sanitation and hygiene-related diseases

Disease	Origin
Waterborne	Ingestion of water contaminated by human or animal excreta or urine containing pathogenic bacteria.
Water-based	Parasites found in intermediate organisms living in water; include dracunculiasis, schistosomiasis, and some other helminths
Water-related	Microorganisms with life cycles associated with insects that live or breed in water; include dengue fever, lymphatic filariasis, malaria, onchocerciasis, and yellow fever
Excreta related	Direct or indirect contact with pathogens associated with excreta and/or vectors breeding in excreta; includes trachoma and most waterborne diseases.
Water collection and storage	Contamination occurs during or after collection, often because of poorly designed, open containers and improper hygiene and handling.
Toxin related	Toxic bacteria, such as cyanobacteria, which are linked to the eutrophication of surface-water bodies; cause gastrointestinal and hepatic illnesses

Source: WHO (2019).

Based on **Table 2**, waterborne diseases are among the major public health problems in LMICs. There are leading causes of morbidity and mortality in all age groups particularly in children under five years (Nguyen et al., 2021). According to the WHO, diarrhoea remains one of the major public health challenges in LMICs and the second most common cause of mortality, and disability among children aged under five globally (Awotiwon et al., 2016; Nguyen et al., 2021). These young children are very susceptible to waterborne diseases because their immune systems are not fully developed. In LMICs resistance may be further impaired by malnutrition.

Lack of access to potable water is accountable for about 829 000 diarrhoea mortality-related diseases yearly (Nounkeu et al., 2019; UNICEF, 2019). Cholera has remained the major global public health problem since the early 70s. LMICs, including South Africa, continue to be vulnerable to cholera epidemics due to alarming socio-economic imbalances such as vast water accessibility challenges, and overcrowded communities. Research has shown these living conditions increase the risk of cholera outbreaks in the future. As per 2024 WHO stats, it is

reported that as for March 2024 in SSA region, there were 62175 confirmed cholera cases and 1232 fatalities. In SA, diarrhea accounts for 20% of deaths in children younger than 5 years (Nguyen et al., 2021). Studies have reported that 80% of all diseases in the world are caused by inadequate sanitation, polluted water, or unavailability of water. Poverty, illiteracy, overcrowding, and low health services are contributing factors that directly or indirectly affect the prevalence of water-borne diseases (Ustün et al., 2014; WHO, 2020). This indicates the ongoing health issue, therefore an integrated prevention and curative approach with community participation is required to tackle this prevalent public health problem (Verlicchi and Grillini, 2019). Of importance sustainable, sufficient, clean, and safe drinking water is essential for protecting human health, by reducing the burden of common illnesses, such as diarrheal disease, especially in young children and vulnerable elderly people (Sundaravadivel and Vigneswaran, 2009; WHO, 2018).

The continuous use of unsafe water, improper disposal of waste, and lack of water for hygienic practices in schools have perpetuated diseases such as cholera, typhoid, and hepatitis (Mercer, 2021).

On many occasions, outbreaks of such conditions have resulted in school closures which have made education impossible in many rural areas. Chemical(s) exposure to water supplies has the potential to cause acute and chronic health effects, even at low doses across the population (Zheng et al., 2020). Adverse health consequences may arise from exposure to chemicals following long-term and, in some cases, short-term exposure (Wee & Aris, 2023). Furthermore, concentrations of most chemicals in drinking water do not normally fluctuate widely over short periods. The communities located in mining areas are more susceptible to exposure to those chemicals in water sources. Few chemical constituents of water can lead to health problems resulting from a single exposure, except through massive accidental contamination of a drinking water supply (Villanueva et al., 2014). The evidence in developing countries is still insufficient due to prolonged exposure pathways, and other factors involved in the development of diseases associated with exposure to chemicals in drinking water.

Ingestion of drinking water with heavy metals and inorganic arsenic is a public health concern, due to its physicochemical properties, and its effects on human health carcinogenic and non-carcinogenic (Milton et al., 2006; Van Halem et al., 2009). The

health risk assessment studies conducted in different countries have proved that drinking 1 L/day drinking water with an arsenic dose of 50 µg/L and chromium dose of 8.3–51 over one lifetime may cause cancer of the lung, liver, bladder, kidney, and central nervous system effects (Villanueva et al., 2014). Arsenic may occur naturally, and excess exposure to arsenic in drinking water has been documented to result in adverse health effects. In addition, skin damage and respiratory disorders are well documented from an arsenic dose of 0.0012 mg/kg/day through drinking water (Alidadi et al., 2019).

Fluoride is one of the corrosive chemicals when exposed to high levels of fluoride, can result in acute to severe health effects which include mottling of teeth and, in severe cases, crippling skeletal fluorosis (Ullah et al., 2017).Various studies have highlighted that nitrate and nitrite in water are associated with methemoglobinemia, especially in bottle-fed infants. These chemicals may arise from the excessive application of fertilisers or the leaching of wastewater or other organic wastes into surface water and groundwater (WHO, 2002; Villanueva et al., 2014). Particularly in areas with aggressive waters, the use of lead pipes and fittings or solder can result in elevated lead levels in drinking water, which cause delay in neurologic in infants.

1.3 Problem statement

Sustainable access to potable water has been achieved in high-income countries, but this is not the case in LMICs. In the South African context, rural settlements are faced with critical water crises as communities still lack access to adequate water supply (Olutola, 2020). Residents of such rural communities often resort to alternative water sources, most of which are susceptible to water pollution, as there is no enforcement of guidelines and monitoring plans that protect the quality of the water (Gomez et al., 2011; Hove et al., 2019). Most of the rural municipalities across the country experience difficulties in meeting water demands (Ramulongo, et al., 2017).

Adequate water supply is of utmost importance to the public and economy for sustainable development. Inadequate water supply and accessibility have remained an ongoing crisis in LMICs and SA with no exception. In addition, there is limited information and statistics on water availability and provision at the household level in rural settlements which hinders the service delivery as this information is critical for water service delivery including planning, design, and operation of water supply

and distribution systems. Numerous municipalities in the country such as Rustenburg, Kagisano Molopo (KMLM), and Majakaneng Brits have adopted various means or control measures to combat water scarcity such as water tankers and water trucks (Edokpayi et al., 2018), however, others do not have such measures in place.

According to Riemann et al., 2014 SA's government is still confronted by many obstacles to the achievement of sustainable, efficient, available, and accessible water. The water resources are at risk due to extensive pollution due to anthropogenic effects. This affects the resource directly by making the water less acceptable for human consumption. This severely affects water quality and impacts negatively on public health, particularly in remote rural communities that are rarely supplied with treated municipal water. Dr. RMDM in the Northwest Province is categorized as a water-scarce region. The district experiences numerous water service delivery problems, such as insufficient bulk water supply, to meet current and future demands and insufficient water infrastructure to support the demand (Dr. RMDM IDP,2020). This is a health risk for the residents in the community who must look for alternative sources of water. Inadequate water at the household level exposes individuals to preventable health risks due to pollution parameters exceeding the SANS 241 limits.

1.3.1 Justification

The study will add value to existing knowledge and statistics about water availability and provision. Such information is necessary for the development and monitoring of water resources and uses in rural settlements. The study findings can be used for policy reform and updating regulatory frameworks to protect water sources. Furthermore, the results will give evidence on the water sources used and water consumption patterns to inform policy about the overall water sources used and quality, which will assist in developing monitoring plans for groundwater and other water sources applicable.

1.4 Study Aim

The aim of the study was to identify water sources and describe water use amongst the residents in a rural settlement in Ganyesa village.

1.5 Objectives

To achieve the above aim, the following objectives were set.

1. To determine and describe water sources used by the community of Ganyesa.
2. To describe and estimate the water use per household in Ganyesa.
3. To determine factors affecting water consumption in Ganyesa.

CHAPTER 2: METHODOLOGY

This chapter focuses on the study's research design and methodology, as well as how data was collected. It starts with a detailed description of the study area and the definition of the study parameters. It also provides insight into the procedures, steps, tools, techniques, methods, and materials used to obtain relevant information to answer the study's aim and objectives. The process of explaining how a researcher intends to carry out research is known as a research methodology; it's a methodical, logical approach and systematic plan to solve a research problem.

2.1 Research design

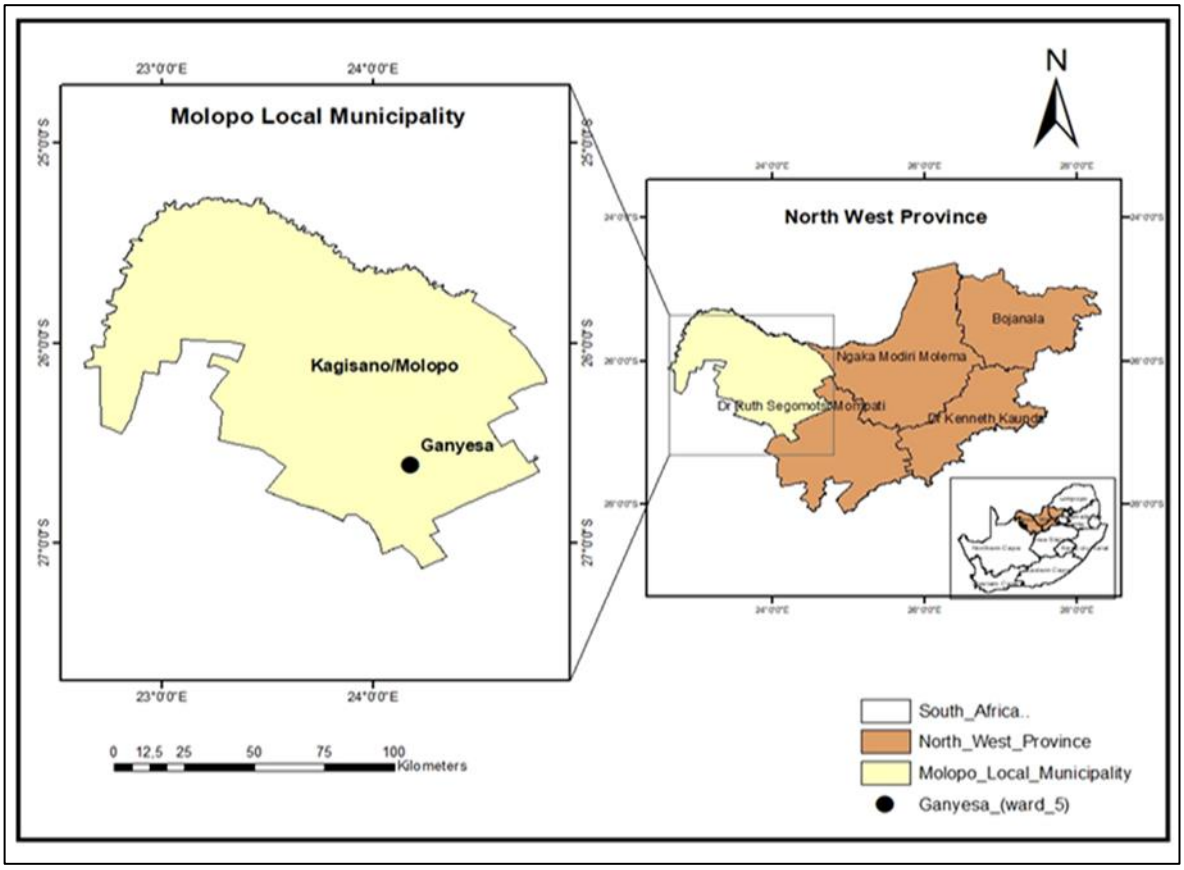
A quantitative cross-sectional design using descriptive and quantitative approaches was employed in the study to provide insight into existing water sources used by the community of Ganyesa, and water used at the household level, describing the socioeconomic characteristics of the population, water sources and consumption patterns. Cross-sectional research design is a type of observational study design (Alexander et al., 2014; Capili, 2021). In a cross-sectional study, the investigator measures the outcome and the exposures in the study participants at the same time. This study design studies can usually be conducted relatively faster and are inexpensive (Setia, 2016).

2.2 METHODS AND MATERIALS

2.2.1 Description of the study area

The study was conducted in Ganyesa village, an underdeveloped rural settlement that is located within the Kagisano Molopo Local Municipality under Dr. RMDM in the Northwest Province, SA. KMLM is 70 km north of Vryburg. Error! Reference source not found., shows the aerial map of the study area. The district is one of the four in the province, with rural areas. The average rainfall of Ganyesa is less than 250 mm annually, the current resident household of Ganyesa has an area of 21.46 km^2 with a total of 5 204 households (South Africa Statistics, 2011). Ganyesa village was purposefully selected due to its location, accessibility to the researcher, and the nature of the water issues that the community is experiencing (Erasmus, 2021). The study was conducted specifically in Ward 5 of Ganyesa as the community was easily accessible and the households used various water sources (Integrated Development Planning, 2020).

Ganyesa village is an underdeveloped rural settlement, residents have few resources, and service delivery is at a slow pace. Agricultural activities such as cattle farming are the most common economic activity in Ganyesa (District Development model, 2020).



Source: (Created using ArcMap GIS version 10.8)

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2.2.2 Target Population

Barnsbee et al., (2018) defines target population as a cluster of individuals with whom the researcher intends to conduct research and draw conclusions. The population size of Ward 5 was n= 1734. The participants constituted members of the community of Ward 5 aged between 18 and 65 years.

The inclusion criteria included both sexes with an age range from 18–65, who had been residing in Ward 5 for a minimum of a year. The study followed a quantitative research approach using a sample size of 180 participants. The researcher used a hard copy map of Ganyesa to select the households randomly. The Taro model was used to calculate the sample size for the study (Israel, 2013; Kayode et al., 2021). The computation was performed using Equation (1).

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

Where n was the sample size, N was the total population and (e) was the level of precision, 5 (0.05). The total sample size was 174, which is equal to 10% of the study population size in Ward 5. The selection of 10% of the study respondents is believed to be scientifically acceptable. Due to financial and time constraints, access to a large sample was not possible. The sample size represented all the subgroups of individuals in Ganyesa, Ward 5 village. An additional 25% of households were added to the sample size to allow for refusal and unusable data. A total of 175 households were sampled.

2.2.3 Sampling

A random sampling technique was employed to select the respondents in the area. A sampling frame was constructed using a map of Ganyesa village. The sampling frame comprised information such as the number of occupants, age, and information on demographics. Kagisano Molopo Local Municipality provided demographic information for Ward 5. For this study, random sampling was deemed suitable as it allowed the researcher to select participants from a larger population using a probability-based method. All participants from both sexes with an age range from 18–65 years were eligible to participate in the study.

2.3 Data collection

2.3.1 Research instruments

The research instruments included semi-structured questionnaires administered through face-to-face interviews, and the filling of daily activities data sheets, and secondary data for participants that were using tap water in their yard.

Questionnaires were used to collect primary data from the respondents. The questionnaires were divided into sections according to the study objectives Section A: Household socio-economic data, Section B: Water sources, and Section C: Water consumption. Questionnaires are effective tools for obtaining personal experiences, and this includes methods like focus groups, observations, and journaling (Roopa & Rani, 2012). The questionnaire represents a prevalent means of data collection, consisting of a series of inquiries with corresponding responses, completed by individuals (drawn from a specific population) to provide the researcher with the

necessary information for the study (Taherdoost, 2021). The data given from a questionnaire cannot be achieved from the secondary resources (Pandey & Pandey, 2015). Questionnaires can be implemented in various ways. A face-to-face questionnaire mode can be employed to present the questions orally, paper-and-pencil types can be utilized with the items presented in the paper or computerized questionnaires for data collection (Kabir, 2016).

Semi-structured interviews are formal and are conducted based on a guideline. During the interview when researchers or interviewers need extra information, they can continue the conversation based on the questions provided ahead of time (Ali & Bhaskar, 2016). For daily activities, there is a self-administered questionnaire that asks participants to fill out the forms in two different situations. The daily water activities sheet was used to estimate the overview of water uses and activities. Based to the research using self-administered questionnaires (Roopa & Rani, 2012), the first is that event-based individuals ask to fill when something happens. The second type is known as time-based diaries which should be filled at a particular time frame. Furthermore, diaries can be elicitation and feedback studies elicitation types allow the participants to utilize media to help their memory. Feedback studies use predesigned questions to get immediate responses (Taherdoost, 2021).

Secondary data sets were obtained from Sedibeng water providers, the data was already gathered by a Sedibeng administrator. Billing information was requested from the Sedibeng water service provider, for households who have taps in the yards. The calculation on per capita was calculated. Identifiers were used to separate these households from the rest of the households.

2.3.2 Data collection procedure

Data collection began in November 2022, and the last interviews were conducted on January 30, 2023. Before the commencement of data collection, approval letters were obtained from the Tlou le Tau tribal office. This study employed a random sampling technique where sampling frames were drawn on a hardcopy map of Ganyesa village. Thereafter, two households were selected from each frame, selected households in Ward 5 were visited. Each morning, the fieldworkers and researchers held a meeting to address any issues and plan for the day ahead. The head of each household was approached and invited to participate in the study. The participants were provided with information about the research, including its purpose, confidentiality measures, and their right to refuse participation if they

wished. Before their involvement in the study, participants were asked to voluntarily sign the consent form, as outlined in (Appendix C).

In cases where the head of the household was not available during the initial visit, the field workers would leave and return later when the head of the household was present. Field workers were trained by the principal researcher. To ensure the accuracy of data collection, the researcher occasionally accompanied the field workers during household visits to verify that the data was being collected correctly. All the questions on the questionnaire were originally in English, as it was the medium of instruction. The questionnaires were not directly translated from English to another language. However, during household visits for questionnaire administration, the field workers provided translations in Setswana for participants who had difficulty understanding English.

2.3.3 Questionnaires

For this study, data were collected using semi-structured questionnaires that consisted primarily of closed-ended questions. The content of the questionnaires was informed by the relevant literature and the study's objectives. Respondents were provided with a predefined list of options and were required to select the most appropriate response. The questionnaires were administered to 180 heads of household in Ganyesa Ward 5 by the principal investigator and two trained field workers. However, only 175 participants participated and finished the study. The questionnaires were divided into three sections: Section A focused on household socio-economic data; Section B addressed water sources; and Section C examined water consumption patterns.

2.3.4 Filling in daily activities

In addition, daily activities were used to determine the water tasks performed by the heads of households and quantify their water consumption. The heads of households were requested to record their daily water usage for seven consecutive days. There was constant monitoring of the participants in the form of short message services (SMS) that were sent to the participants as a reminder to complete all their daily activities. Field workers were constantly checking participants progress and encouraging them to complete the diaries on time. All heads of households used standardized volumes to note all activities that resulted in water consumption in

litres. To calculate the per capita water consumption per day for an individual (person), the following equation was utilized:

$$Consump = \frac{number\ of\ people\ in\ a\ household \times total\ (household)}{30\ days} \quad (2)$$

2.3.5 Piloting of the study

Before commencing the data collection process, a pilot study was conducted in Ganyesa, involving five households selected through convenience sampling. The participants selected to participate in the pilot study were from Ward 5; however, they were excluded from the main study. The pilot study served multiple purposes, including assessing the feasibility of the study, testing the reliability and validity of the questionnaire, and evaluating the time taken by participants to complete the questionnaires. In addition, it also determines the appropriateness, understandability, and practicality of the instrument by identifying and addressing any issues or challenges before the main study and estimating the time required for completing the questionnaire (Garg, 2016).

2.4 Data processing and analysis

Microsoft Excel was used to record data from REDcap (v 5 24.2) questionnaires and weekly daily activities. The data was analyzed by the principal investigator (PI) using R programming software. The data gathered was to answer the research questions and to compare this study to other studies conducted by other researchers in this field. The data collected using REDcap questionnaires and the weekly daily activities were transferred to Microsoft Excel to clean and code the data. The data were coded according to predefined categories or numerical values for further analysis. Frequency distributions were generated to quantify the demographic data of households based on the type of water used. Categorical variables were presented as percentages, while means, medians, and ranges were calculated for continuous variables. The data analyses included demographic and technical data such as age, status of employment, gender, educational level, and number of occupants in the household. Data from participants on daily water consumption provides an excellent picture of water availability at the household level and the amount of water used

daily in a rural setting. T-tests were conducted to assess the differences between means of water consumption per household size and volume of water used for various activities within the community of Ganyesa villager refusals, unusable data.

2.5 Quality control

To maintain confidentiality, Identifiers were used for questionnaires and daily activities instead of using respondents' names or details that could be traced back to the respondents to ensure anonymity and confidentiality. All data-capturing sheets were stored in a lockable room and electronic versions of the sheets were encrypted with a password known only to the principal investigator.

2.6 Ethical Consideration

Ethics was obtained from the University of the Witwatersrand Human Research Ethics Committee (HREC) before data collection (Ref no. M220923). The study is a stand-alone project. A request for approval to conduct the study at Ganyesa village was obtained from the Tlou le Tau tribal chief office. All data collected during the study was stored and only accessible to the principal investigator of this study. Before the commencement of the study, a community meeting was arranged through the Tlou le Tau representative and the ward councilor for the researchers to inform the members of the community (respondents) about the study. The study respondents were informed that participation was voluntary, without any benefits or penalties, depending on their decision about study participation.

The study participants were given information on the research study and consent forms, and the process was thoroughly explained to them. There was no penalty or victimization for refusing to participate in the study. It was voluntary, and this was explained to them. An informed consent form was given to the respondents to sign as an agreement to partake in the study. They were further informed about the study's aim and their rights to withdraw at any time during the data collection process should they feel uncomfortable continuing. The questionnaires were administered by both field workers and the principal researcher. A daily activity diary/log was filled by the respondents to document their water usage they partake in their respectively households.

CHAPTER 3: RESULTS

This chapter presents the findings and interpretation of the results obtained from questionnaires and data sheets on daily water consumption administered to 175 participants in Ward 5 Ganyesa village. The data analysed includes information collected through questionnaires, a secondary data set of water consumption from the Sedibeng water provider, daily activities recorded by participants, and water consumption data collected by trained field workers and principal investigators. A response rate of around 97.7% was achieved. This was a statistically significant sample since it surpassed the required response rate of 30% (Memon et al., 2020).

3.1 Sociodemographic information of the study participants

Table 3: Sociodemographic information of the study participants

Variables	Categories	Number (n)	Percentage (%)
Sex	Female	137	78.28
	Male	38	21.72
Age groups (years)	18–30	14	8
	31–40	62	35.43
	41–50	65	37.14
	51–60	34	19.43
Level of education	None	7	4
	Primary	23	13.14
	Secondary	103	58.5
	Tertiary	42	24
Employment status	Employed	61	34.86
	Self-employed	21	12
	Unemployed	85	48.57
	Other	8	4.57
Monthly household income (Rands)	1001–5000	113	64.57
	5001–10000	31	17.72
	>10000	31	17,71
Type of household	Other	39	22.29
	Own	121	69.14
	Renting	15	8.57
Number of occupants	1–3	37	21.14
	4–6	106	60.57
	7–9	32	18.29
Years stayed in Ganyesa	1–5	28	16
	6–10	44	25,14

	>11	103	58,86

Table 3: Sociodemographic information of the study participants

Table 3 shows the sociodemographic information of the study participants. A total of 175 people participated in the study, and as shown in Table 3, the study included more females (78.28%, n = 137) than males (21.72%, n = 38). Many of the study participants (37.17%, n = 65) were between the ages of 41 and 50, and the majority (58.5%) had secondary education. From Table 3, many (69.14%, n = 121) of the study participants owned the property they were living in, and many of the homes had 4–6 occupants.

3.2 Description of water sources used in Ganyesa Village

Table 4: Primary and alternative water sources used.

Primary sources	n	%	Alternative sources	n	%
Communal tap	137	78.29	Borehole	115	65.71
Borehole	34	19.43	Communal tap	35	20.00
Borehole and communal tap	4	2.29	Borehole and water tanker	13	7.43
-			Borehole and rainwater	5	2.86
-			Borehole and communal tap	4	2.29
-			Borehole and bottled water	1	0.57
-			Communal tap and bottled water	1	0.57
-			Communal tap and water tanker	1	0.57

Table 4: Primary and alternative water sources used.

Table 4, shows the primary and alternative sources used in Ganyesa village for accessing and collecting water. From Table 4, it can be observed that there were more alternative sources than primary sources. Many of the residents (78.8% n=137) used communal taps as their primary source of water followed by boreholes (19.4% n=33). A small percentage (2.29%) of the residents used both communal taps and boreholes for primary water. Borehole (65.7%), borehole and bottled water (20%), boreholes and water tanker (7.4%), communal tap and water tanker, borehole, and rainwater (2.9%) and borehole and communal tap (2.3%) were the main alternative sources of water in Ganyesa village. Borehole and bottled water, communal tap, and bottled water and water tanker were the least-used alternative sources of water, used by (0.6%) of the residents.

Table 5: Primary and alternative water used for drinking and bathing.

Drinking	N	%	Bathing	n	%
Communal tap	123	70.29	Communal tap	131	74.86
Borehole	31	17.71	Borehole	34	19.43
Communal tap and bottled water	13	7.43	Yard tap	5	2.86
Borehole and communal tap	3	1.71	Borehole and Communal tap	2	1.14
Borehole and bottled water	2	1.14	Borehole and yard tap	2	1.14
Yard tap	2	1.14	Communal tap and bottled water	1	0.57
Borehole and yard tap	1	0.57			

Table 5: Primary and alternative water used for drinking and bathing.

Table 5 shows the different uses of water in households. It can be noted that residents rely mainly on communal taps and boreholes for drinking water. Seventy percent of the residents relied on water from communal taps for drinking while 75% used it for bathing.

Table 6: Primary and alternative water sources used for house chores and outdoor activities.

House chores	n	%	Outdoor activities	n	%
Communal tap	137	78.29	Communal tap	137	78.29
Borehole	34	19.43	Borehole	34	19.43
Borehole and communal tap	2	1.14	Borehole and communal tap	2	1.14
Borehole and yard tap	2	1.14	Borehole and yard tap	2	1.14

Table 6: Primary and alternative water sources used for house chores and outdoor activities.

Table 6 shows water use or domestic chores such as washing dishes, laundry, cooking, and mopping the floor. Similarly, the residents (78.3%) mainly relied on communal taps for household chores. From Table 6, it can also be noted that the residents (78.3%) mainly relied on communal taps and boreholes for outdoor activities such as washing vehicles and irrigating the garden.

3.3 Water consumption by the number of occupants in a household in Ganyesa Village.

Table 7: Water consumption (L/day) based on the number of occupants in a dwelling.

Occupants	Min	Mean	Max	SD	Q1	Q3	CI
1 to 3	15	26.62	65	11.33	18	31	3.78
4 to 6	10	28.36	70	13.35	19	35	2.57
7 to 9	15	31.53	96	20.82	17.25	40	7.51

SD: standard deviation, Q1: first quartile, Q3: third quartile, CI: confidence interval

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Error! Reference source not found. shows the consumption of water (L/day) by the number of occupants in a household. It can be observed that households with fewer occupants (1 to 3) used less water (mean = 26.62 L/day) while occupants with high occupants used more water (mean = 31.53 L/day).

Table 8: Participants distance traveled (kilometers) to get water in Ganyesa Village.

Minimum	Mean	Maximum	SD	Q1	Q3	CI
0	1.6	5	1.58	0	0	0

SD: standard deviation, Q1: first quartile, Q3: third quartile, CI: confidence interval

Table 8 shows the distance (km) traveled to obtain water from both primary and alternative water sources. On average the participants traveled 1.6 km to fetch water. The participants who traveled fewer distances or 0 km relied on boreholes that were in their yards or communal taps located just outside of their yards.

Figure 21: A point plot of the average distance traveled to fetch water and the average water consumption (L/day)

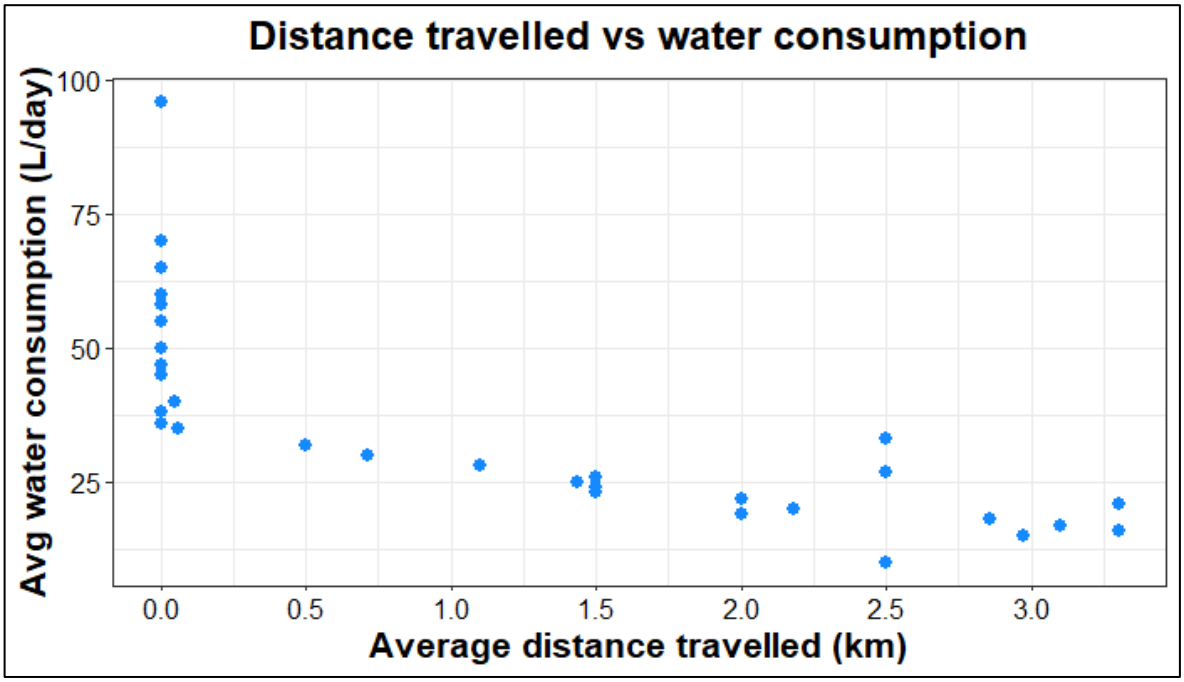


Figure 2 shows the average water consumption (L/day) based on the distance traveled to fetch water. From **Figure 2,** it can be observed that participants who traveled longer distances used less water whereas those who traveled less, or no distances used more water in a day.

Figure 23: Participant's answers on the state of water service delivery in Ganyesa village.

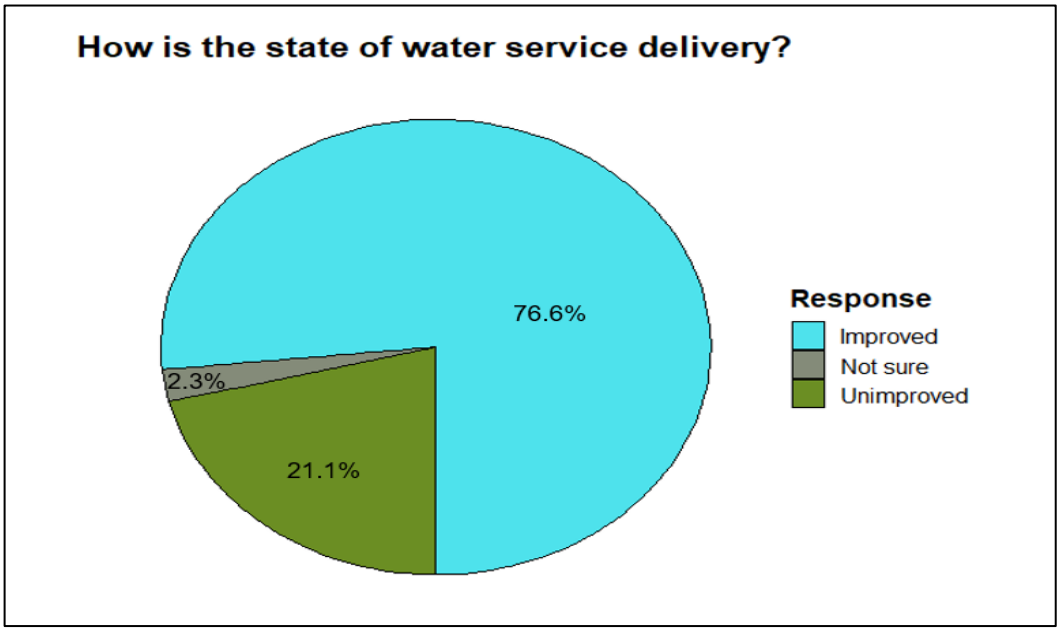


Figure 23: Participant's answers on the state of water service delivery in Ganyesa village.

Figure3 shows the perception of the participants regarding the state of water service delivery. It can be noted that many of the participants answered that the state of water service delivery in Ganyesa has improved in the past years, while 21.1% think it has not improved. On the other hand, a small number of participants (2.3%) were not sure if the state of water service delivery in Ganyesa had improved or not.

Figure 3: Water collection in Ganyesa village, (a) methods used to collect water, (b) person responsible for collecting water, (c) how frequently water is collected in a week, (d) the size of containers used to collect water. Figure (c-d) shows no categories; it simply means there is no need for the collection of water; households have water in their yards.

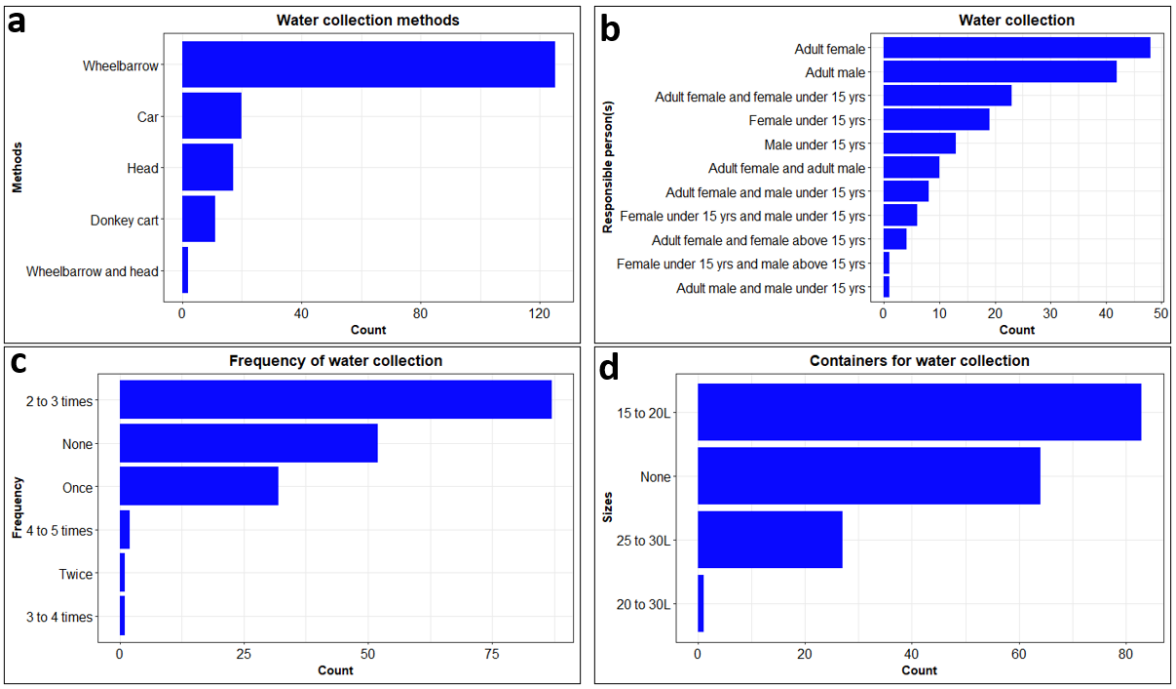


Figure 3: Water collection in Ganyesa village, (a) methods used to collect water, (b) person responsible for collecting water, (c) how frequently water is collected in a week, (d) the size of containers used to collect water.

Figure 3 (a-d) shows the methods used to collect water and the person responsible for collecting water in each household. From Figure 4a, it can be noted that many (71.4%) of the participants used wheelbarrows for collecting water, followed by cars (11.4%), donkey carts (6.3%), and this means carried by a person on their head (9.7%). A small fraction of participants (1.1%) used both the wheelbarrow and the head for collecting water. This was observed in households where they have big families. Adult females (27.4%) were primarily responsible for collecting water in the households, followed by males (24%), and adult females and female children under 15 years (13.1%) were primarily responsible for collecting water in the households (Figure 4b). Many (49.7%) of the households collected water 2 to 3 times a week, whereas (18,3%) collected water once a week, followed by (29.7%). The participants that answered “none” were those with boreholes in the yard and running water in the house. Many (47.4%) of the households collected water using 15 to 20 L containers, whereas 15.4% used 25 to 30 L containers.

Figure5 4: Amount of money spent on water per month (a), containers used to store collected water (b), measures taken by Ganyesa respondents to make water safer for consumption (c), types of toilet system used in Ganyesa village (d).

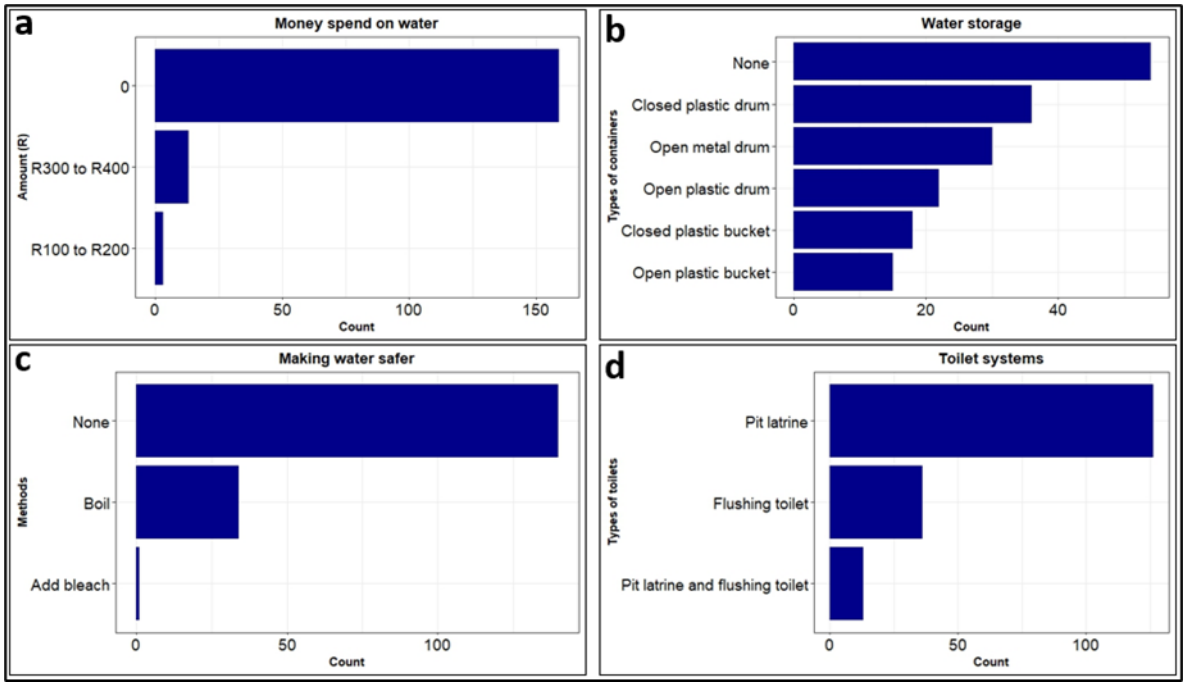


Figure5 (a-d) shows the findings regarding money spent on water and water and sanitation in Ganyesa village. As shown in Figure 6a, many of the residents (90.9%) do not pay for water, while 7.4% spend between R 300 to R 400 and 1.7% spend between R 100 to R 200 on water per month. From Figure 6b, it can be noted that most (30.9%) of the households do not store water “None”. These are households with running water, either a borehole or taps in the yard, therefore, there is no need to store water. Most households (20.6%) with no boreholes and taps in the yard used plastic drums with a lid while the 30 households used open metal drums. Most (n=111) participants used 25L to 30L to store water which is stored inside the house. Figure 6c shows the measures that the Ganyesa residents take to make drinking water safer. Most of the residents (80% n=140) did not take any measures to make water safer while 19.4% boiled water to make it safer and 0.6% added bleach to the water to make it safer for consumption. Figure 6d shows the types of toilet systems used in Ganyesa village, it can be noted that most (72%) of the households relied on pit latrines which is not surprising since the area has a shortage of water. Despite the shortage of water, a huge number of households (20.6%) used flushing toilets while 7.4% relied on both pit latrines and flushing toilets.

Figure 6: Shows the sources, containers, and methods used to collect water in Ganyesa village.



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3.4 Water consumption by sex

Table 9: Comparison of water consumption by sex

Sex	Minimum	Mean	SD	Maximum	Q1	Q3	CI
Female	10	29.56	15.45	96	20	38	2.61
Male	15	25	10.55	58	18	28	3.47

The consumption of water by sex is shown in **Table 9.** It can be observed that females consumed more water (mean = 29.56 L/day) than males (mean = 25 L/day). A two-tailed student t-test showed that there was a statistically significant difference (p = 0.04) between the average water consumption of males and females in Ganyesa village.

3.5 Water consumption by age

Table 10: Water consumption within age groups

Groups	Min	Mean	Max	SD	Q1	Q3	CI
18–30	15	24.07	70	14.11	15.75	25	8.14
31–40	15	28.23	70	13.72	19	35.75	3.48
41–50	15	29.43	96	15.90	20	35	3.94
51–60	10	29.41	65	14.13	18	38.75	4.93

Table 10 shows the average water consumption by various age groups. The 41–50-year-old age group years age group consumed more water (mean = 29.43 L/day) compared to the other age group, followed by the 51–60 age group (mean = 29.41 L/day) and the 31–40 age group (mean = 28.23 L/day). Of all the four age groups, the 18–30 -year-old group consumed less water (mean = 24.07 L/day).

Table 11: One-way analysis of variance comparing water consumption by age.

Source of variation	SS	df	MS	F ratio	P-value	F critical
Between groups	362.92	3	120.97	0.56	0.64	2.66
Within groups	36831.94	171	215.39	-	-	-
Total	37194.86	174	-	-	-	-

SS: sum-of-squares, df: degrees of freedom, MS: mean squares

Table 11 shows the ANOVA single-factor results indicated that there was no statistically significant difference (p = 0.64) in water consumption between the four age groups **(11).** Therefore, it can be concluded that age does not determine the quantity of water used per day by the participants.

3.6 Household income and water consumption

Table 12: Comparison of household income per month and average consumption (L/day).

Income (R)	n	%	Min	Mean	Max	SD	Q1	Q3	CI
1 000	2	1.14	16	27.00	38	15.56	18	32	139.77
1 001–5 000	113	64.57	10	26.35	70	13.18	18	28	2.46
5 001–10000	31	17.71	15	30.87	96	18.11	18	39	6.64
> 10 001	29	16.57	15	34.86	70	14.39	25	45	5.47

n: number of participants, %: percentage of participants, min: minimum, max: maximum, SD: standard deviation, Q1: lower quartile, Q3: third quartile, CI: confidence interval

Table 12 shows the water consumption (L/day) based on household income (R). it can be noted that the higher the household income, the higher the water consumption per day. Households with an income above R 10 001 (16.57%) consumed more water (mean = 34.86 L/day) whereas households (1.14%) with an income of R 1 000 consumed less water (mean = 34.86 L/day).

Table 13: One-way analysis of variance comparing the water consumption by household income.

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	1872.08	3	624.03	3.02	0.03	2.66
Within Groups	35322.77	171	206.57	-		
Total	37194.86	174	-			

SS: sum-of-squares, df: degrees of freedom, MS: mean squares

Table 13 shows the ANOVA results for water consumption based on household income. A statistically significant difference was found (p = 0.03).

Table 14: Linear regression models for the relationship between water consumption and socio-demographic factors (N=175)

Variable	Category	Coefficient	SE	p-value	95% CIs
Sex: [Female]	Male	-4.56	2.67	0.09	-9.82 0.70
Age: [18-30y]	31-40y	4.15	4.34	0.34	-4.42 - 12.73
	41-50y	5.36	4.32	0.22	-3.18 13.90
	51-60y	5.34	4.66	0.25	-3.86 - 14.54
Education: [None]	Primary	4.60	6.31	0.73	-7.86 17.06
	Secondary	-0.01	5.71	0.99	-11.28 11.27
	Tertiary	3.45	5.97	0.56	-8.33 15.24
Employment status: [Employed]	Other	-3.82	5.40	0.48	-14.49 - 6.85
	Self-employed	4.84	3.64	0.19	-2.34 - 12.02
	Unemployed	-4.69	2.41	0.05	-9.45 - 0.07
Income: [R1001-R5000]	R5001-R10000	**-8.00****	**2.91**	**0.01**	**-13.74 -2.26**
	>R10000	-3.48	3.65	0.34	-10.68 3.71
Distance	In km	**-5.82*****	**0.55**	**0.00**	**-6.90 - -4.74**
Water source: [Borehole]	Communal tap	**-26.30*****	**1.64**	**0.00**	**-8.26 - -23.04**
	Tap in yard	-3.06	2.63	0.25	-8.26 - 2.13
Housing tenure: [Other]	Own	**6.40****	**2.64**	**0.02**	**1.18 - 11.61**
	Renting	-1.55	4.36	0.72	-10.16 7.06

Note: SE, Standard Error; 95% CI, Confidence Interval; p-value **<0.05 ***<0.0001

Table 14 presents regression coefficients based on unadjusted models. Highlighting some of the most important results. Several socio-demographic factors were independently associated with water consumption. Intermediate income, i.e., earning R 5001-R 10000 per month had a statistically significant negative relationship with water consumption ($p = 0.01$), with a coefficient of -8.00. Similarly, the distance variable was highly significant ($p < 0.001$), with a negative coefficient of -5.82, suggesting that as the distance from the water source increases, the average water consumption at the household level decreases. The type of water source, in particular communal taps, had a significant negative relationship with water consumption compared to boreholes ($p < 0.001$ and coefficient = -26.30). Lastly, housing tenure: Owning a house had a statistically significant positive association with water consumption ($p = 0.02$), with a coefficient of 6.40. For the variables sex, age, education, and employment status, none of the coefficients were statistically significant**.**

Table 15: Multivariate linear regression model for association between water consumption and socio-demographic covariates (N=175).

Variable	Category	Coefficient	SE	p-value	95% CIs
Sex: [Female]	Male	**-3.84****	**1.67**	**0.02**	**-7.13 - -0.55**
Age: [18-30y]	31-40y	0.28	2.50	0.91	-4.65 - 5.21
	41-50y	1.58	2.51	0.53	-3.37 - 6.53
	51-60y	-2.99	2.78	0.29	-8.49 - 2.51
Education: [None]	Primary	1.03	3.85	0.79	-6.59 - 8.64
	Secondary	-2.83	3.63	0.44	-9.99 - 4.34
	Tertiary	-2.99	4.10	0.47	-11.10 - 5.11
Employment status: [Employed]	Other	-4.21	3.64	0.25	-11.40 - 2.98
	Self-employed	2.37	2.31	0.31	-2.19 - 6.93
	Unemployed	-1.04	1.89	0.58	-4.77 - 2.69
Income: [R1001-R5000]	R5001-R10000	2.19	2.58	0.40	-2.91 - 7.30
	>R10000	-0.42	2.35	0.86	-5.07 - 4.22
Distance	In km	**-1.65*****	**0.55**	**0.00**	**-2.74 - -0.57**
Water source: [Borehole]	Communal tap	**-22.97*****	**2.14**	**0.00**	**-27.20 - -18.73**
	Tap in yard	-2.53	2.65	0.34	-7.76 - 2.70
Housing tenure: [Other]	Own	2.28	1.65	0.17	-0.97 - 5.54
	Renting	0.10	2.82	0.97	-5.48 - 5.66
R^2	0.7120				
Adjusted R^2	0.6808				
F-value	22.83				
p-value of the model	0.000***				

Note: SE, Standard Error; 95% CI, Confidence Intervals; p-value **<0.05 ***<0.0001

Table 15 presents the results of a multivariate linear regression model examining the intricate interplay between water consumption and socio-demographic covariates and identifying associated confounders. Several key findings emerged. Firstly, there is a gender disparity in water consumption; males continuously had a statistically significant reduction in water usage compared to their female counterparts ($p = 0.02$), with a coefficient of -3.84. Secondly, the distance to water sources has an impact, as evidenced by the highly significant negative coefficient ($p < 0.001$, coefficient = -1.65) as in the unadjusted analysis. Proximity to communal taps remained a substantial determinant of water consumption, with a pronounced negative association ($p < 0.001$, coefficient = -22.97). However, housing tenure did not significantly influence water consumption; all other covariates were considered.

Overall, the model exhibits high explanatory power, with an R^2 of 0.7120, suggesting that nearly 71.2% of the variance in water consumption can be explained by the

included socio-demographic variables. Whereas the adjusted R2 (0.6808) accounts for the number of predictors, offering a robust measure of the model's generalizability. The F-value of 22.83 is highly significant (p = 0.000***), affirming the overall explanatory strength of the model. Taken together, these findings generate a nuanced picture of the complex relationship between socio-demographic factors and water consumption, highlighting the importance of simultaneously considering multiple variables in modeling this relationship.

CHAPTER 4: DISCUSSION

In this chapter, the findings of the study are discussed. The discussion will be based on the comparison of the literature review in chapter two and the results in chapter three. It highlights the correlations and contradictions of the results and current literature based on water consumption at the household level and water consumption within gender. Lastly, to close the chapter, the limitations and strengths of the study are explained.

4.1 Sociodemographic information of the study participants

The study aimed to identify water sources and describe water use among the residents of a rural settlement in Ganyesa village. Based on **Table 3,** there were more females (78.28%) compared to their male counterparts (21.72%) who participated in the study. This finding suggests that females are predominantly responsible for domestic chores, such as fetching water. This finding agrees with Graham et al., (2016), who conducted a study across twenty-four countries that showed that adult females typically assume the role of water collection. The findings in **Table 3** shows that age distribution, a significant proportion (37.17%) were within the age range of 41-50 years. Furthermore, the study participants were predominantly those who were solely dependent on social grants as a source of income; many (n = 113) earned between R 1 000 and R 5 000. It is not surprising, as data from Statistics South Africa showed that unemployment rates are higher among South African youth. The participants earning between R 5001 and R 10000 per month had a statistically significant negative association with water consumption (p = 0.01), with a coefficient of -8.00. Concerning the education level, most participants (58.5%) have a secondary level of education as shown in **Table 3**. This aligns with data from Statistics South Africa which reveals about 64% of people in Northwest province have completed Grade 9 or higher grades. This indicates a similar educational profile among the study participants (Statistics South Africa, 2011).

This can be attributed to the socioeconomic context of Ganyesa, being a small and underdeveloped, village accompanied by scarce resources and poor service delivery. The agricultural sector is the predominant source of employment for the local population (District Development Model, 2020).

4.2 Water sources used in Ganyesa Village

The study discovered that municipal and natural sources (groundwater) are the dominant sources of drinking water for the community of Ganyesa village, communal taps installed by the municipality are the primary source of drinking water, as shown by 78.29% of the respondents, followed by boreholes, as mentioned by 19.4% of participants. For households that have boreholes in their yards, water from boreholes was stored in JoJo tanks. It is noteworthy that bottled water and water tankers were the least used. Bottled water is expensive, which some of the residents may not be able to afford. Water tankers are expensive for the municipality to supply and maintain. When primary sources are not available, the community uses alternative water sources, as illustrated in

Figure3, where 65.7% of participants are reliant on boreholes.

The results further showed that 20% rely on communal taps, whilst 7.4% use a combination of boreholes and communal taps, and 0,57% utilize a combination of boreholes and rainwater, which highlights the heavy reliance of the community on communal taps and boreholes for their daily water needs. The reliance on these sources of water in Ganyesa village is a major challenge because of the unsustainable water supply. This leads to residents seeking water from alternative sources, which might be unhealthful for human use. This is in agreement with a previous study conducted by Omarova et al., (2019), which highlighted an unreliable tap water supply often drives people in rural areas to rely on alternative sources such as groundwater boreholes and water tankers. It should be noted that these alternative sources, including boreholes as indicated by Edokpayi et al., (2018), may not undergo proper quality monitoring, potentially leading to contamination with faecal matter and other pollutants. Groundwater, despite its potential, has historically received limited attention and has not been recognized as a significant water resource in South Africa. This is reflected in the statistics, showing that only 13% of the nation's total water supply originates from groundwater. However, evidence suggests that groundwater should be given more attention and considered a valuable resource. The use of unmonitored

water sources increases the risk of waterborne diseases and epidemics within the population, as highlighted by Fredrick et al., (2015). Therefore, there is a clear need for improved water supply systems and proper monitoring of water quality in rural areas like Ganyesa village. Adherence to regulations such as SANS 241, which sets standards for water quality, is crucial to ensuring safe and sustainable access to drinking water for the community.

4.3. Containers used for fetching water by households.

The 15-20-litre plastic containers were the most common type of water collection used for water storage in the households. Drums, that is, 50 L or 200 L, were used to store water. The choice of storage containers can have implications for water quality and safety. For instance, after a certain period, drums develop rust, which can result in the need to treat the water. Another factor to consider is whether these drums are old or new. If used, what was previously stored in them, for example, chemicals. Participants when asked about the water treatment methods as shown in **Figure5(c)**, however, it was found that water was not treated from the water sources, 80% of participants consumed water directly from the source, only 19.4% boiled water before use to make it safer. This is in contrast with Clasen et al., (2008), who have highlighted that boiling water can be a costly method, particularly for low-income populations.

4.4. Water consumption patterns and lifestyle

Indeed, the living standards of participants have been observed to have an impact on water consumption at the household level. Studies conducted by Garcia et al., (2019) and Murwirapachena, (2021) have confirmed that the use of modern appliances, such as dishwashers and washing machines, which reduce labor, tends to increase water consumption in households. As living standards rise, people tend to use more water, as noted by Narmila et al., (2021). The number of occupants in a household is also an important factor influencing water consumption patterns, as shown in **Table 4**. The results further showed that the number of occupants is directly related to water consumption patterns. Although there was a difference in the average water consumption patterns by the number of occupants in households, ANOVA single-factor results showed that the difference was not statistically significant ($p = 0.37$). Households with one to three occupants tend to use less water on average (mean = 26.62 L/day), while households with seven to nine occupants use the most water (mean = 31.53 L/day). This finding is consistent with studies conducted by Rathnayaka

et al., (2017) and Jacobs et al., (2022), which have identified household size, measured in terms of people per household, as a significant factor affecting water consumption. This figure is within the estimated average water use of 20–40 liters/person/day in the majority of rural Africa as reported by Wallingford, (2003).

4.5 Water consumption by sex and age

The study also addresses the sex and age data gaps in quantifying water use at the household level. Most of the literature has looked at water intake and drinking water for different age groups and sexes. This study has provided gender disaggregated data on water uses and water demand at the household level (rural settings) and made such data available and accessible to all for evidence-based decisions. The study has provided important information on water consumption and insights into per capita water consumption for both males and females and at the household level. The study has confirmed that females consume more water than males, accounting for 29.56 L/day and 25L/day respectively.

The results of the study were not surprising in terms of water consumption since females are most responsible for domestic chores, compared to their male counterparts. In addition, females spend more time on water-related activities per day, such as taking care of children and their personal hygiene during the menstruation period; hence, they use more water than males (Sorenson et al., 2011; Baguma et al., 2013). It is important to note that an individual's day-to-day water consumption is dynamic and is affected by many factors, including personal preferences, activity level, body weight, and medical status. The study has shown that women 27.4% were responsible for collecting water in households. This finding is consistent with the study conducted by the United Nations, (2010) which found that in African and Asian countries, women often bear the primary responsibility for water collection. The time invested in water has significant opportunity costs for individuals and households. This time could otherwise be utilized for education or income-generating activities. In addition, the study has explored various age groups of participants in relation to water consumption. The results show that participants 41-50 years on average consume 29,43L and 18-30 years participants consume lesser water 24,07L. This was anticipated due to the fact that this age group of 18 to 30 years was actively studying or working, so during the day they were not in the household. Younger respondents with better education level may be more ware of the water scarcity the country is

experiencing. The study by Browne et al., 2014 looked at water consumption with age, however, this variable was excluded from the results as it shows a relatively small impact on water use or consumption. This study agrees with our results there is not much of a difference ($p = 0.64$).

4.6 Water consumption comparison with minimum water use baseline.

Water requirements are essential for living in terms of health and hygiene. This is also an important aspect for checking whether the water provided to the community is accessible, sustainable, and sufficient to facilitate health and hygiene. The World Health Organization (WHO) outlines a global drinking water availability benchmark that recommends that between 50 and 100 L/capita/day (LPCD) is required to meet domestic needs, including washing, personal hygiene, and cleaning. The water availability at the household level of some participants was below the minimum requirement by WHO, these participants were mainly using standpipes as their water sources, as shown in **Figure 2**. Most of participants who uses less water were the one with small families, some of the activities relating to water were carried out at the source, such as washing of laundry and thus was not factored into the water measurement. Participants who use water sources in their household's yard meet the minimum requirements of the WHO. This shows that participants who use standpipes have inadequate water accessibility and raises concerns about potential health risks to the participants. The findings of the study support existing evidence that the 50-100 liters per capita per day (LPCD) benchmark recommended by the World Health Organization is rarely being met in LMICs, especially in rural areas.

In South Africa, water guidelines for basic water services are defined as 25 liters per day per person, while the Department of Water Affairs suggests a value of 60 liters per day per person. This result shows the gap between LMICs and HICs compared to European countries which used (around 200-300 liters per person per day).

4.7 Water consumption by distance and frequency

The study findings indicate an inverse relationship between the distance traveled to the water source and the level of water consumption in the households, which is consistent with previous research conducted by Admassu et al., (2003), Wallingford (2003), and Gulyani et al., (2005). These studies have demonstrated that as the distance to the water source increases, the amount of water consumed by households tends to decrease. It does not appear that any relationship exists between per capita

water consumption and the distance of the primary water source. Most studies, however, have found a per capita reduction in water use (White et al., 2002). According to the results in **Figure 2**, participants who walk to fetch water from the communal tap consume less water than participants who have taps in their households. On average the participants traveled between 1,6km-5km. The United Nations, (2010) study in Asian and African countries is in agreement with the results, indicating that the average distance walked by community members to obtain water is approximately 6 kilometers. These distances exceed the recommendations set by the World Health Organization (WHO), which states that the water source should be within 1,000 meters (1km) of the residence, and the time taken to collect water should not exceed 30 minutes (UNDP, 2004).

4.8 Summary

These findings emphasize the need to address the challenges associated with water collection in rural areas like Ganyesa village. It calls for interventions that promote gender equality, improve water infrastructure, and reduce the physical burden on individuals. By alleviating the burden of water collection, communities can allocate their time and resources more effectively, leading to improved well-being and development opportunities.

4.9 Limitations of the study

- The study's limitations include the stereotypical belief that women are responsible for household chores, and the majority of men were not willing to participate in the study.
- The study was self-funded, which put more constraints on the size of the study as only one community ward could be afforded (Ward 5).
- The study only focused on water profiling and did not explore water quality, as most participants used boreholes which were not tested.
- The anticipated sample size was not met due to participants who left out during the study.
- Load shedding heavily impacted the study. Due to load shedding, people whose source of water is a borehole would not be able to get a continuous water supply. As a result, the data they were providing would not be perfectly accurate at times because of the interruptions in water availability.

- The ANOVA single-factor results indicated that there was a significant difference when comparing water consumption with household income. However, a post-hoc test could not be performed to determine which income bracket the difference came from.
- The difficulty of measuring water quantity in non-metered water users' communities remains a challenge.

CHAPTER 5: SUMMARY AND CONCLUSION

This chapter gives a summary of the main findings of the study and the conclusions reached. Even though the results achieved the study's aim, knowledge gaps were identified, and the study is giving rise to a need for possible research ventures which are highlighted in this chapter.

5.1 Summary

The most important and main outcomes of this study can be used by stakeholders for service delivery. The average water consumption at the household level in a rural setting was identified. Notably, there has been a noteworthy rise in access to improved water sources in South Africa over the past quarter century. In rural areas, which had previously been overshadowed by urban counterparts, communal taps have emerged as the predominant water source. However, recurrent disruptions in water supply from these communal taps have compelled communities to seek alternative sources.

Several of these alternate sources utilized by the community entail untreated water. Essential protocols like environmental impact assessments are regrettably overlooked. Inaccurate borehole placement within households, occasionally near pit latrine toilets, has been noted. Such instances inadvertently expose individuals to pathogens and heavy metals due to the absence of protective groundwater regulations. Given the municipality's unsustainable water delivery to the community, boreholes and rainwater are viable alternative water sources. The average household water consumption is susceptible to external influences such as education levels and water source proximity.

Educated individuals tend to consume more water, likely attributable to their awareness of waterborne diseases like cholera and the significance of proper hand hygiene. Women and young children persist in shouldering the responsibility of water collection, a practice that predisposes them to risks like musculoskeletal disorders due to the consistent physical strain. Disturbingly, the research underscores the prevalence of school dropouts among young children in Sub-Saharan Africa due to water-related obligations.

5.2 Future research avenues

Firstly, it would be valuable to conduct studies on water quality at the household level, examining factors in storage containers. The studies on the fetching of water and the development of health effects need to be expanded, especially in rural settlements.

Variables such as seasonal variations and sample size in water consumption at the household level need to be expanded. This would provide a comprehensive understanding of the overall water situation in rural settlements and help identify areas for improvement. Additionally, investigating the containers used for water storage in households would provide insights into the safety and suitability of storage methods. Understanding the types of containers used and their potential influence on water quality and consumption patterns would be beneficial in developing appropriate interventions and recommendations. Lastly, expanding the research sample size and including a broader range of variables would enhance the generalizability and depth of the findings. With a larger sample size, it would be possible to analyze the data across different regions, demographic groups, and socio-economic backgrounds, providing a more comprehensive picture of water availability and consumption in households in South Africa.

5.3 Conclusion and significance

Results showed that most respondents use communal taps as their primary water sources. While the other percentage uses groundwater boreholes as their primary water source. The number of occupants, household income, and type of water source used were important predictors of water consumption. The unavailability of a database on water consumption at the household level in the rural settlement, in the absence of the South African data base, we are forced to use the USEPA data base. The South African subpopulation differs from those in high-income countries, making this study particularly important. It provides information that is more relevant to low- and middle-income countries (LMICs) like South Africa, highlighting the real scenarios faced in these contexts

Moreover, this study may add value to borehole policy development, implementation and monitoring of regulatory frameworks, especially in both private and public boreholes. This study was conducted on a small population, with only a small percentage being men. A broader study should be conducted across various South African subpopulations, including men

5.4 Recommendations

- ✓ Future studies may be carried out covering a larger population density to gain more detail on water consumption, uses at the household level and types of water sources.

- ✓ This study recommends that for rural water supply sustainability to be improved in rural settlements, all the stakeholders must work together to prioritize and address the policy gaps constraining service delivery.
- ✓ ⎫ Furthermore, boreholes must be declared as a public water source and proper water quality monitoring plans must be designed and adhere to as per SANS 241 stipulate, to ensure water quality.

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Appendix A: Plagiarism declaration form



PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I (Student number: **2260932**) am a student registered for the degree of **MASTER OF SCIENCE IN EXPOSURE SCIENCE** in the academic year **2022**.

I hereby declare the following:

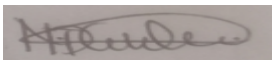
- I am aware that plagiarism (the use of someone else's work without their permission

  and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided.

  work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against

  me if there is a belief that this is not my own unaided work or that I have failed to.

  acknowledge the source of the ideas or words in my writing.

Signature:  Date: **05 August 2024**

Appendix B: Research ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Ms NT Xulu

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M220923

NAME: (Principal Investigator)	Ms NT Xulu
DEPARTMENT:	School of Public Health Medical School University
PROJECT TITLE:	*Community profiling of water sources and uses in a rural setting in North West Province, South Africa*
DATE CONSIDERED:	2022/09/30
DECISION:	Approved unconditionally
CONDITIONS:	Proof of ethics training for research assistants should be submitted to the HREC (Medical)
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Dr D Mmereki and Professor N Naicker
APPROVED BY:	Dr N Naran, Co-Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/11/07

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **September** and therefore reports and re-certification will be due in the month of **September** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator _____ Date _____

Appendix C: Data collection tool

Water consumption per capita per person(L)$= \frac{\text{number of people in the household} * \text{total(household)}}{30 \text{ days}}$

Equation 2

Research Instrument

Appendix H: Daily activities

Date Time	Activities	Water source used	Container of water used (Liters/ Millilitres)
00:00			
1:00			
2:00			
3:00			
4:00			
5:00			
6:00			
7:00			
8:00			
9:00			
10:00			
11:00			
12:00			
13:00			
14:00			
15:00			
16:00			
17:00			
18:00			
19:00			
20:00			
21:00			
22:00			
23:00			

Data capturing sheet Questionnaires.

Record ID

_____

_____

Section A: Household Socio-demographic features

1. Sex	☐ Female ☐ Male
2. Age	☐ 18-28 ☐ 29- 38 ☐ 39-49 ☐ 50-65
3. Martial status	☐ Single ☐ Married ☐ Divorced ☐ Widowed
4. Level of education	☐ None ☐ Primary ☐ Secondary ☐ Tertiary
5. Employment status	☐ Self-employed ☐ Employed ☐ Unemployed ☐ Specify if other.
6. What is the total income for the family group? living in the dwelling per month excluding grant and pension?	☐ No income ☐ R1001 - R5000 ☐ R5001 - R 10000 ☐ > R10000
7. Do you receive the grants? To be answered by participants who receive a grant	○ Yes ○ No
8. Which kind of grant does the household's individual receive? for only participants who receive grants. only	☐ Old age grant ☐ Disability grant ☐ Child support grant ☐ specify if other the type of grant and the num of recipients
9. How many people live in the household?	☐ 1-3 ☐ 4-6 ☐ 7-9 ☐ ≥10
10. Type of house ownership, you are staying in it.	☐ Rent ☐ Own ☐ specify if other.

11. How long have you stayed in the community?

Less than a year

1-5 years

6-10 years

Above 11 years

Section B: Domestic water Sources

12. Which water source does your community rely on? please tick all sources that applicable in your community	☐ Piped water into dwelling. ☐ Tube well/boreholes. ☐ Unimproved dug well. Unimproved dug well. ☐ Bottled water. ☐ Piped water to yard/plot. ☐ Public taps/standpipes ☐ Improved dug well. ☐ Improved spring ☐ Rainwater collection ☐ Cart with small tank/drum. ☐ Tanker-truck
13. Does your household have source of water inside? the yard?	○ Yes ○ No
14. Which sources of water does the household have, please tick all applicable source used in the household	☐ Piped water into dwelling. ☐ Tube well/borehole. ☐ Unimproved dug well. ☐ Bottled water. ☐ Piped water to yard/plot. ☐ public taps/standpipes ☐ Improved dug well. ☐ Rainwater collection ☐ Cart with small tank/drum. ☐ Tanker-truck
15. What is the source/s of water used by your household for handwashing?	☐ Piped water in the dwelling. ☐ Piped water to yard/plot. ☐ Tube well/boreholes. ☐ Improved dug well. ☐ Improved spring ☐ Rainwater collection ☐ Cart with small tank/drum. ☐ Public taps/standpipes ☐ unproved dug well. ☐ Unproved spring ☐ Bottled water. ☐ Cart with small tank/drum. ☐ Surface water (river, dam, lake, pond, stream canal, irrigation channels)

16. What is the source/s of water used by your household for cooking? please tick all

- Piped water in the dwelling.
- Piped water to yard/plot.
- Tube well/boreholes.
- Improved dug well.
- ☐ Improved spring
- ☐ Rainwater collection
- ☐ Cart with small tank/drum.
- ☐ Public taps/standpipes
- ☐ unproved dug well.
- ☐ Unproved spring
- ☐ Bottled water.
- Cart with small tank/drum.
- ☐ Surface water (river, dam, lake, pond, stream, canal, irrigation channels)

---

17. what is the source/s of water used by your household for drinking water?

- ☐ Piped water in the dwelling.
- ☐ Piped water to yard/plot.
- ☐ Tube well/boreholes.
- ☐ Improved dug well.
- ☐ Improved spring
- ☐ Rainwater collection
- ☐ Cart with small tank/drum.
- ☐ Public taps/standpipes
- ☐ unproved dug well.
- ☐ Unproved spring
- ☐ Bottled water.
- ☐ Cart with small tank/drum.
- ☐ Surface water (river, dam, lake, pond, stream, canal, irrigation channels)

---

18. what is the source/s of water used by your household for bathing?

- ☐ Piped water in the dwelling.
- ☐ Piped water to yard/plot.
- ☐ Tube well/boreholes.
- ☐ Improved dug well.
- ☐ Improved spring
- ☐ Rainwater collection
- ☐ Cart with small tank/drum.
- ☐ Public taps/standpipes
- ☐ unproved dug well.
- ☐ Unproved spring
- ☐ Bottled water.
- ☐ Cart with small tank/drum.
- ☐ Surface water (river, dam, lake, pond, stream, canal, irrigation channels)

---

19. What is the source/s of water used by your household for toilet flushing? To be answered by participants who have flushing toilets

- ☐ Piped water in the dwelling.
- ☐ Piped water to yard/plot.
- ☐ Tube well/boreholes.
- ☐ Improved dug well.
- ☐ Improved spring
- ☐ Rainwater collection
- ☐ Cart with small tank/drum.
- ☐ Public taps/standpipes
- ☐ unproved dug well.
- ☐ Unproved spring
- ☐ Bottled water.
- ☐ Cart with small tank/drum.
- ☐ Surface water (river, dam, lake, pond, stream, canal, irrigation channels)

sources used for cooking purposes

20. please describe the previous source number 14 with Smell, please tick all applicable	Fishy Smell Chlorine smells No smell I do not know.
19. Describe the water by taste.	☐ Tasteless ☐ Salty ☐ Metallic taste
20. Describe the water with color.	☐ Brown Clear white ☐ Green ☐ Greyish
21. Is the water source that you used reliably. if yes please answer the following question	○ Yes ○ No
22. Which source is used as an alternative for water? provision in your household please tick all applicable	☐ Piped water into dwelling. ☐ Public taps/standpipes ☐ Improved dug well. ☐ Improved dug well. ☐ Rainwater collection ☐ Cart with small tank/drum. ☐ Tube well/boreholes. ☐ Unimproved dug well. ☐ Unimproved dug well. ☐ Bottled water. ☐ Tanker-trucker ☐ Surface water (river, dam, lake, pond, stream canal, irrigation channels)
23. How long does it take to travel to and from the source, to fetch water. to be responded by participants who use sources located away from the yard/ communal taps.	☐ < 1 to 30 minutes ☐ 31 to 60minutes ☐ 61 to 90 minutes ☐ >120 minutes
24. Who usually goes to this source to fetch water for? the household? please tick all that applicable in your household	☐ Adult woman ☐ Adult man ☐ Female child under 15 years ☐ Male child under 15 years ☐ Do not know.
25. Do you treat your water in any way to make it? safer to drink? if yes please answer the following. question	○ Yes ○ No
26. What do you usually do to the water to make it? safer to drink? Please tick all methods applicable in your household	☐ Boil ☐ Add bleach. ☐ Strain it through cloth. ☐ Use water filter (ceramic, sand, composite) ☐ Let it stand and settle. ☐ Solar disinfection ☐ I do not bother.

27. What kind of toilet facility do members of your household usually uses. Please tick all applicable in your household	piped sewer system septic tank pit latrine. elsewhere ☐ Unknown place ☐ Ventilated improved pit latrine (VIP ☐ Pit latrine with slab. ☐ Pit latrine without slab/open pit. ☐ Composting toilet ☐ Bucket ☐ Hanging toilet/hanging latrine No facilities or bush or filed.
28. Do you share this facility with other households?	○ Yes ○ No
29. How many households use this toilet facility.	☐ 2-3 ☐ 4-5 ☐ >6
30. Type of domestic wastewater	☐ Proper disposal ☐ Improper disposal

Section C: Water uses/consumption.

32. How many rooms does the household have?	☐ 1-2 rooms ☐ 3-4 rooms ☐ 5-6 rooms ☐ 7-8 rooms ☐ 9-10 rooms
33. Are there any extended rooms like cottage/ outbuildings	○ Yes ○ No
34. Approximately how much water does the household. use daily?	☐ 50 liters/day ☐ 100 liters/day ☐ 150 liters/day ☐ 200 liters/day
35. How is the water stored after collection/fetching?	☐ In the closed container ☐ Stored in the container without the lid. ☐ I do not usually bother myself. ☐ in drums
36. How is the container used to store water general? hygiene	☐ washed with soap before storing water. ☐ Rinse with water without any disinfectants. ☐ If I do remember ☐ Do not know.
37. In the amount of water collected, approximate how. much is used for handwashing.	☐ 25 liters/day ☐ 50 liters/day ☐ 75liters/day ☐ 100 liters/day
38. In the amount of water collected, approximate how. much is used for cooking.	☐ 25 liters/day ☐ 50liters/day ☐ 75liters/day ☐ 100liters/day
39. In the amount of collected water, approximate how much is used for bathing?	25 liters/day 50liters/day 75liters/day 100liters/day
40. In the amount of water collected, approximate how. much is used for flushing.	☐ 25 liters/day ☐ 50liters/day ☐ 75liters/day ☐ 100liters/day
41. In the amount of collected water, approximate how. much is used for drinking water.	25 liters/day ☐ 50liters/day ☐ 75liters/day ☐ 100liters/day

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