FREE BASIC WATER SERVICES STANDARDS AS INDICATORS TO ASSESS INEQUALITIES IN SUSTAINABLE ACCESS TO IMPROVED WATER SERVICES

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Submitted in fulfilment of the requirements
for the degree of PhD (Bioresources Systems)

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Pietermaritzburg
October 2020

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PREFACE

I **DOCTOR CALVIN SAMBO** declare that;

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination at any other university.

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ABSTRACT

Sustainable access to improved water services is essential to sustain human life and a fundamental human right. Water is used by rural communities for activities that improve their health, wellbeing and livelihoods. As a result, the Sustainable Development Goals (SDG) aim to attain universal access to improved water services provided by Improved Water Sources (IWS). IWS include standpipes in dwellings, communal standpipes and protected dug wells. Aligned to the SDG, the South African government conceived and effected the Free Basic Water Services (FBWS) policy to coordinate efforts to attain universal access to improved water services. However, there have been challenges in implementation of the FBWS policy resulting in a vast proportion of the rural communities without sustainable access to improved water services. The challenges vary from issues related to institutional capacities, accountability and monitoring. A substantial part of the challenge is the lack of reliable data to inform decision-makers involved in the planning and management of improved water services in the rural communities. The challenge is worsened by the indicator used to monitor water access as it only considers the proportion of the population provided with an IWS. This indicator does not track the sustainability aspects of the level of water services provided by IWS over their useful life. The research sought to address the gaps that exists with regards to making available the information required to inform decision-makers involved in the planning and management of improved water services, and the use of indictors to measure sustainability aspects of water services provided. The aim of the research was to assess inequalities in access to improved water services using a set of indicators derived from the FBWS standards, and investigate and analyse the complex interactions of the factors that influence access to improved water services in Makhudutamaga Local Municipality (MLM), Limpopo Province, South Africa. Stratified random sampling was employed to determine representative samples of the settlements (39) and households (396) in the study area. Survey questionnaires were administrated to collect qualitative data on households' satisfaction with FBWS policy and water services provided as well as to collect qualitative and quantitative data on the level of water services provided based on distance, quantity, reliability, flow rate, water quality, and cost. Transect walks were employed to collect supporting information to enhance an understanding of the local context. Furthermore, key informant interviews combine with complex systems approach (e.g. network) were employed to collect qualitative data and analyse the complex interactions of factors that influenced sustainable access to improved water services. The results indicated that between 69.7% - 95.0% of households were satisfied with aspects of the FBWS standards. When using the standards to assess households' satisfaction with improved water services provided, most of the households were satisfied with distance (62.0%), quantity (61.2%), flow rate (52.7%), and water quality (54.8%), but unsatisfied with the reliability (56.3%) and cost of buying water (58.0%). An assessment of the level of water services provided indicated that aspects (e.g. reliability and cost) of the improved water services provided did not comply with the FBWS standards. The results also indicated that there were statistical differences in access to improved water services across the 4 water schemes for distance [$H(3) = 61.33$, $p = 0.00$], quality [$H(3) = 72.83$, $p = 0.00$, flow rate [$H(3) = 20.12$, $p = 0.00$], and quality [$H(3) = 17.21$, $p = 0.00$] no difference for reliability [$H(3) = 1.37$, $p = 0.712$]. The majority of households (78.5%) could not afford the cost of buying water. An investigation of the factors that influence sustainable access to improved water services found that limited budget, limited/no water supply and improper operation and maintenance (O&M) were critical factors that influenced sustainable access to improved water services. Therefore, the proposed targeted interventions included increased budget, improved institutional capacity and improved monitoring. It was concluded that there are inequalities in sustainable access to improved water services provided based on FBWS standards. The inequalities are as a result of the complex interactions of categories of factors that influence sustainable access to water services. This study provides an informational advantage in understanding why the situation is as it is on the ground to contribute to evidence-based strategic planning and management of improved water services to ensuring sustained water access in rural municipalities. It is a recommendation of this study for the proposed targeted interventions to be piloted and adopted if found to be suitable to address identified challenges in the study area. The proposed interventions include but not limited to a review of the funding model to respond to the situation on the ground-based on monitoring information, and develop and implement a reasonable participatory water rationing strategy.

DECLARATION 2 – PUBLICATIONS

Details of contribution to publications that form part of this dissertation, which include papers in preparation, are given in each paper.

Publication 1 – Chapter 3

Sambo DC, Senzanje A, and Mutanga O. 2021. Benchmarking households' perceptions with Free Basic Water Services (FBWS) policy standards and improved water services provided in a rural municipality of South Africa . *Manuscript under peer-review by WaterSA Journal.*

Sambo DC, Senzanje A, and Mutanga O. 2020. Socio-economic and demographic factors as predictors of access to improved water services in the rural municipality of South Africa. *Poster presentation at the University of Kwa-Zulu Natal (UKZN) Postgraduate Research & Innovation Symposium (PRIS)-2020.*

Publication 2 – Chapter 4

Sambo DC, Senzanje A, and Mutanga O. 2021. Assessing Geographical Inequalities in Sustainable Access to Improved Water Services Using Service Level Indicators in a Rural Municipality of South Africaa. *Manuscript accepted for publication by Journal of Water, Sanitation and Hygiene for peer review.*

Publication 3 – Chapter 5

Sambo DC, Senzanje A, and Mutanga O. 2021 Systems analysis – complex interactions of factors that influence the sustainability of access to improved water services in a rural municipality in South Africa. *Manuscript accepted for publication by the Water Supply Journal.*

Publication 4 – Chapter 6

Sambo DC, Senzanje A, and Mutanga O. 2020. Framework to improve sustainable access to free basic water services in Makhudutamaga local municipality, South Africa. *Paper in preparation.*

Signed: [redacted]

ACKNOWLEDGEMENTS

Unreserved acknowledgements goes to;

(a) Almighty GOD for blessing me with life and strength to complete my PhD studies.
(b) My wife and son for their understanding when I could not give them the well-deserved time with me when working on the PhD.
(c) Dr Senzanje and Prof Mutanga for taking the time to supervise my PhD work and support provided in challenging times.
(d) The University of Venda (UNIVEN), Department of Higher Education and Training (DHET) and National Research Foundation (NRF) and University of Kwa-Zulu Natal (UKZN)
(e) Enumerators that assisted with household data collection. Thank you for the good work.
(f) Sekhukhune District Municipality (SDM) personnel for their participation in the key informant interviews. The information provided in highly appreciated.
(g) The communities and households for welcoming me and providing information that I required to complete my PhD research. Your participation is greatly appreciated and my hope if for my work to bring positive change in your livelihoods.

DEDICATION

Special dedication to my Father and Mother

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LIST OF ABBREVIATIONS

DH	De Hoop
DWAS	Department of Water Affairs and Sanitation
FB	Flag Bosheilo
FBWS	Free Basic Water Services
GIS	Geographical Information System
GPS	Global Positioning System
IWS	Improved Water Sources
LR	Local Resources
MDG	Millennium Development Goals
NGO	Non-Governmental Organisation
O&M	Operation and Maintenance
PG	Piet Gouws
SAICE	South Africa Institute of Civil Engineering
SDG	Sustainable Development Goals
SLR	Systematic Literature Review
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children Education Fund
USD	United States Dollars
UWS	Unimproved Water Sources
WHO	World Health Organisation
WPM	Water Point Mapping
WSA	Water Services Authority
WSP	Water Services Provider

1. INTRODUCTION

"SA's water debt grows by R8-million every 24 hours" (Mail & Guardian/Sipho Kings, 01 Feb 2019)

1.1 Background

Sustainable access to improved water services is essential to sustain human life and a fundamental human right. Rural communities use water for activities that generate economic benefits and ensure their food security resulting in an improvement in their livelihoods (Kayser *et al.*, 2013). As a result, efforts with significant progress have been noted to increase access to improved water services in rural communities. Such efforts include the Millennium Development Goals (MDG) agenda, which guided the planning, development, and implementation of interventions aimed at increasing access to improved water services at global, regional, and national scales. A spectrum of stakeholders involved in the water sector united in a coordinated manner under the MDG agenda to focus their efforts to achieve the MDG goal (Target 7.C) of reducing the proportion of people without access to sustainable and safe drinking water sources (World Health Organization (WHO, 2015)). As a result, the goal was reported to have been attained in 2010 (WHO, 2015). This meant that it was attained 5 years earlier than anticipated. The achievement was celebrated globally, but more needed to be done as there was still a substantial proportion of the population remaining without access to improved water services, particularly in rural communities (WHO, 2015).

At the end of the MDG agenda in 2015, five developing regions, including sub-Saharan African, failed to meet their targets, leaving eight out of ten people living in the rural communities without access to improved water services (WHO, 2015). Around the same time (in 2015), 96% of the urban and 84% of the rural population were estimated to have gained access to improved water services (WHO, 2017). With regards to piped water on-premises, 79% of the urban population was estimated to have direct access to piped water compared to 33% of the rural population (WHO, 2017). This indicated that more needed to be done to sustain the achievements of the MDG as well as enhance and accelerate efforts in ensuring sustainable access to improved water services, particularly in rural communities. As a result, post-MDG, the Sustainable Development Goals (SDG) were conceived and adopted to sustain and build on the achievements of the MDG. With regards to water, the SDG (Target 6.1) aims to achieve universal access to improved water services provided by Improved Water Sources (IWS).

WHO (2015) refers to IWS as safe and affordable water sources dominant in rural communities. These IWS include; standpipes connected in the dwellings, communal standpipes, equipped boreholes (*e.g.* hand pump), rainwater technologies, and protected dug wells and springs used in rural communities as water sources (WHO, 2015). IWS are designed to provide a basic level of water services (drinking, cooking, and personal hygiene) to comply with the human right to sufficient access to water for all and attainment of SDG target for universal access to improved water services. This is notwithstanding research evidence arguing that rural communities do not only require water to meet their basic water needs but also for irrigation of backyard gardens, development (*e.g.* building of house), and recreation purposes (Liu *et al.*, 2013; Sambo, 2015). However, providing basic water services is considered a starting point to attain universal access to improved water services, and then focus on improving water services based on available water resources.

As mentioned before, the MDG to halve the percentage of people without access to safe and affordable water sources was met earlier than expected. At the time (in 2010) of the report, national statistics estimated that 97% of South African citizens had access to improved water services (DWA, 2010). This meant that at the time, South Africa was remaining with 3% of the population to achieve universal access to improved water services. However, the estimated figure is not without controversy, as the same report cautions that the estimated figure of the population with access to improved water services could be slightly lower than reported (DWA, 2010). This is because the figure is based on the number of IWS provided to a proportion of the population (Martinez-Santos, 2017). Thus, the estimated figure does not reflect the quality of the ongoing water service provided by IWS over their useful life. In the South African context, the Free Basic Water Services (FBWS) policy guide the standards of improved water services. The FBWS standards include sustainability aspects of physical access, water quantity, reliability, and water quality, and affordability of improved water services. Therefore, it is expected that improved water services should comply with FBWS standards. However, the reported figures do not represent the level of improved water services provided according to the FBWS standards, but the number of IWS provided to a certain proportion of the population.

Same as South Africa, at the global scale, the figures reported for water access also do not represent the reality on the ground with the level of improved water services provided (Martinez-Santos, 2017; Lestera and Rhiney, 2018). The assumption made is that merely providing IWS to a particular percentage of the population translated to sustained access to improved water services. This is because the Joint Monitoring Programme (JMP) global indicator used to track progress in the attainment of universal access to improved water services does not have a precise method to track temporal changes in improved water services (Lestera and Rhiney, 2018). The limitation is as a result of proxy indicators used, which are based on the primary water source reported being used by households during the administration of national household surveys (*e.g.* census) (Lestera and Rhiney, 2018). However, the existence of IWS does not mean people have access to safe and affordable water sources, as the technologies fail due to a multiple of factors that negatively influence sustainable access to improved water services (Guardiola *et al.*, 2010; Sambo, 2015; Martinez-Santos, 2017).

A survey conducted in 11 countries in the rural parts of sub-Saharan Africa found that an estimated 15% of IWS fail after one year of installation and 25% within the fourth year (Fusey, 2013). Research conducted in the rural areas of South Africa found that more than 30% of IWS were not functional and in poor condition as they were not properly operated and maintained (Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Sambo, 2015). To address this, and for the sake of reporting ‘good’ numbers, governments continue to employ a “quantification approach” by investing in providing more IWS neglecting their maintenance, including those already existing in the rural communities (Rietveld *et al.*, 2008; Sambo, 2015). It has been proven that IWS that are operated for a long time without proper maintenance eventually breakdown, and sometimes water quality will change due to natural occurring contaminates or human and animal activities or the water source (*e.g.* boreholes) dry-out due to environmental factors or poor siting (Rietveld *et al.*, 2008; Sambo, 2015). As a result, this negatively influences sustainable access to improved water services. To address this, there is a need for accurate, current, and reliable data that represent the reality on the ground with regards to the level of water services provided by IWS without any distortion

(Giné-Garriga *et al.*, 2015). The availability and accessibility of such information which is routinely collected, disseminated, and updated at various national administrative levels, can help understand inequalities in the level of water service provided. The availability and accessibility of the information combined with an understanding of the factors that influence access to improved water services can yield sustainable benefits for the rural communities. This is because the information can be used to; (i) inform decision-making, (ii) formulate and implement evidence-based policies and strategies, (iii) enhance transparency in budgetary procedures, (v) measure progress and performance, and (iv) allocate resources where they are much needed to make an impact (Giné-Garriga *et al.*, 2013; Giné-Garriga *et al.*, 2015). This will, in turn, contribute to sustainable access to improved water services in rural communities.

1.2 Rationale and Research Problem

In 2010, the proportion of the population without sustainable access to improved water services was reported to have been halved (WHO, 2015). In the same year, 97% of the South African citizens were reported to have access to improved water services (DWA, 2013). This resulted in the diversion of investments earmarked for the development of improved water services to other priority areas in the economy as only 3% of the population was considered to be without access to improved water services (Fukuda-Parr *et al.*, 2014). However, the figure is not accurate and cannot be used for decision-making with regards to improved water services coverage as it is based on the number of households claiming to use IWS as their primary water source (DWA, 2013; Pullan *et al.*, 2014; Shaheed *et al.*, 2014; SAICE, 2017). This is used as a proxy indicator, and the data required to inform the indicator is easily attainable through household surveys (*e.g.* national census), which are constrained by data gaps (Hoque and Hope, 2018). Therefore, reducing the burden on the government to collect accurate data, which incorporates basic aspects of sustainable access to improved water services. This is because traditional methods used to obtain such data are considered to be labour intensive, time-consuming, and expensive, especially those employed for water quality data (Guardiola *et al.*, 2010; Martinez-Santos, 2017). However, to achieve sustainable access to improved water services as well as support evidence-based strategic planning, and appropriate development and management of water services, there is a need to incorporate aspects of sustainability in indicators used to measure sustainable access to improved water services provided by IWS over their useful life. The sustainability aspects include accurate data on physical access, reliability, affordability, and water quantity and quality of improved water services (Fukuda-Parr *et al.*, 2014; Shaheed *et al.*, 2014). The data should be updated on a regular basis and made available and accessible as it will provide an informational advantage in determining needs and priorities in accordance with the water services provided. This should be complemented by an understanding of factors influencing sustainable access to improved water services in rural communities (Graciana and Nkambule, 2012; Fan *et al.*, 2013). This is because literature reviewed indicate that sustainable access to improved water services is influenced by a magnitude of technical, social, institutional, economic and environmental factors, which are complex in nature (Harvey and Reed, 2004; Hoko and Hertle, 2006; Graciana and Nkambule, 2012; Sambo, 2015; Selala, 2016). However, there is little understanding of their complex interactions as most research studies use methods that focus on analysing a single category of factors or analyse the factors in isolation. Therefore, there is a need for more research that analyses the multitude of factors as a complex system. In doing so, it will provide an enhanced understanding of the synergies and trade-off resulting from the interactions of the factors in order to propose sustainable solutions to address challenges that impact access to improved water services in rural communities.

The information gap identified required to support the sustainable access to improved water services; limitations in indicators, and methods and techniques employed to measure and track access to improved water services, and lack of understanding of factors that impact water access are to blame for the patchy access to improved water services in rural communities. It is for these reasons that the proposed study sought to explore the use of FBWS standards that incorporate aspects of sustainability to measure and track temporal changes in improved water services access in rural communities. This will be complemented by a holistic and systematic analysis of the complex interactions of the factors that influence sustainable access to improved water services at a level of a complex system. This is expected to contribute to an enhanced and more accurate understanding of why the situation is as it is on the ground. Furthermore, it is also expected that the approach employed will contribute to closing the information gap, as it will provide direction in terms of development and implementation of sustainability indicators that measure and track temporal changes in the level of improved water services provided, and provide a coherent understanding of the multitude of factors that affect water access to take advantage of the synergies and trade-offs that occur due to their complex interactions. The approach may be adopted and used at different administrative levels of government to generate data that can be used to support strategic planning and decision-making in terms of the development and management of improved water services.

It is worth noting that this study does not seek to replace the water access indicator used by the JMP but to complement the meaning of the data presented by the indicator in such a manner that it captures sustainability aspects of improved water services over the useful life of IWS. It is expected that it will result in a more accurate representation of the situation on the ground instead of the situation presented by the proxy indicators currently in use.

1.3 Research Questions

The research questions to be answered by the study are as follows:

(a) Are the households satisfied with the FBWS policy standards?
(b) Are the households satisfied with the water services provided?
(c) What are the factors that influence sustainable access to improved water services?
(d) Are there inequalities in sustainable access to improved water services based on (i) distance, (ii) quantity (iii) reliability, (iv) flow rate (v) water quantity and (vi) cost?
(e) Can a monitoring framework that contribute to sustainable access to improved water services be proposed and demonstrated?

1.4 Scope of the Study

The scope of the study was limited to the following;

(a) to assess household satisfaction with FBWS policy standards and water services provided,
(b) covered households using standpipes connected in the dwellings and communal standpipes.

(c) to using a set of indicators to measure inequalities in sustainable access to improved water services based on (i) distance, (ii) quantity (iii) reliability, (iv) flow rate (v) water quantity and (vi) cost,
(d) to analyses factors that influence sustainable access to improved water services,
(e) to propose and demonstrate a decision support framework to contribute to sustainable access to improved water services,

1.5 Aim and Objectives

The main objective of the study was to assess inequalities in sustainable access to improved water services provided and analyse the complex interactions of the factors that influence sustainable access to improved water services to propose site-specific targeted interventions.

The specific objectives are as follows:

(a) to assess households satisfaction with the FBWS policy standards in Makhudutamaga Local Municipality,
(b) to assess households satisfaction with water services provided based on FBWS standards in Makhudutamaga Local Municipality,
(c) to assess inequalities in access to improved water services based on (i) distance, (ii) quantity (iii) reliability, (iv) flow rate (v) water quantity and (vi) cost,
(d) to investigate and analyses the factors that influence sustainable access to improved water services in Makhudutamaga Local Municipality,
(e) to propose and illustrate a monitoring framework to contribute to sustainable access to improved water services in Makhudutamaga Local Municipality.

1.6 The Originality of the Study

The originality of the study is attributed to the following;

(a) The study assessed the perceptions of households to understand their satisfaction with the FBWS standards. As assessment of household satisfaction of all the FBWS standards in one study has not been conducted in South Africa.

(b) The study assessed the perception of households to understand their satisfaction with the level of water services provided. The assessment of improved water services using all the FBWS standards in one study has not been conducted in South Africa.

(c) The study used a set of indicators to access inequalities in sustainable access to improved water services. The use of all the FBWS standards as a set of indicators to assess inequalities in sustainable access to improved water services has not been conducted in South Africa.

1.7 Ethical Consideration

The study was approved by the University of KwaZulu Natal (UKZN) ethics office to conduct household surveys and key informant interviews in the study area (*Protocol reference number: HSS/0863/018D*) (*c.f.* Appendix B).

1.8 Thesis Outline

The layout of the document is as follows;

(a) Chapter 1 presents the background, rationale, problem statement, research questions as well as scope, aim and objectives and originality of this research study.

(b) Chapter 2 presents a discussion of the literature reviewed on the definition of improved water services and IWS, linking it with the human right to sufficient water for all and institutions and partnerships mandated to provide water services in rural communities. This is followed by a discussion about indicators developed by various stakeholders to assess sustainable access to improved water services and approaches used to collect and analyse data to inform the indicators. This is then followed by a discussion about the factors that influence sustainable access to improved water services and definition of sustainability in the context of this study and a summarised discussion and conclusion section.

(c) Chapter 3 addresses issues to do with the perceptions of households with the policy instruments used to guide water services provision and improved water services provided.

(d) Chapter 4 addresses issues to do with assessing inequalities in sustainable access to improved water sources.

(e) Chapter 5 addresses issues to do with complex interactions of factors that influence sustainable access to improved water services.

(f) Chapter 6 addresses issues to do with the use of a monitoring framework to support decision-making and formulation of targeted interventions at the level of the Water Services Provider (WSP).

(g) Chapter 7 presents an overall conclusion of the thesis, as well as proposed recommendations and future research.

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2. LITERATURE REVIEW

This chapter discusses relevant literature reviewed on the definition of improved water access linking it to global and domestic policy instruments declaring universal and sustainable access to improved water services provided by Improved Water Sources (IWS) as a fundamental human right. It also covers indicators adopted at various levels by a spectrum of stakeholders to benchmark sustainable access to improved water services and approaches used to collect and analyse data on IWS coverage. Lastly, it discusses factors that influence sustainable access to improved water services, the potential of the complex system approach in analysing the factors and puts into perspective sustainability in the context of this study as wells a summarised discussion and conclusion focused on the literature reviewed.

2.1 Water Access Definition and Perspective

There is a wide debate on the appropriate definition of improved water access. This is because improved water access is defined and understood differently by a spectrum of stakeholders involved in water services provision. Nganyanyuka *et al.* (2014) state that the stakeholders base their definition of improved water access on the locality, economic status, environment, politics, institutions, and other diverse conditions of a region or country. The diverse conditions make it difficult to derive a universal definition of improved water access.

At a global scale, the Millennium Development Goals (MDG), Goal 7 indicator defined improved water access as the proportion of people with access to sustainable and safe drinking water sources (WHO, 2015). Post-MDG, the Sustainable Development Goals (SDG), Goal 6, Target 6.1, Indicator 6.1.1 refers to improved water access as the proportion of the population using safely managed and affordable drinking water services (WHO, 2015). Unlike the SDG definition, the MDG definition does not make mention of affordability of water services but covers sustainability. It is assumed that sustainability is build-in as part of the SDG. The safety of the water supplied by the water source is emphasized by both MDG and SDG, given that it touches on human rights. Affordability, which is covered by SDG, is also an important aspect that can restrict access to water. Currently, the SDG definition of improved water access is used at a global scale in support of universal access to Improved Water Sources (*cf.* Figure 2.1) that are intended to provide improved water services. This is despite critics arguing that the definition does not cover aspects of sustainable access to water services due to the indicator used to measure and track the attainment of universal access to improved water services (Kayser *et al.*, 2013). These aspects include physical accessibility, reliability, affordability and water quality and quantity, which influence sustainable access to improved water services. Not reporting on the mentioned aspect of sustainability of improved water services is advantageous for United Nations (UN) member countries, including developing countries committed to achieving the SDG target of universal access to improved water services. This is because the member countries only report on IWS provided and the number of people reached but not on the level of water services provided by IWS over their useful life (Martinez-Santos, 2017). The data to support this is based on the response of households who claim to use IWS as their primary water source (Giné-Garriga *et al.*, 2013). It is assumed that the IWS are maintained to provide lasting good quality and sustained improved water service. This results in a misrepresentation of the reality on the ground with regards to access to improved water services. However, countries are not compelled to adopt the global definition of improved water access, but as part of their agreement are required to provide the information required to measure and track progress in the attainment of SDG, Goal 6, Target 6.1. This gives them flexibility to derive their own definition of improved water access taking into consideration their prevailing diverse conditions in their respective countries.

Figure 2.1 Improved and unimproved water sources (Yale-University, 2018)

South Africa is one of the UN member countries that has derived its own definition of improved water access in the form of standards, defined in the Free Basic Water Services (FBWS) policy. Basic water service refers to improved water services provided by IWS to meet minimum human water requirements for drinking, food preparation and personal hygiene (Statssa, 2016), which are considered to be improved water services. The definition is based on key sustainability aspects that influence sustainable access to improved water services, which are as follows; (i) distance – 200 meters from households within the community, (ii) water quantity – supply 25 litres/capita/day, (iii) water quality - the water should meet standards for human consumption, (iv) water delivery – a minimum of 10 litres/minute, (v) reliability of 98% (available 350 days in a year), and (vi) cost – for free (DWA, 2010). It is therefore expected that improved water services provided in rural communities comply with the FBWS policy standards. The standards cover fundamental aspects of sustainable access to improved water services. Therefore can be used to derive appropriate indicators for measuring and tracking temporal changes in the level of improved water services provided. The indicators should be supported by the routine collection, dissemination and update of data to inform evidence-based strategic planning and appropriate development of improved water services (Lestera and Rhiney, 2018). This is paramount as access to sufficient water is a fundamental human right recognized by global and national statutes. Therefore, the FBWS defining standards used by South Africa are preferred by the researcher to assess inequalities in sustainable access to improved water services in rural communities.

2.1.1 Water access as a human right

South Africa's FBWS standards were derived taking into consideration the Constitution of South Africa, which recognizes water as a human right rather than a commodity. This is embedded in Section 27(1) (b) of the Constitution of South Africa, which states that "*Everyone has the right to sufficient water*". This is because the Constitution recognizes water as essential to sustaining human life and a fundamental human need in achieving a host of other human rights, including the right to life, health, education, and an adequate standard of living. The lack of access to water directly infringes on human rights. To attain the human right, Section 27(2) of the Constitution requires the government to develop the necessary mechanisms or measures within the available resources. It is, therefore, the government's responsibility to provide water in rural communities as a human right. As a result, the government established relevant institutions and forged partnerships in the water sector mandated to provide water in rural areas in such a manner that everyone has sustainable access improved water services.

2.1.2 Overview of institutional arrangements and partnerships in water service provision in South Africa

The establishment of strong institutions and partnerships in order to deliver on the constitutional mandate to achieve sustainable access to improved water services was critical. This was in view of the historical background of South Africa, as during the apartheid era, black people were forcedly moved to parts of the country where poor services, including water services, were offered to them. Post-apartheid, the institutions and partnerships developed, as a result, were allocated roles and responsibilities along the water sector value chain (*cf.* Figure 2.2 and Figure 2.3). The Department of Water Affairs and Sanitation (DWAS) has oversight responsibility for the institutions and partnerships existing and operating in the water sector as well as setting policies and regulations, and provide budgetary support.

At the district and local levels, the Water Service Authorities (WSA) and Water Service Providers (WSP) are responsible for water service provision in their respective municipalities, including rural municipalities. The mandates of WSA and WSP are defined in the Water Service Act of 1997 (Water Service Act, 1997). In summary, the WSA is responsible for ensuring sustainable access to improved water services through policy setting and monitoring of the performance of WSP in respect to water services provision. The WSP is responsible for providing water in line with the policies and performance agreement of the WSA. However, before the year 2000, the functions of WSA and WSP rested with the DWAS. After the establishment of municipalities in the rural communities (former homelands), some of the functions of the DWAS were decentralized to the WSA and WSP operating in the newly established municipalities.

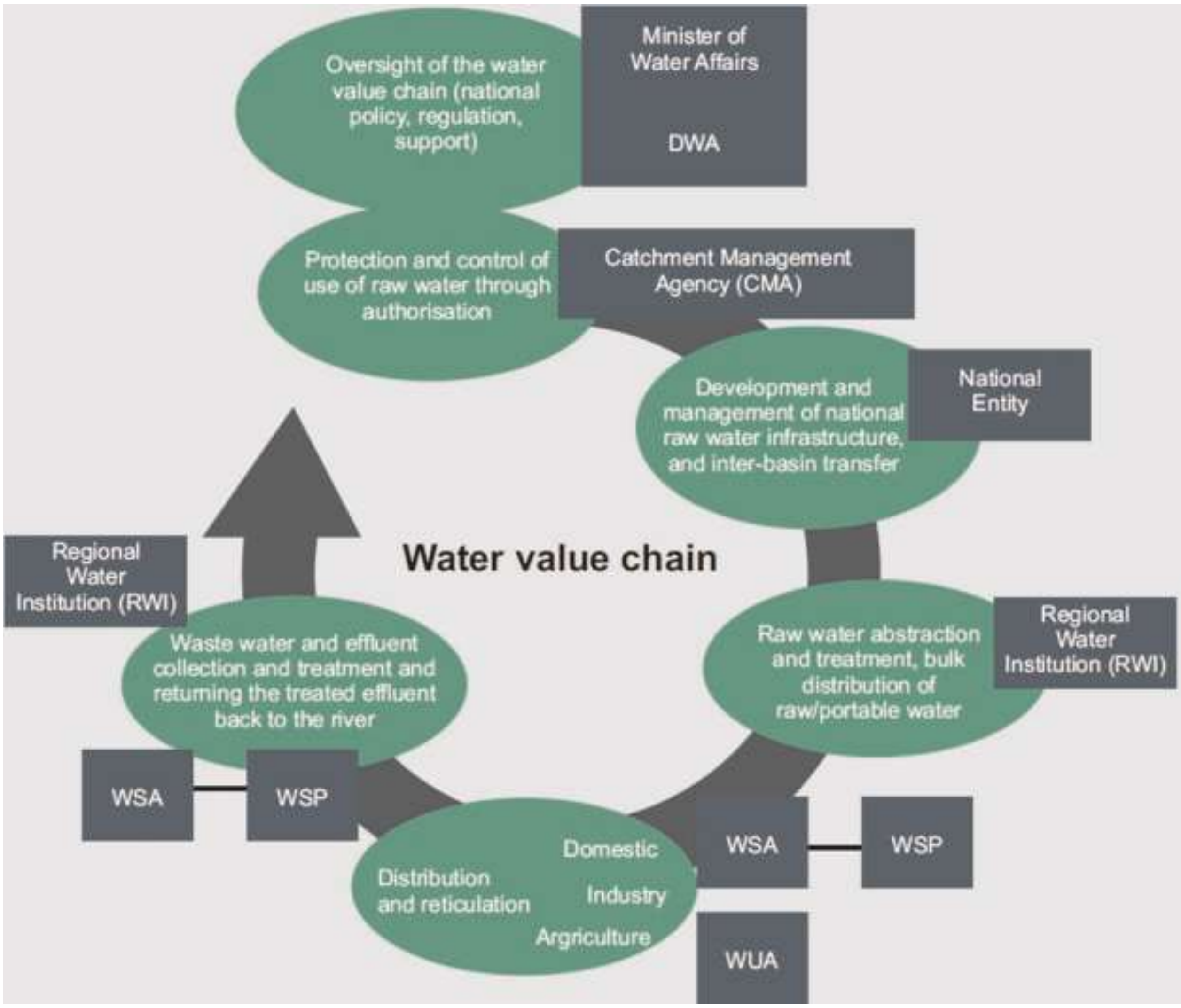

Figure 2.2 Water value chain (DWA, 2013)

The decentralization was believed to offer an informational advantage over the centralized government with regards to needs and priorities, for provision of demand-driven water services, equitable allocation of resources, and development of evidence-based policies and strategies in support of improved service delivery. In most cases, district and local municipalities were designated as WSA and WSP, respectively. In other areas, local municipalities were designated as both WSA and WSP. WSA has the responsibility of deciding on the WSP, which can be private companies, water boards, community-based organizations, non-governmental organizations (NGOs), and others.

Typically, the partnership between the WSA and WSP is established through a performance-based agreement with specific deliverables. As a result, the performance evaluation of the WSP is based on the deliverables agreed on with the WSA with regards to water services provision. However, the performance agreement does not include mechanisms for rural communities to rate the water service provided. This means that the quality of water service is rated by the WSA and not the user of the services. This creates problems as water users are unable to give feedback on the performance of water services provided. Hence the prominence of water service delivery protest in South Africa as rural communities views protests action as a communication channel available to provide feedback on the water services provided (Muller, 2008). Despite this, where a performance-based agreement exists, the specific deliverables are not clear (World-Bank, 2011), and the WSA and WSP do not consult communities to understand their water needs (Sambo *et al.*, 2018). Service level indicators that measure and track temporal changes in improved water services access can play an important role in providing WSA and WSP with the relevant and accurate information to support water service provision (Fukuda-Parr *et al.*, 2014). This will aid in the identification and prioritization of communities at risk (Hoque and Hope, 2018) and inform decision-making and investment in respect to the development and management of improved water services to ensure sustainable access to water.

2.2 Indicators of Sustainable Access to Improved Water Services

The FBWS policy standards used by South Africa can be modified to derive indicators for measuring and tracking sustainable access to improved water services in rural communities. The FBWS includes aspects of physical accessibility, reliability, affordability, and water quantity and quality that contribute to sustainable access to improved water services. The development and implementation of such indicators will result in a sophisticated, accurate and better understanding of the progress made with regards to the attainment of SDG and the human right for water (Clasen, 2012; Kayser *et al.*, 2013; Shaheed *et al.*, 2014). As mentioned in previous sections of this document, current measures of access are based on IWS provided as the focus is on quantification. In their study, Fukuda-Parr *et al.* (2014) found that MDG indicators were poorly selected and distorted the reality on the ground as other aspects of water access were not considered in the development of the indicator. This had a far-reaching implication for policy priority setting - as a consequence, it led to the unintended diversion of investments to other problem areas (Fukuda-Parr *et al.*, 2014). This is because in 2010, it was reported that the proportion of people without sustainable access to improved water services were halved, meaning MDG, Goal 7 was achieved. However, the figure reported did not reflect continuous ongoing improved water service provided in rural communities. A similar mistake has been repeated with the SDG indicator used to track universal access to improved water services. The indicator does not measure fundamental aspects that contribute to sustainable access to improved water services. It is not adequate to measure improved water services access by the number of households claiming to collect water from an IWS. This is because IWS fail, with the failure rate increasing yearly as equipment ages (Fusey, 2013). This raises a need for the development of indicators that measure and track sustainable access to improved water services supported by simple, less labour intensive and cost-effective methods and techniques that allow for routine collection of accurate and reliable data. This is because methods with the potential of measuring and tracking sustainable access to improved water services are regarded as expensive and labour intensive, especially water quality data (Kayser *et al.*, 2013; Martinez-Santos, 2017; Lestera and Rhiney, 2018). Availability and accessibility of such data will allow for an accurate measure of improved water services access by reflecting the reality on the ground (Clasen, 2012; Kayser *et al.*, 2013; Kulinkina *et al.*, 2017). As a result, the information provided by the indicators will inform policy priority setting and development of strategies that will ensure sustainable access to improved water services. Table 2.1 shows indicators or standards used by different stakeholders that can be employed to measure and track access to improved water services (Scanlon, 2004; DWA, 2010; World-Bank, 2011; WHO, 2015). The indicators or standards are discussed in the sub-sections below.

2.2.1.1 Physical accessibility

Physical accessibility refers to the distance or walk time travelled by users such as children, elderly persons and persons with disabilities to access improved water services in a particular location within a community or village. As shown in Table 2.1, the recommended distance varies depending on stakeholders. For example, DWAS recommends a distance of not more than 200 m from the households, while WHO and UNICEF recommend a distance of 1000 m. DWAS does not take into account walk time while WHO and UNICEF recommend a walking time of 15 minutes, which is calculated from the time the user leaves the household to the IWS, queuing, and return.

Table 2.1 Possible indicators and criteria for measuring access to IWS (Scanlon, 2004; WHO, 2010; World-Bank, 2011; DWA, 2013)

Indicator	**Criteria**	**Institution**
Physical accessibility (distance)	Distance: 1000 meters Walk-time: not more than 15 minutes	WHO/UNICEF
	Distance: 0 – 200 meters Walk-time: not available	DWAS
Quantity of water	50 – 100 liters/capita/day	WHO
	25 liters/capita/day	DWAS
Reliability	24 hours per day	WHO/UNICEF
	98% reliability	DWAS
Affordability	5% disposable income	World Bank
	3% disposable income	UNDP
	Free	DWAS
Quality and safety	WHO water quality standards	WHO

Majuru *et al.* (2012), in their study conducted in the rural municipalities of South Africa, found that when IWS was not operational, users had to walk distances two times longer than the recommended distance of 200 m to the next operational water source. This suggests that there might be a directly proportional relationship between the distance and operational status of IWS. Furthermore, the study found that when people walked a long distance to collect water, they collected less quantities of water relative to when the water was collected at a water source close to the household. In support of this, Figure 2.4 shows how the time taken to walk to collect water affects the average quantity used for domestic purposes in litres/capita/day (Howard and Bartram, 2003). As a result, households were forced to prioritize domestic water use over, for example, irrigation of backyard gardens and livestock watering (Majuru *et al.*, 2012; Fan *et al.*, 2013). It is, therefore, necessary to ensure that IWS are located within the recommended distance (*e.g.* 200 m) to the households and are maintained as it influences sustainable access to improved water services. This will prevent water users from travelling long distances to collect water at an alternative operational water source, resulting in them not collecting sufficient water to cater for their needs. Furthermore, it will avoid households resorting to unsafe water sources which can have a devastating health impact (Sambo, 2015).

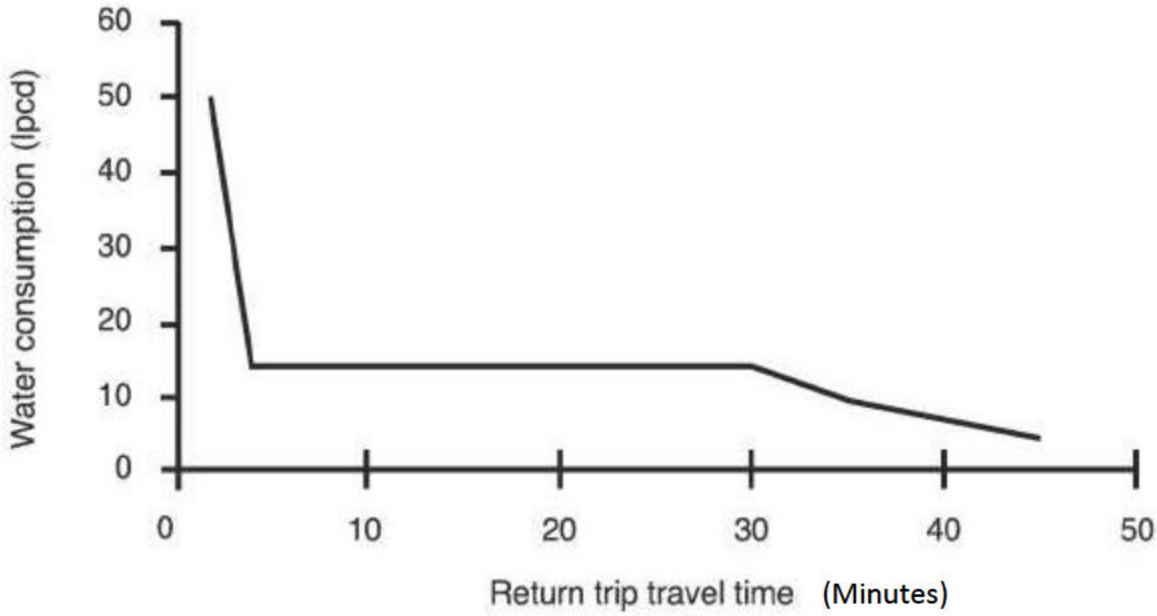

Figure 2.3 Water consumption *vs* return trip travelled (Howard and Bartram, 2003)

2.2.1.2 Reliability

Reliability refers to the ability of IWS to continuously provide an ongoing improved water service (Martinez-Santos, 2017). As shown in Table 2.1, WHO and UNICEF recommend that IWS should be operational for 24 hours/day (100% reliability), and the DWAS recommend 98% reliability or should not be out of service for more than 2 days in a month. To achieve this, DWAS has committed to supporting the maintenance of IWS but will not take responsibility to maintain those provided by other stakeholders (DWA, 2013). However, the focus has been on providing more IWS, neglecting their maintenance (Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Sambo, 2015; SAICE, 2017). As a result, reporting of access to improved water services at a global and national scale has been on IWS provided and does not take into consideration the operational status of the IWS over their useful life (Kayser *et al.*, 2013; Sambo, 2015). It is estimated that more than 30% of IWS existing in rural municipalities of South Africa are not functional (Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Sambo, 2015). Yet, it is reported that a greater part of the population has sustainable access to improved water services. This may have been true at the time of their establishment, but given that they are not maintained over their useful life, a greater percentage of the IWS are not operational. Sambo (2015) reports that broken down IWS sometimes takes weeks, even months in a state of disrepair influencing sustainable access to improved water services in rural communities. Other studies found that where IWS are not operational, rural communities resorted to unprotected water sources that could have been contaminated (Hoko and Hertle, 2006; Rietveld *et al.*, 2008; Sambo, 2015). This exposes rural communities to water-borne diseases that pose a threat to their life. Therefore, maintenance of IWS is crucial to ensure that they provide continuous ongoing improved water services. However, this is not always in place, especially in rural communities (Martinez-Santos, 2017). DWA (2013) blames the lack of current information on the operational status of the IWS to address the problem effectively. This is because it is difficult to obtain the information as some villages are located in remote areas, which are difficult to reach (DWA, 2013). There is also the issue of capacity at the WSA and WSP as they do not have sufficient staff to support the monitoring of improved water services (Sambo, 2015). However, during election time, political parties with the assistance of local government are able to access the most remote areas to canvas for votes promising to address all the challenges experienced by the communities if elected.

2.2.1.3 Water quantity

Water quantity refers to sufficient water supplied by improved water services for hydration and domestic use (Shaheed *et al.*, 2014). As an estimate, WHO recommends between 50 – 100 liters/capita/day, and DWA (2013) recommends 25 liters/capita/day (*cf.* Table 2.1). The recommended quantity of water does not take into account changes in water consumption behaviour as a result of increased access to improved water services. Fan *et al.* (2013) state that with increased access to improved water services, household's water consumption behaviour changes. A study conducted in the rural communities of China found that water supplied by improved water services was not only used for domestic purposes but was also used for agricultural purposes (vegetable gardening) and some younger community members bought and used washing machines; resulting in an increase in the quantity of water used (Fan *et al.*, 2013). The same study found a significant positive correlation between water consumption in litres/capita/day with water supply patterns and vegetable garden area (Fan *et al.*, 2013). Fukuda-Parr *et al.* (2014) state that governments must review their policy priorities to consider changes that arise as a result of increased access to improved water services. To achieve this, it is important to understand water consumption behaviour to design efficient and effective water use strategies and related policies (Fan *et al.*, 2013). Therefore, the implementation of indicators that can measure and track quantities of water used and water uses by rural communities can inform the development of such policies and strategies.

2.2.1.4 Water quality

Water quality refers to water that is safe for human consumption free from harmful microorganisms and other toxic substances (Martinez-Santos, 2017). At global and national levels, WHO water quality standards are used as a guideline for water meant for human consumption. Nonetheless, globally reported estimated figures on access to improved water services do not cater for water quality as testing is regarded as "prohibitively expensive" and "logistically" complicated (Shaheed *et al.*, 2014). To address this, the Rapid Assessment of Drinking Water Quality (RADWQ) method was introduced (WHO, 2010). The method is field-based, dubbed to be rapid and low-cost to obtain water quality data and was piloted in China, Ethiopia, Jordan, Nicaragua, Nigeria and Tajikistan between 2004 and 2005 (WHO, 2010). The method was found to be rapid, but the way it was implemented made it expensive (WHO, 2010). A recommendation was made to increase the efficiency of the method to enhance the statistical approach used (WHO, 2010). Given the results of the study, the methods was not adopted by UN member countries. It is assumed that since improved water services are more protected from outside contamination of water than unimproved water sources, the water is safe for human consumption (Majuru *et al.*, 2012; Patunru, 2015). The literature reviewed indicated that the use of IWS does not necessarily mean that the water is safe as water quality can change due to naturally present microbes and chemicals in the environment (Patunru, 2015; Martinez-Santos, 2017). The water can be contaminated by human and animal activities, agrochemicals, and chemicals from industrial processes (Martinez-Santos, 2017). Therefore, monitoring of water supplied by improved water services is a key part to maintaining consistent safe water supplies in rural communities.

2.2.1.5 Economic access

Economic access refers to the cost associated with accessing water from improved water services. This is expressed as a percentage of the households' disposable income per month or year (World-Bank, 2011). Scanlon (2004) and World-Bank (2011) recommend payment for water services that does not exceed 5% and 3% of households' disposable income, respectively. This makes it difficult for governments to determine the payment rate for water services provided as households do not earn the same income; some households do not have income at all. It will mean that those without income will not have to pay for water or as a result of not being able to pay will not access water. This may also cause conflict among users of improved water services as they will be paying different rates for the same water service. As a result, it could discourage users from paying for the improved water services. Lack of payment may result in water service disruptions, as the cost for O&M may not be met. Van Houtven *et al.* (2017) reviewed 60 research studies on urban and rural communities' households' willingness to pay, and it was found that households' willingness to pay is sensitive to the magnitude of the improved water services and household income. The study also found that households are willing to pay between USD 3 to USD 30 per month for improved water services provided (Van Houtven *et al.*, 2017). Martinez-Santos (2017) states that the cost of water should not deter households from accessing water and should not place the user in debt as they have the right to sufficient water. To attain its constitutional mandate, the government of South Africa has committed to providing basic water services for free.

2.2.2 Measures of access to improved water services

Generally, measures of access to improved water services (I_{iws}) in its fundamental form is computed, as shown in Equation 2.1 (Kulinkina *et al.*, 2017). Equation 2.1 can be used in different administrative areas (*e.g.* ward, district, and national). The data to compute I_{iws} is obtained through the administration of a survey instrument in a particular community of interest. However, for reporting purposes, national governments use national census data which can also be used for research purposes, if made publicly available and accessible. When using national census statistical data, I_{iws} is computed by dividing the number of people reported to be using improved water services with the total number of people surveyed. Although this approach is widely used, it has limitations as it does not take into account basic aspects of sustainability that influence access to improved water services (Clasen, 2012; Kayser *et al.*, 2013; Patunru, 2015; Martinez-Santos, 2017). Despite this, governments continue to use the approach to report on sustainable access to improved water services (Kulinkina *et al.*, 2017). The computed figures feed into the UNICEF's Joint Monitoring Programme (JMP) global indicator for monitoring universal access to improved water services. However, as mentioned previously, the indicator has limitations as it does not cover sustainability aspects of physical accessibility, reliability, affordability, and water quantity and quality of improved water services over the useful life of IWS (Clasen, 2012; Kayser *et al.*, 2013). Therefore not capturing temporal changes in water access. As a result, reported figures of sustainable access to improved water services distort the reality on the ground.

$$I_{iws} = \frac{P_{iws}}{P_{tot}} * 100 \qquad (2.1)$$

Where

I_{iws} = access to improved water sources [%],

P_{iws} = number of people using an IWS, and

P_{tot} = total estimated population.

In a quest to address the problem, researchers developed tools to measure and track sustainable access to improved water services in the rural communities (Majuru *et al.*, 2012; Sambo, 2015; Kulinkina *et al.*, 2017; WaterAid, 2017). Most researchers covered one or two aspects of sustainable access to improved water services. Rietveld *et al.* (2008) developed a technical tool to assess the condition of communal standpipes in rural communities. Sambo (2015) modified the technical tool (Rietveld *et al.*, 2008) to include IWS and unimproved water sources (UWS). Rietveld *et al.* (2008) and Sambo (2015) focused on technical (reliability) aspects and did not cover other aspects of sustainable access to improved water services. A study conducted in the rural communities of Ghana employed a distance-based approach (spatial) and designed a capacity-based approach (non-spatial) as indicators to measure and track access to improved water services (Kulinkina *et al.*, 2017). The study also covered aspects of water quality. Majuru *et al.* (2012) used selected indicators (distance, reliability, and water quantity and water quality) derived from South Africa FBWS standards to benchmark improved water services (communal standpipes) in a rural municipality of South Africa. Majuru *et al.* (2012) and Kulinkina *et al.* (2017) studies yielded interesting results as they gave insight about sustainable access to improved water services in rural communities and also provided direction in terms of the development of sustainability indicators that can be used to measure and track the level of water services over time. The methods employed by the mentioned studies can be modified and integrated to derive sustainability indicators that cover sustainability aspects of improved water services access.

The development of the indicators should take into consideration the significant differences that exist with regards to access to improved water services at regional, district and local levels as a result of density and population catered by IWS (Ntozini. *et al.*, 2015). Furthermore, significant variation in indicators values can exist at village and sub-village level as a result of operational status of IWS, heterogeneity in topography and other social, demographics, economics and environmental factors (Bartram *et al.*, 2014; Pullan *et al.*, 2014). Kayser *et al.* (2013) state that it is important to take into account the differences due to their influence on the sustainable access to improved water services as they are implemented at a local scale. To address this, researchers (Giné-Garriga *et al.*, 2013; Ntozini. *et al.*, 2015) used the Water Point Mapping (WPM) (WaterAid, 2017) approach combined with statistical approaches which enabled a more detailed and systematic assessment of sustainability aspects of access to improved water services at the local level.

The WPM approach was successfully piloted in Malawi and Tanzania to measure and track access to improved water services based on aspects of distance and functional status of IWS (WaterAid, 2017). The pilot study used a survey instrument to collect relevant qualitative and quantitative information about the IWS. Geospatial information was also collected to determine the location of the IWS. The information obtained was integrated with demographical, administrative and physical data using a Geographical Information System (GIS) package to visually present improved water services access based on distance and functional status using a map at a local scale. As a result, the approach provided insight into the aspects of access to improved water services (WaterAid, 2016). Therefore, the WPM approach combined with other methods/approaches can be successfully employed to measure and track aspects of sustainable access to improved water services in rural communities (Giné-Garriga *et al.*, 2013; Ntozini. *et al.*, 2015; WaterAid, 2017). The computed figures can be used to empirically inform policies and strategies which guide the development and management of improved water services. This will contribute to sustainable access to improved water services in the rural communities without distorting the reality on the ground and diverting investments elsewhere, leaving rural communities with patchy access to water. This should be supported by a coherent understanding of the factors that influence sustainable access to improved water services.

2.3 Factors Influencing Sustainable Access to Improved Water Services

The indicators that measure and track sustainable access to improved water services are mainly qualitative in nature. The qualitative information paints a picture of the situation on the ground without providing a reason why the situation is as it is. It is for this reason that this section discusses the literature reviewed on the factors that influence sustainable access to improved water services in rural communities. Research studies conducted in the rural communities found that sustainable access to improved water services is affected by a multitude of factors (Harvey and Reed, 2004; Rietveld *et al.*, 2008; Graciana and Nkambule, 2012; Majuru *et al.*, 2012; Fan *et al.*, 2013; Sambo, 2015). These factors are categorised as technical, social, institutional, financial and environmental. The factors are interconnected; as a result, they interact to influence sustainable access to improved water services at a level of a complex system (Harvey and Reed, 2004; Sambo, 2015). However, the literature reviewed does not capture the complex nature of the factors. This is mainly to do with the approaches used in the analysis of the factors (Sambo, 2015). The factors are analysed in a compartmentalized manner resulting in gaps that can be captured by an approach that takes into account their complex interactions. The categories of factors are discussed below.

2.3.1 Technical factors

Factors in this category are technical and related to design, construction and operation and maintenance (O&M) of improved water services. Graciana and Nkambule (2012) in a study conducted in the rural communities of Swaziland, found that technical factors are critical in ensuring availability, reliability, and sustainability of impoved water services. Other research studies conducted in the rural communities found that inappropriate system design, poor borehole siting, ageing IWS, lack of maintenance, and broken-down IWS which can go for weeks, and even months without being repaired are some of the major technical factors that influence sustainable access to improved water services (Mann, 2003; Rietveld *et al.*, 2008; Boshoff, 2009; Graciana and Nkambule, 2012; Marks and Davis, 2012; Sambo, 2015; Martinez-Santos, 2017). Majuru *et al.* (2012) found that when the commonly used IWS is not operational, rural communities are forced to travel longer than the usual distance to collect water at the next available water source, which can be either an IWS or unimproved water source. Majuru *et al.* (2012) and Kulinkina *et al.* (2017) in separate studies found that rural communities collected less volume of water when they had to travel long distances to collect water relative to when they collected water at a nearby by IWS. Rietveld *et al.* (2008) state that the use of unimproved water sources poses a health risk to the rural communities as they run the risk of contracting water-borne diseases. The lack of technical knowledge and skills at WSP and communities levels result in improper O&M of IWS, resulting in a breakdown (Sambo, 2015). This is a common problem that influences sustainable access to improved water services (Mann, 2003; Hoko and Hertle, 2006; Rietveld *et al.*, 2008; Boshoff, 2009; Marks and Davis, 2012; Sambo, 2015; Selala, 2016; Martinez-Santos, 2017)

2.3.2 Social factors

Social factors refer to cultural, religious, gender, and other human-related activities that influence sustainable access to improved water services. These factors cut across all other factors as the improved water service is centred on the water needs of the rural households or communities (Sambo, 2015). For example, the following are some the factors identified (Sambo, 2015; Selala, 2016); (i) improper disposal of human waste can contaminate groundwater (ii) improper use of IWS can lead to the breakdown of IWS, (iii) inadequate consultation with communities can result in communities not claiming ownership of IWS, and (v) low-income households may not be able to afford water service. Households' lifestyles and cultural backgrounds also influence sustainable access to improved water services (Fan *et al.*, 2013). This is because their lifestyles and cultural backgrounds can influence the preferred IWS technologies.

2.3.3 Institutional factor

Institutional factors refer to issues to do with governance, accountability, rules, norms, behaviour, practices, institutional arrangements, and partnership as well as policies and strategies (Sambo, 2015; Selala, 2016). Corruption and poor leadership in institutions responsible for providing water to rural communities have been cited as some of the major factors that influence sustainable access to improved water services (SAICE, 2017; Hofstetter *et al.*, 2020). This results in poor planning and a top-down approach where improved water services are provided in rural communities without consulting communities about their water needs and technologies preferred to provide water services (Hofstetter *et* *al.*, 2020). As a result, there are also no feedback mechanisms to rate the improved water service provided to the communities. World-Bank (2011) reported that in South Africa, where an agreement exists between a WSA and WSP, the specific deliverables are not clear and not followed in most cases. As a result, WSP is not fully held accountable for the poor water service in rural communities.

2.3.4 Economic factors

These are factors to do with the budget availability, economic welfare, costs, and utilization on the supply side (WSA and WSP) as well as the affordability of improved water services on the demand side (users). On an annual basis, WSA receives a grant from the DWAS based on their Integrated Development Plan (IDP), which outlines the budget for the development of water infrastructure and O&M in the respective district or local municipality. However, as mentioned earlier in this document, the focus has been on providing more IWS neglecting O&M. The DWA cites the lack of accurate information on the level of water service provided by existing IWS for the lack of maintenance (DWA, 2013). Due to this, the budget meant for O&M is channeled to provide more IWS or moved to other line items to address other problem areas. This is an indication of the wasteful use of public funds as the main problem is not the shortage of IWS but the poor service delivery as a result of a lack of maintenance of IWS. Due to this, households are forced to contribute funds for repairs of broken down IWS through water committees, which may be existing at the time (Marks and Davis, 2012). This puts a strain on households that cannot afford to contribute as they run a risk of been restricted from using the improved water services or use it with limitations. However, as a human right, the cost of water should not deter households from accessing water from improved water services.

2.3.5 Environmental factors

Environmental factors refer to issues that affect the availability and quality of water provided by improved water services. Poor siting of boreholes resulting in no water discharge or drying-out of the water source can influence sustainable access to improved water services and will not be available for use (Sambo, 2015). Human and animal activities can result in contamination of the water sources, which will render the water discharged unsuitable for human consumption. The use of agro-chemicals in agriculture can contaminate groundwater and surface water resulting in loss of crops and livestock and human life. The existence of unwanted mineral in the water can react with the material used for IWS, resulting in water not to be suitable for drinking. Therefore, it is important to understand environmental factors as most time; they pose a threat to human health and life and loss of income.

2.4 Complex Systems

As mentioned in section 2.3, the factors that influence sustainable access to improved water services are complex in nature depicting a complex system (Harvey and Reed, 2004; Sambo, 2015). A complex system refers to a system that consists of interconnected and interacting factors that exhibit emergence and behaviour that cannot simply be understood by analysing a single category of factors existing within the system (Bezuidenhout *et al.*, 2013). A cause-effect relationship is what connects the factors within the system. The system can sometimes be complex to understand as the number of interconnected and interacting factor increase resulting in complicated connections. Therefore, to accurately understand a complex system, one would need to employ an approach that captures the complex interaction of the factors within the system (Sambo, 2015).

Researchers have employed different approaches to understand complex systems (Cross *et al.*, 2002; Martinez-Lopez *et al.*, 2009; Fairweather, 2010; Bezuidenhout *et al.*, 2013). Watson (2004) recommends the Fish-bone approach to analyse and understand interconnected factors within a system. This approach compartmentalizes factors in the same category and analyses them separately. It does not take into consideration the interconnection and interaction between different categories of factors. Some researchers have used cognitive mapping to represent complex cause-effect relationships between factors at a level of a system in complex agricultural systems (Fairweather, 2010; Bezuidenhout *et al.*, 2013), policy analysis administrative sciences and management sciences (Wanga, 1996). Bezuidenhout *et al.* (2013) used a social network approach in mapping the opinions of stakeholders to generate a network representative of the cause-effect relationship of the different categories of factors within a system. The generated network facilitated the diagnosis of complex systems. Martinez-Lopez *et al.* (2009) state that such networks are prone to subjectivity as a result of the qualitative methods used for data collection. To reduce subjectivity, the use of Q-methodology is recommended (Fairweather, 2010). In addition, Bezuidenhout *et al.* (2013) state that the analysis of the generated map can be subjected to the researcher's perceptions and biases. Therefore for one to understand a complex system, subjectivity and biases should be minimised as much as possible.

The theme and domain network analysis approach can be used to analyse complex interactions of factors at a level of a complex system (Bezuidenhout *et al.*, 2013; Sambo, 2015). The approach uses a combination of techniques from graph theory, statistics, and algebra to analyse relationships between factors within a complex system (Zhang and Luo, 2017). Borgatti and Li (2009) state that such an approach can aid researchers to visualize the system and is especially powerful in systems in which researchers have limited knowledge. The graph theory allows for a systematic analysis of the system in identifying critical points where opportunities for improvement exist (Zhang and Luo, 2017). Therefore, the network analysis approach can be used to understand the complex interactions of factors influencing sustainable access to improved water services in rural communities (Sambo, 2015). Literature indicates limited use of the approach in the water sector for the analysis of factors that influence sustainable access to improved water services in rural communities. Therefore, this presents an opportunity to further explore the use of the approach in combination with other approaches to derive a coherent understanding of the synergies and trade-off resulting from complex interactions of the different factors.

2.5 Sustainability of Improved Water Services

Sustainable access to improved water services is defined in this document as water services constituting safe, sufficient, affordable, reliable, and continuous supply of potable water provided by an IWS daily (Lestera and Rhiney, 2018). As mentioned in the previous sections, the SDG aims to ensure the sustainability of and build on the achievements of the MDG. This is because some regions achieved, and others did not achieve the MDG targets for water (WHO, 2015). The unlimited collective goal of the SDG is to permanently end poverty in all its forms and dimensions in the world. To attain this, it is critical to build in aspects of sustainability in interventions aimed at achieving the SDG targets and indicators used to measure and track progress on the attainment of SDG. Therefore, proper monitoring of the achievements of the SDG should go beyond 2030. This is to ensure that investments and efforts targeted to ensure the sustainability of the achievements beyond the SDG are allocated to problem areas that threaten to reverse the achievement of the SDG.

Universal access to safe and affordable water sources is recognized as one of the core goals to achieve in order to end poverty. However, the indicator used to measure the goal does not include basic aspects of sustainability built in it. This raises difficulties in defining and measuring such a complex and cross-cutting concept of sustainability (Lestera and Rhiney, 2018). From the SDG point of view, sustainability refers to ensuring continuous water services safely and affordably. However, these parameters are overlooked when reporting on universal access to improved water services. This is because it is assumed that IWS provided to a community today will continue to provide an ongoing improved water service over their useful life (Martinez-Santos, 2017). As a result, national governments count providing an IWS such as a hand pump installed on a borehole as part of the national statistics of access to improved water services. However, once established, the IWS are not maintained, nor are they revisited to check if they are still providing an ongoing improved water service (Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Fan *et al.*, 2013; Sambo, 2015). In reality, IWS fail due to a variety of factors that influence their sustainability resulting in patchy access to water in rural communities (Graciana and Nkambule, 2012; Sambo, 2015).

The application of indicators that can be used to regularly measure temporal changes in sustainability aspects that influence access to improved water services will ensure that the reported figures reflect the reality on the ground. The sustainability aspects can be measured at different times over the useful life of the IWS to ensure the development and management of improved water services are informed by recent, accurate, and reliable data. As a result, resources meant for the development of IWS will not be reallocated elsewhere, resulting in patchy access to water in rural communities where access is reported based on the IWS provided and not on the quality of improved water services provided. This will result in sustainable access to improved water services over the useful life of IWS.

2.6 Discussion

Sustainable access to improved water services provided by IWS is essential to sustain livelihoods and human life. Rural communities use water supplied by improved water services for activities that generate economic benefits as well as those that contribute to their food security. Therefore, sustained access to improved water services can contribute to enhanced rural livelihoods. However, rural communities are deprived of these benefits as the literature suggests that more than 30% of IWS are non-functional. In response to this, the Sustainable Development Goals (SDG) aim to attain universal access to improved water services. This is in light of the fact that post-Millennium Development Goals (MDG) some regions did not achieve their national targets with regards to halving the proportion of the population without access to safe and affordable improved water sources. However, at a global scale, the MDG target to have the proportion of the population without access to improved water services was reported to have been achieved. Despite this, it is estimated that eight out of ten dwellers are without access to improved water services. It is for the reason that the SDG aims to build on the achievement of the MDG and accelerate efforts in the attainment of universal access to improved water services with a focus on sustainability. To attain this, the approach to provide more IWS has been adopted, neglecting their monitoring and maintenance over their useful life. This has a negative impact on water access and distorts the reality on the ground.

The indicator and methods and techniques used at the global and national levels to monitor progress in the attainment of SDG are to blame for the current situation with regards to sustainable access to improved water services in rural communities. The global indicator uses a “people-reached approach” where it tracks the number of IWS provided to a proportion of the population. It does not measure and track sustainable access to improved water services over their useful life once constructed or installed in the rural communities. It assumes that all the necessary requirements are met to ensure that IWS provides ongoing improved water service. However, it is common knowledge that IWS fails over time resulting in limited or no access to water. Literature indicates that collecting data that include aspects of sustainability is expensive and labour-intensive due to the methods and techniques used. However, to ensure sustainable access to improved water services provided by IWS, the indicator should go beyond “people-reached approach” to also measure and track temporal changes of sustainability aspects of physical access, reliability, affordability, water quantity, and quality over the useful life of IWS. Using such indicators will ensure sustained access to improved water services. The indicators should be simple and cost-effective but adequately measure and track key aspects that influence the sustainability access to improved water services. Simple in terms of not being data and labour intensive, and not leave anything to assumption, and cost-effective in terms of resources required to collect data to inform the indicators. The integration of such aspects will only be an initial step in the development and implementation of policies and strategies informed by empirical evidence resulting in proper channeling of investment aimed at increasing water access in rural communities.

To attain the above mentioned, a variety of methods have been employed by researchers to measure one or more aspect(s) of sustainable access to improved water services. Most of the researchers focused on physical accessibility (distance) and some on water quantity and water quality as a measure of improved water services. However, the methods employed by the studies can be modified and integrated to develop indicators that include key aspects of sustainable access to improved water services. The Water Point Mapping (WPM) approach can be modified to measure and track aspects of sustainable access to improved water services. The approach integrated with other methods can be used to map aspects of access to improved water services based on indicators at different geographical scales. Just like the national census, the data required to inform the indicators can be collected on a routine basis. Some indicators will require sampling of a statistically representative population of IWS in a certain geographical area as it may be expensive and labour-intensive to cover all the IWS. However, the quantitative information computed will only give a picture of the reality on the ground. This should be supported by qualitative data, which explains why the situation is as it is. This can be achieved by understanding the factors that affect access to IWS in rural communities.

Understanding of factors that influence sustainable access to improved water services is essential to design relevant policies and water management strategies to address challenges influencing water access. The factors can be categorized under technical, social, institutional, economic, and environmental factors. These factors are interconnected and interact, making them complex in nature. The factors are connected by a cause-effect relationship, which makes them difficult to understand, especially when they are a multitude of factors to consider within a given system. However, little research on the complex interactions of the factors has been conducted. It is, therefore, necessary to employ methods that can capture the complex interactions of the factors to have coherent understanding factors that influence sustainable access to improved water services. Therefore, a complex system approach can be employed to capture the complex nature of the factors for a detailed and systematic analysis. The use of the approach in the water sector is still in its infant stage. This presents an opportunity to use the approach in a more advanced manner to understand the synergies and trade-off that exist to ensure sustainable access to improved water services in rural communities.

2.7 Conclusion

In conclusion, universal and sustainable access to improved water services is key to sustaining human life. However, focusing on providing more IWS and neglecting their maintenance over their useful life is not a sustainable approach in ensuring ongoing improved water services in rural communities. To address this, at the global and national levels, indicators used to measure and track access to improved water services should include sustainability aspects of physical accessibility, reliability, water quality, water quantity, and affordability of water services provided to reflect the reality on the ground. This complemented by a coherent understanding of the factors influencing sustainable access to improved water services is key to the design of relevant water management policies and strategies to ensure sustained access to improved water services in rural communities.

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3. BENCHMARKING OF HOUSEHOLD PERCEPTIONS - FREE BASIC WATER SERVICES POLICY AND WATER SERVICE PROVISION

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Abstract

Sustainable access to improved water services is a fundamental human right that is directly linked to the right to a good quality of life and health. Therefore, understanding household perceptions of policy instruments employed to guide the planning and management of water services provision and improved water services provided in rural communities can contribute to household satisfaction. However, literature indicates that rural communities have patchy access to improved water services as a result of a number of challenges. The patchy access to improved water services is worsened by that rural communities are not always afforded the opportunity to rate their experience of the improved water services provided as a form of feedback mechanism to highlight areas of improvements. It is for the reasons mentioned above that this study benchmarked households' perceptions of the South African Free Basic Water Services (FBWS) policy and improved water services provided in Makhudutamaga Local Municipality (MLM) in Limpopo Province, South Africa. A survey questionnaire was administrated to collect demographics information and perceptions of households regarding the FBWS policy standards and improved water services provided based on distance, quantity, reliability, flow rate, water quality, and cost. The approach was complemented by the use of transect walks to collect supporting information to enhance the understanding of the local context. The results showed that the majority (71.5%) of the households were not aware of the existence of policy instruments employed to guide water services provision.

However, more than 69.7% of households were 'satisfied' with FBWS standards. When using the standards to benchmark water services, households were satisfied with distance (62.0%), quantity (61.2%), flow rate (52.7%), and water quality (54.8%), but unsatisfied with the reliability (56.3%) and cost of buying water (58.0%). This study concludes that proper implementation of FBWS policy and addressing the issues of the unreliability can improve household satisfaction and sustainable access to improved water services provided. It is recommended that the FBWS policy should be properly implemented to attain the human right to sufficient water for all.

Keywords: basic water services, improved water sources, benchmarking water services

3.1 Introduction

Water is a scarce natural resource that is fundamental to social welfare and sustainable development. The importance of water to social welfare is embodied in international law, as explained by Kuokkanen (2017) and declarations by WHO/UNICEF (2019) as well as constitutions of democratic countries, *e.g.* South Africa, which state that access to sufficient water by all is a fundamental human right. The human right on access to water links to a host of other rights, including the right to life, education, health, and sanitation. In support of this, the Sustainable Development Goals (SDGs) agenda coordinates stakeholders' efforts at global, regional, and national levels towards ensuring the attainment of the human right to access to water for all (WHO, 2015). Target 6.1 of the SDGs aims to achieve universal and equitable access to safely managed and affordable drinking water for all by 2030 (WHO/UNICEF, 2018). Improved Water Sources (IWS) are provided in rural areas to attain the SDGs target. IWS refers to water sources that are safely managed and provide affordable drinking water services (WHO, 2015), which includes piped water in dwelling, communal standpipes, boreholes, and protected dug wells and springs (WHO/UNICEF, 2018). IWS is perceived to provide an improved water services that supply affordable and sufficient quantity of safe water suitable for human consumption.

Substantial progress has been made towards attaining universal and equitable access to IWS that provides improved water services (WHO/UNICEF, 2019). However, there is still a substantial proportion of the population living in the rural areas of developing countries without sustainable access to improved water sources (WHO, 2017). When taking into consideration the level of improved water services provided, researchers argue that the reported statistics of IWS coverage are slightly lower than what is reported (Lestera and Rhiney, 2018). The figures tracks the number of IWS provided or claimed to be used by a percentage of the population. It does not go beyond tracking the level of improved water service provided by the IWS over their useful life. The ‘simple’ manner in tracking IWS coverage is strategic, as it was decided on so that all countries can agree on the indicator that monitors the attainment of universal access to improved water services. The operation and maintenance (O&M) aspect of the improved water services, which contributes to sustainable water services, is neglected (Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Shaheed *et al.*, 2014; Sambo, 2015; Martinez-Santos, 2017; Sambo *et al.*, 2018). As a result, over time, the level of improved water service deteriorates (Rietveld *et al.*, 2008; Sambo, 2015). The deterioration of level of improved water services is not monitored at all because the indicator(s) used do not account for it.

In developing countries, including South Africa, the approach used to track progress in universal attainment of improved water services poses serious problems, as mentioned above. These problems culminate from the fact that a significant proportion of the households in rural communities are experiencing low-quality water services provided through IWS (Rietveld *et al.*, 2008; Boshoff, 2009; Majuru *et al.*, 2012; Sambo, 2015; Sambo *et al.*, 2018). The deterioration in improved water services can be as a result of (i) change in the quality of water due to chemical contamination, (ii) water pipe burst causing supply interruption, or (iii) distance from a water source can result in the collection of low volumes of water which does not meet household water needs (Fan *et al.*, 2013; Liu *et al.*, 2013; Martinez-Santos, 2017). These should be considered when monitoring access to improved water services and not just assume that since rural communities report to be using IWS, they are experiencing the intended benefits.

Water Service Providers (WSP) are responsible for water services provision in rural communities in South Africa. A WSP is typically contracted by the Water Service Authority (WSA) through a Service Level Agreement (SLA). The SLA outlines the roles and responsibilities of the WSP, including the level of improved water services expected to be provided to the households according to the relevant policy instruments that guide water service provision. Since access to sufficient water for all is a human right in South Africa -

the Free Basic Water Service (FBWS) policy guides WSA and WSP regarding the level of improved water services all citizens should receive for free (DWAF, 2002). As a result, small community water systems (*e.g.* standpipes connected in the dwelling or communal standpipes) are used to supply water in rural communities of South Africa, according to FBWS policy (Majuru *et al.*, 2012; SDM, 2019). A majority of the rural communities water systems were upgraded from rudimentary systems (*e.g.* boreholes equipped with hand pumps located between 500 meters from households and supply 5 to 15 liters per capita per day) to IWS (Majuru *et al.*, 2012; SDM, 2019) that provide improved water services. The FBWS policy stipulates that the improved water services should comply with the following standards; (i) *distance:* within a maximum distance of 200 meters from the household, (ii) *quantity:* supply not less than 25 liters of water per capita per day, (iii) *reliability:* should at least have a downtime of not more than two days in a month, (iv) *flow rate:* with a minimum discharge rate of 10 liters per minute, (v) *water quality:* suitable for human consumption, and (vi) *cost:* water is for free (DWAF, 2002). For standpipes connected in dwelling, 6000 liters/household/month of water should be provided to each household for free (DWAF, 2002).

However, a study conducted by the World Bank found that in many instances, a SLA does not exist between WSA and WSP in South Africa. Where they were found to exist, they were ignored, and as a result, were not used to hold the WSP accountable for providing water at certain service levels (World-Bank, 2011). Despite whatever level of water service provided, the rural communities do not have means of rating the water service (Sambo, 2015). This, as a result, has compelled communities dissatisfied with water services provided to engage in protest action (Muller, 2008), which sometimes turns violent, involving destruction of critical infrastructure and loss of life (Alexander, 2010; Netswera, 2014). This happens despite communities having IWS assumed to be providing improved water services according to FBWS standards and above. This, therefore, raises a need for the relevant authorities responsible for water provision in rural communities to allow the communities to rate the quality of water service provided so that they can identify areas of weakness and improvement. This, as a result, will inform the development and management of IWS contributing to sustainable water services. FBWS standards can be used as a tool to rate households' perceptions of the improved water services.

According to common knowledge, there is limited, if at all, literature on household perceptions regarding improved water service provided by IWS in South Africa. Most of the studies focused on technical aspects of reliability, accessibility (distance to a water source), and water quality provided by IWS (Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Sambo, 2015), neglecting the social aspects of how the communities perceive the level of improved water services. Understanding the perceptions of communities is crucial as it helps to improve the users' experience and water service as demands and needs change over time. This is because users' experience of the same service is not always the same since it is determined by a number of complex factors (Yang, 2010). The technical aspects of the service might comply with all the standards on paper, but users may not be satisfied with the service due to what they experience while using the service. Due to the nature of their business, the practice of understanding user satisfaction is common in the private sector as businesses are continuously looking for innovative ways to satisfy their customers. Yang (2010) states that understanding user perceptions with a service provided is not only to learn the actual satisfaction levels, it also aids in the identification of areas of strengths and weaknesses to implement corrective measures. Although necessary, WSA and WSP do not seek to understand communities' perceptions of the water service provided (Sambo *et al.*, 2018). The reliance on the so-called 'hard indicators' by government and municipality that measures the quality of water service provided does not reflect the users' perception of the service (Bouckaert and Van de Valle, 2003). This is because it measures, for example, resources used and outputs. In the context of water services, the output would refer to the IWS provided, which is what is used to measure access to IWS, and not the beneficiaries perceptions of the service.

This study sought to close the gap in understanding the perceptions of rural households regarding their satisfaction with the level of improved water services provided in the study area. The study's objective was two-fold; first, it sought to understand rural households' perceptions with regard to the FBWS policy and what standards they would like amended in the policy based on current water demands and needs, then secondly, their perceptions with regards to improved water services were benchmarked using the FBWS standards. The findings of this study are expected to contribute to informing decision-makers about aspects of water services provision that need improvement as well as identification of households that are unsatisfied with aspects of the improved water services provided. Furthermore, the results are expected to inform the planning and management of IWS to ensure sustainable access to improved water services in rural communities.

3.2 Material and Methods

This section presents a description of the study area. It also describes the statistical sampling approach employed to determine sample size as well as the research approach employed to achieve the objectives of the research.

3.2.1 Study Area

The study was conducted from November 2019 to February 2020 in Makhudutamaga Local Municipality (MLM) in Limpopo Province, South Africa. MLM is one of the four local municipalities under the jurisdiction of the Sekhukhune District Municipality (SDM). The SDM is both a WSA and WSP responsible for water services provision in the four local municipalities. The water service provision is centralized, meaning that the local municipalities do not carry the responsibility to provide its inhabitants with water services. The role of the local municipalities is that of identifying water needs of its inhabitants through political engagements with the purpose of providing the information to the SDM to provide water services according to its mandate in line with the South African constitution, Water Services Act (1997) and FBWS policy.

Geographically, the SDM is located in a part of South Africa considered to be water-scarce; as a result, it is facing significant challenges in providing water to its inhabitants, especially during prolonged periods of low rainfall (SDM, 2019). To fulfill its mandate to provide water, the SDM is divided into different water schemes with sub-schemes. The main water schemes are namely; De Hoop (DH), Flag Boshielo (FB), Piet Gouws (PG), and Local Resources (LR) (will be referred to as water schemes) (see Figure 1). The 3 water schemes (DH, FB and PG) refer to major dams used to supply water to the communities, with LR referring to communities using boreholes solely as a water source. However, groundwater (boreholes) remains a major alternative water source used in MLM to provide water services, even in the 3 water schemes (Sambo, 2015; SDM, 2019). The use of boreholes is to comply with FBWS policy. A majority of the boreholes were upgraded from rudimentary systems and equipped with electric pumps which pump water from a cluster of boreholes to a small reservoir to supply water to communal standpipes or standpipes connected in dwellings (Momba *et al.*, 2008; Majuru *et al.*, 2012; SDM, 2019).

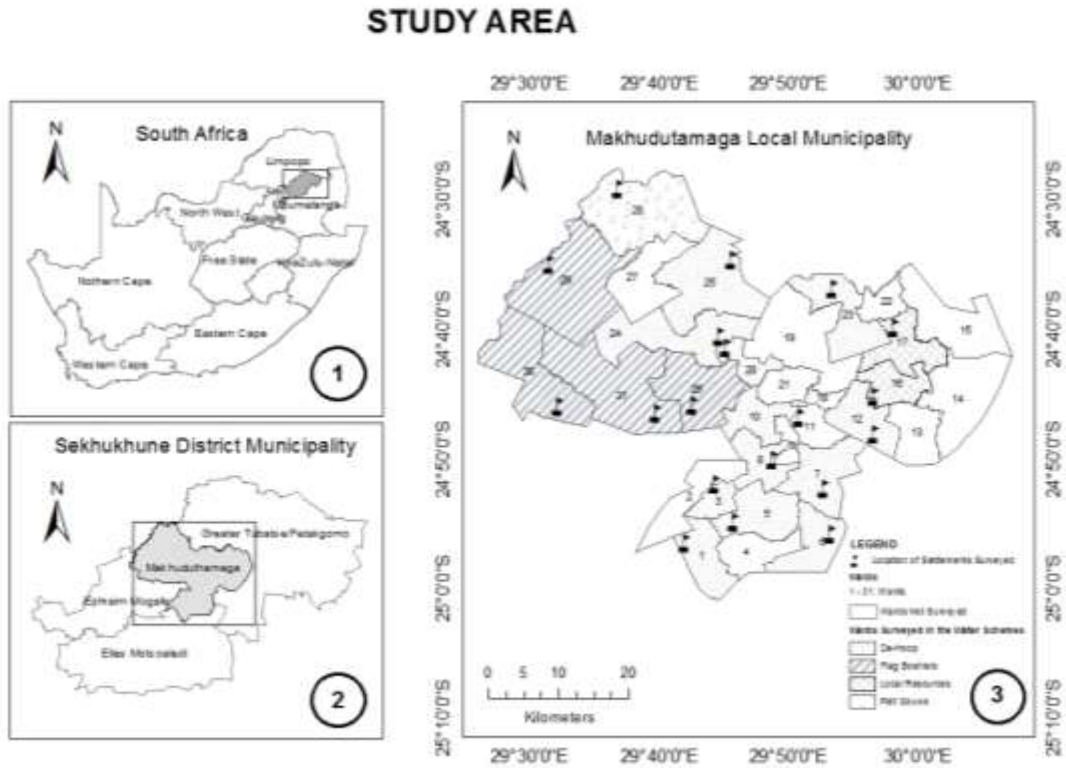

Figure 3.1 Study area of Makhudutamaga Local Municipality and the related water schemes

MLM has 64 769 households with a population of 342 892 (SDM, 2019). Compared to other municipalities in the SDM, MLM has the youngest population, with 51% of the population under the age of 18 (SDM, 2019). The majority of the population is unemployed or not economically active, with an average annual household income of R38 109 compared to R45 977 for SDM (SDM, 2019). The majority of the households use communal standpipes or standpipes connected in dwellings to supply water. According to an IDP report, MLM is experiencing a water backlog of 64% (SDM, 2019). The figure is based on water infrastructure that needs maintenance and communities that are yet to be provided with improved water services. The figure could be higher as the WSP does not have a proper monitoring strategy to understand the status of the remaining 36% altogether. This is a major concern because, despite the backlog, there is a push to provide more IWS while neglecting maintenance. It is because of the above that MLM was chosen as the study area because it has similarities with other rural municipalities in South Africa. Therefore, some of the findings of this study could be related to other rural municipalities in South Africa.

3.2.2 Research Methodology

A mixed method approach combined with Water Point Mapping (WPM) approach (explained in detail in section 2.2.2) was employed to attain the objective of this study. The approaches employed allowed for the collection of data from a statistical representative sample for analysis. Upon analysis, the findings can be generalized to the entire population (Ghauri and Grønhaug, 2005; Malebana and Swanepoel, 2015), using a map (WPM approach). A survey questionnaire as a quantitative research approach was designed and administrated to collect data on the perceptions of households regarding FBWS standards and water services provided. Complementary to the survey questionnaires, transect walks (combined with interviews) as a qualitative research approach were conducted for the researcher to understand the local context. The sampling method and research approach employed in this study are elaborated in the sections below sections.

3.2.3 Statistical sampling of settlements and households

Stratified random sampling was employed for sampling purposes. Stratified random sampling is a statistical sampling approach used when a population is divided into strata (Stehman, 1996; Kadilar and Cingi, 2003). Sample items in each stratum are selected using random sampling. Random sampling involves a process of selecting items to satisfy a computed sample size from a population using a statistical equation (Stehman, 1996; Kadilar and Cingi, 2003). According to Dunn and Clark (2009) a random sample must satisfy two criteria; (i) items in the sample should have an equal probability of being selected, and (ii) the items should be selected independently without the selection of one item affecting selection of the other.

A hierarchy approach was employed to define the different levels of population sampling in order to conduct stratified random sampling (*cf.* Figure 3.2). In the context of this research, a population refers to a group from which a sample representative of certain defined characteristics of the group is extracted for research purposes (Dunn and Clark, 2009). If the population is not correctly defined, it will result in the determination of an incorrect sample, which will result in the research being invalid (Dunn and Clark, 2009). The population was defined as all settlements (1st level), and households (2nd level of sampling) that have access to improved water services in the water schemes that cut across MLM. Information regarding which settlements and households have access to IWS was not available, even from the WSA and WSP. As a result, the population, in this case, was taken as all the settlements (156) and households (64769) in MLM. The decision to define the population as all the settlements and households was validated by the observations made during reconnaissance survey of the study area. It was observed that a majority of the settlements and households were using standpipes connected in the dwelling and communal standpipes. In the context of this study, a settlement refers to a place where you find people have established a community. A household refers to a house in a settlement where you find people living together.

Raosoft® (Raosoft, 2019), a web-based sample size calculator that uses statistical equations to calculate a sample size representative of a population-based on the specific parameters, was used to compute the sample size of households and settlements. The parameters used to calculate the sample size of settlements are; population (156), confidence interval (95%), and margin of error (5%). A sample size of 39 settlements was computed. Parameters inputted to calculate the sample size of households are; population (64769), confidence interval (95%), and margin of error (5%). A sample size of 382 households was computed.

A random selection of settlements was conducted to comply with the stratified random sampling approach. Microsoft (MS) Excel® was employed to conduct a random sampling of the settlements. In MS Excel®, all the settlements were listed and were allocated a random number. The allocated random number changed randomly every time a settlement was allocated a random number until the allocation was completed. The allocated random numbers were sorted in ascending order, to randomize the selection of settlements. Once randomized, settlements were selected from top to bottom until the required number of sample size was reached. For households, purposeful sampling was used for selection of households during the administration of the survey questionnaire in the study area. The reason for using purposeful sampling was because of the availability and willingness of the households to participate in the survey (Palinkas *et al.*, 2015). As a result, households were selected until the allocated sample size of each settlement was reached according to proportional allocation.

Proportional allocation is a process, technique, or strategy of allocating a portion of the sample to each stratum in strata (*cf.* Figure 3.2 and Table 4.1). In this case, stratum refers to water schemes. The proportion of settlements in each stratum was determined to be 62%, 24%, 8% and 6% for DH, FB, LR, and PG, respectively.

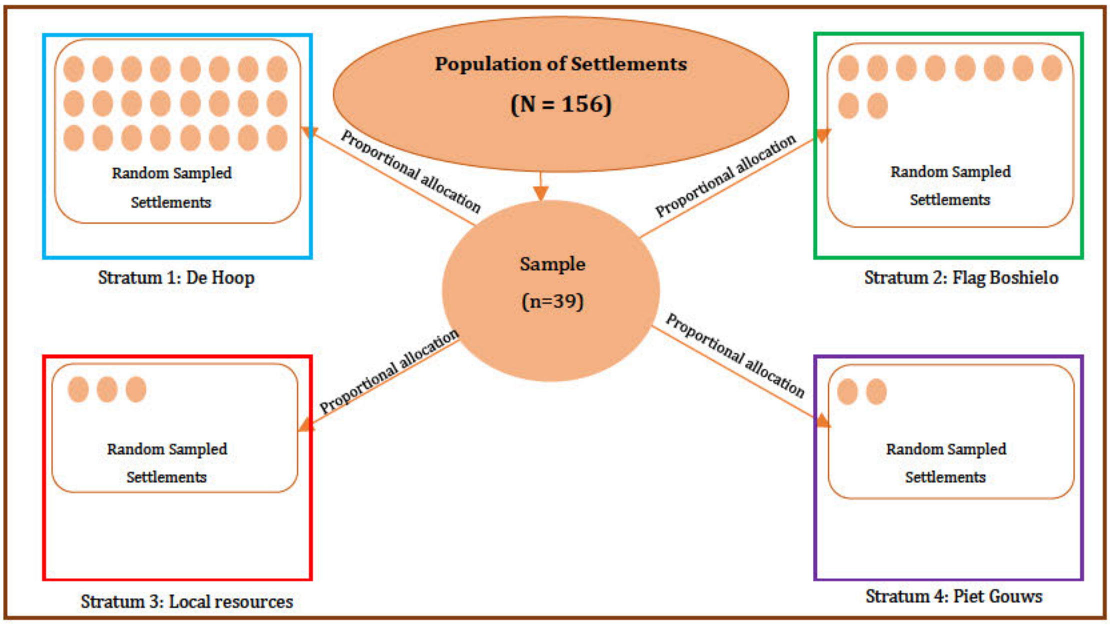

Figure 3.2 Illustration of stratified random sampling for settlements used by the research

3.2.4 Survey questionnaire

A survey questionnaire is used where a researcher is interested in a particular subject matter to collect information in order to describe, compare, or explain individual and societal knowledge, feelings, values, preference and behaviour (Hussey and Hussey, 1997; Fink, 2009). Fink (2009) states that survey questionnaires are best used to evaluate policies and programmes as well as conducting research. This is provided that the information is collected directly from people, and information provided is descriptive of their feelings and perceptions, values and habits (Fink, 2009). Information on demographic characteristics (gender, age, education, etc.) as well can be collected during the administration of the survey questionnaire (Fink, 2009). However, the administration of the survey questionnaire should not be conducted in such a manner that is threatening to the respondents (Hussey and Hussey, 1997). The benefit of using surveys is that it allows for many people to be surveyed, and detailed information can be collected. However, surveys do not always capture the full story (Fink, 2009). Therefore, surveys should be combined with other methods such as observations or transect walks to capture the full story of the research subject matter (Hussey and Hussey, 1997). Taking this into account, it was decided that survey questionnaires will be administrated to collect data regarding perception of household with FBWS standards and water services provided in MLM.

A survey questionnaire was designed to collect information regarding perceptions of households with the FBWS standards and water services provided in the study area. The research adopted a modified 8 step-by-step process outlined by Cant *et al.* (2005) and Fink (2009) as a guide to design the survey questionnaire used to collect quantiatative data for the research (*cf.* Figure 3.3). The 8 steps followed by the research are discussed below.

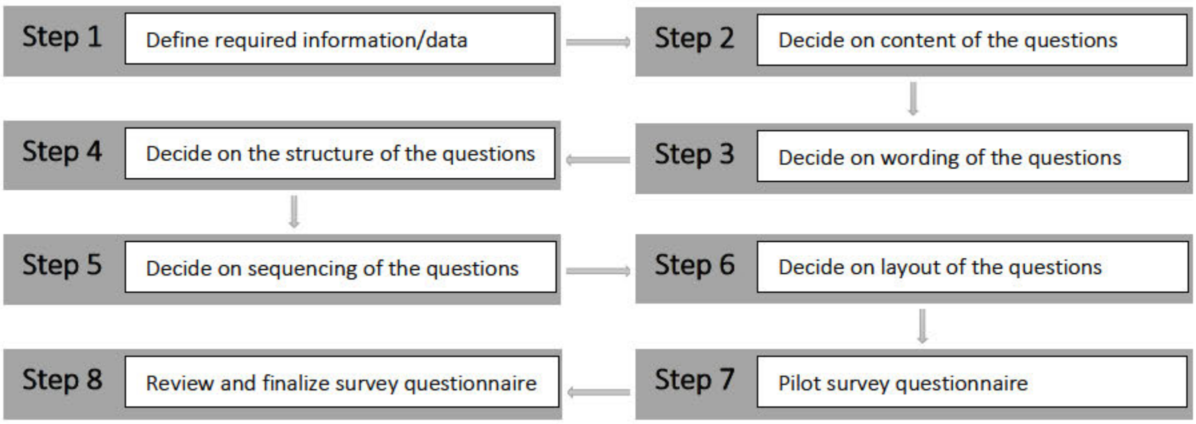

Figure 3.3 Step-by-step process of designing of survey questionnaire (Cant et al., 2005; Fink, 2009).

Step 1 - Required information/data: The survey questionnaire was designed to collect information regarding perceptions of households with FBWS standards and recommended amendments to the FBWS standards as well as satisfaction levels with water services provided.

Step 2 - Content of the questions: A consent form was designed with the aim to use it to seek consent in the form of a question from the prospective respondents prior to the administration of the survey questionnaire. This was followed by questions asking demographic information of the respondents. The demographic information included age, position in the household, household income, education and size of household. The demographics information was needed in order to understand the differences in perceptions according to demographic groups. Following this, questions seeking to understand if respondents were aware of policy instruments that are used to guide the development of water services were asked. The questions helped to get a feel of how much the respondents knew about water-related policy instruments in preparation for the next set of questions. The next set of questions collected information on perceptions of households regarding FBWS standards. These questions were followed by questions that collected information to do with the recommended amendment of FBWS standards. The aim was for the information to aid in improving the FBWS standards. The next set of questions collected information on household perceptions of the water service provided. The information was useful in understanding household perceptions with water services provided to identify weaknesses and opportunities for improvement. The last set of questions sought to understand the safety of water users when walking to collect water and while collecting water. This was to bring about an understanding with regards to the safety of community members when waking to collect water and while collecting water, especially when IWS is located far from their households.

Step 3 – Structure of questions: Close-ended questions were used in order not to take up too much time from the respondents. The close-ended questions used required dichotomous (‘yes’ or ‘no’) and multiple (5 point-Likert scales ranging from “very satisfied” to “very unsatisfied”) responses. This was done to make the administration of the survey questionnaire much quicker due to the respondent having to choose from preselected responses, this is supported by Fink (2009). Questions that required multiple category dominated as they provided more detail than dichotomous responses, this is supported by Cant *et al.* (2005). The respondents ticked the box that represented their response. For those that could not read and write the researcher and enumerator tick the boxes representing their responses. Ticking boxes made responding to the questions or statements less confusing than circling their choice, this is supported by Hussey and Hussey (1997).

Step 4 – Wording of questions/statements: The questions and statements were phrased in such a way that they were not offensive to the respondents. They were made to be simple and specific.

The survey questionnaire was translated from English to the local language (Sepedi) to administrate to respondents that did not understand English. This was also done not to confuse the respondents by using a language they did not understand.

Step 5 – Sequencing of questions/statements: The sequencing of the questions was done in such a way that the respondent felt comfortable while participating in the survey. The consent form was first, then questions on demographics information of the respondent. The decision to start with questions on demographic information of the respondent was to encourage them to provide more information. This section was very short and did not require the respondents to think deep at the beginning of the survey. The placing of the demographics section at the start or end of the survey is something that researchers are yet to find common ground. Laxton (2004) recommends placing the demographics section at the start of the survey, while Cant *et al.* (2005) recommends placing the section at the end or later on during the survey.

The sections that followed focused on perceptions of respondents regarding FBWS standards, proposed amendments to FBWS standards as well as their perceptions regarding water services provided. The sequencing of this section was done to raise awareness of the respondents regarding the existence of the FBWS standards while recording their perceptions regarding the defining criteria of FBWS.

Step 6 – Layout of the questionnaires: The decision made was to make the survey questionnaire not more than three pages, including the consent form. However, despite the page limitations, the layout was in such a way that the relevant questions and statements were included to collect the required data.

Step 7 – Piloting of the questionnaires: The survey questionnaire developed was piloted in 20 households in the study area. Piloting was mandatory in checking whether respondents understood the contents of the survey questionnaire in the way in which the researcher intends it to be; supported by Cant et al. (2008). Furthermore, it helped the researcher to identify issues to do with layout, phrasing of questions and statements, and also to gauge the willingness of the responded to respond to certain questions or statements.

Step 8 – Review and finalize the survey questionnaire: Issues to do with the layout and phrasing of questions were identified during piloting. The identified issues were corrected, and the survey questionnaire was finalized (*cf*. Appendix C, Section A).

3.2.4.1 Administration of survey questionnaire

The researcher trained two enumerators from the MLM municipality to assist with the administration of the survey questionnaire. It was also a form of empowerment by the research as the enumerators gained knowledge and skills which they can use to access opportunities of similar nature. The use of locals as enumerators did not introduce biases in the data reflecting their interest. This was minimized by scanning through some of the completed surveys to check for any abnormalities in the data collected by the enumerator compared to the data collected by the research in the same area. The transect walks (to be explained in the next section) conducted in each settlement also helped to understand the data collected due to that they were informative.

The research did not secure an appointment with the households to conduct the research on a particular date and time of their convenience. This was due to the fact that it was not known beforehand which households would be part of the survey. If it was decided to secure an appointment with the households, it could have extended the time and increased the budget to complete the surveys. The selection of households did not follow any particular order, upon arrival in a certain community/settlement, households were purposefully selected. Where there was no one in the household or not willing to participate, the next household would be visited. On arrival, greetings would be exchanged, and the purpose of the visit was briefly explained, and representative of the household asked to participate in the survey. If there were more than one person in the household, they decided on who should represent the household. Once a representative of the household was identified, the consent form would be read to them, or they would read it. The research used two consent forms, one written in English and the other translated to Sepedi, which is the local language. Depending on language preference, either of the forms would be used. Once the consent form was read and understood, the respondent would be asked to print their name and append their signature giving permission for the survey questionnaire to be administrated. Respondents were asked to respond to questions in the survey questionnaire. At the end of the survey, the respondent was thanked for their participation. Of the survey questionnaires administrated, there wasn't any that was left incomplete. The data collected was captured and organized using MS Excel®. This is because it was easy to capture, organize and manipulate data in MS excel®. In addition to that, data can be easily exported from MS Excel® to different software packages (such as SPSS) for analysis due to that MS Excel® is compatible with many of them.

3.2.5 Transect walk

Transect walks were employed to enhance the understanding of the researcher with regards as to why the respondents responded in the manner they did. This was to address the limitations of the survey questionnaires as they do not tell the full story (Hussey and Hussey, 1997). The researcher asked a community member willing to assist in walking with them while asking questions related to water issues and making observations in the respective communities. This was informative due to that, in most cases, people were willing to provide information. In some cases, respondents of the survey questionnaires provided detailed information willingly regarding their water situation without them being asked.

3.2.6 Data analysis

Statistical Package for the Social Sciences (SPSS) (Version 25) (SPSS, 2017) was employed to conduct statistical analysis of the collected data. Descriptive statistics were employed to analyse data in terms of percentages using cross-tabulations and graphs. Inference statistics was employed to determine statistically significant difference across the different demographic groups and water schemes. In this regard, the Kruskal-Wallis H test ($\alpha = 0.05$; CI = 95%) was used to determine the difference across the groups (Field, 2009). However, the test only indicated that there was a difference across the groups but did not indicate the difference between groups. Mann-Whitney test ($\alpha = 0.05$; CI = 95%) was then employed to establish groups with statistically significant differences. The use of 'too much' Mann-

Whitney test on multiple groups inflated the Type I error rate. A Bonferroni correction was applied to ensure that the Type I error rate does not build up to 0.05. Maps were used to graphically represent the satisfaction ratings of households at municipality and water schemes levels. The maps were created using ArcGIS (Version 10.7) (ESRI, 2019), which is a Geographic Information Systems (GIS) computer software.

3.3 Results

3.3.1 Socio-demographic characteristics of the households

A total of 396 households responded to the survey questionnaire. Table 3.1 shows the demographic information collected during the administration of the survey and the results of the Kruskal-Willis H test. Respondents were mostly female (66.7%), and 45.7% of the respondents were in the '31- 40' age group, followed by the 51+ age group (22.5%). The respondents held positions of a child (48.0%) and head of the household (46.2%). More than half of the respondents obtained secondary education (56.6%), and 20.2% did not have formal education. Most of the respondents were unemployed (79.3%) with 14.4% and 6.3% self-employed and employed, respectively. Household monthly income was between ZAR 1501 – ZAR 3500 (31.3%), followed by 0 - ZAR 500 (24.0%) and ZAR 1001- ZAR 1500 (24.0%) income groups. The average household size was 5 people per household.

Table 3.1 shows the results of the Kruskal-Willis test. The test was employed for the satisfaction rating of FBWS standards and water services provided. It shows difference in satisfaction rating of FBWS standards and water services provided across the groups (e.g. gender, household position and educational level).

Table 3.2 shows summary results of the posthoc test conducted to identify statistically significate differences between the different socio-demographic groups based on satisfaction rating regarding water services provided. The results indicate that there was no statistically significant difference in the satisfaction rating of water services provided between female and male groups ($p > 0.05$). Higher age groups ('50+' and '41-50') were more satisfied with distance, reliability, flowrate, quality and cost compared to age groups below them ($p < 0.05$).

Table 3.1 Respondents demographic information and differences in satisfaction rating

Demographics/ Standards	% (*n*)	Satisfaction Rating	Distance (*P-value*)	Quantity (*P-value*)	Reliability (*P-value*)	Flow rate (*P-value*)	Quality (*P-value*)	Cost (*P-value*)
Gender		Free Basic Water Service standards	0.161***	0.659***	0.026**	0.072***	0.296***	0.258***
Male	33.3 (132)							
Female	66.7 (264)							
		Water services provided	0.446***	0.261***	0.505***	0.841***	0.496***	0.701***
Age		Free Basic Water Service standards	0.890***	0.915***	0.652***	0.485***	0.058***	0.578***
18-30	15.9 (63)							
31-40	45.7 (181)							
41-50	15.9 (63)	Water services provided	0.024**	0.090***	0.033**	0.002*	0.029*	0.021*
51+	22.5 (89)							
Education		Free Basic Water Service standards	0.019**	0.094***	0.330**	0.004*	0.000*	0.000*
Tertiary	11.4 (45)							
Secondary	56.6 (263)							
Primary	8.8 (35)	Water services provided	0.504***	0.154***	0.005*	0.088***	0.122**	0.037**
None	30.3 (80)							
Employment		Free Basic Water Service standards	0.225***	0.459***	0.431***	0.194***	0.273***	0.194***
Employed	6.3 (25)							
Self-Employed	14.4 (57)							
Unemployed	79.3 (314)	Free Water services provided	0.012*	0.207***	0.225***	0.277***	0.003*	0.004*
Position in Household		Free Basic Water Service standards	0.408***	0.937***	0.790***	0.680***	0.416***	0.164***
Head of Household	46.2 (183)							
Child	47.7 (189)							
House Helper	5.3 (21)	Water services provided	0.379**	0.537***	0.189***	0.831***	0.426***	0.046*
Other	0.8 (3)							
Monthly income		Free Basic Water Service standards	0.000*	0.174***	0.702***	0.000*	0.000*	0.005*
R0-500	24.0 (95)							
R501-1000	15.7 (62)							
R1001-1500	24.0 (95)	Water services provided	0.000*	0.290***	0.000*	0.180***	0.002*	0.106***
R1501-3500	31.3 (124)							
R3501+	5.1 (20)							
Size of Household		Free Basic Water Service standards	0.000*	0.419***	0.351***	0.001*	0.019*	0.043*
2	6.8 (27)							
3	8.6 (34)							
4	32.1 (127)	Water services provided	0.002*	0.439***	0.000*	0.008*	0.001*	0.328***
5	23.5 (93)							
6+	29.1 (115)							

* p < 0.01 | **P < 0.05 | ***p > 0.05| α = 0.5| Confidence Interval: 95%

Less-educated groups ('no education' and 'primary education') were more satisfied with reliability and cost compared to a higher level of education groups ($p < 0.05$). Employed groups were more satisfied with the reliability, quality and cost of water compared to 'self-employed' and 'unemployed' groups ($p < 0.05$). High household monthly income groups were more satisfied with reliability and distance compared to those with low household monthly income groups ($p < 0.05$). Surprisingly, low household monthly income groups were more satisfied with the quality of water compared to high household monthly income groups. Households with a small number of people were more satisfied with distance and flowrate of water services compared to households with a large number of people ($p < 0.05$).

Table 3.2 Summary of post-hoc test – water services provided

Demographics/ Standards	Distance	Quantity	Reliability	Flow rate	Quality	Cost
Gender	***	***	***	***	***	***
Age	'50+' > '41-50' *	***	'51+' > '41-50' *	'51+ > '18-30' * '51+' > '31-40' *	'41-50' > '18-30' **	'41-50' > '18-30' ** '50+' > '18-30' **
Education	***	***	'No education' > 'Secondary' *	***	***	'Primary' > 'Tertiary' *
Employment	'Employed' > 'Unemployed' **	***	***	***	'Employed' > 'Unemployed' *	'Employed' > 'Unemployed' *
Position in household	***	***	***	***	***	***
Monthly income	''501-1000' > '0-500' ** '1001-1500' >'0-500' ** '1501-3500' > '0-500' ** '3501+' > ''0-500' **	***	'501-1000' > '0-500' ** '1001-1500' > '0-500' * '1501-3500'> '0 - 500' * -'3501+' > '0-500' * -'1501-3500' > '501 - 1000' ** '1501-3500+' > '1001 - 1500' **	***	'0-500' > '1501-3500' *	***
Size of Household	***	***	'3' > '6+' * '5' > '6+' *	'3' > '5' * '3' > '6+' *	'3' > '5' * '6+' > '5' *	***

* $p < 0.01$ | **$P < 0.05$ | ***$p > 0.05$
> more satisfied

Table 3.3 shows the summary results of Jonckheere's test conducted to determine if there was an ordered pattern of the medians of the different socio-demographic groups. The test was conducted to support the results shown in Table 3.2, as they indicated a meaningful order in satisfaction rating within the different socio-demographic groups. The results indicated a significant trend in the satisfaction rating of some of the FBWS standards in the different demographic groups. With an increase in age groups, there was an increase in satisfaction regarding flow rate, quality and cost. An increase in education levels indicated a decrease in satisfaction regarding distance, quality and cost. When the position of the respondents went higher there was an increases in satisfaction with cost of buying water. Satisfaction increased with an increase in monthly household income regarding distances, reliability and flow rate. However, for quality, when monthly household income increased, there was a decrease in satisfaction. When the size of the households increased, satisfaction decreased with regard to distance and reliability. It is worth noting that the effect size was mostly small, with the effect size of monthly household income with reliability being medium.

Table 3.3 Summary results of Jonckheere's test – Water Services Provided

Demographics/Standards	Distance	Quantity	Reliability	Flow rate	Quality	Cost
Age	-1.939*** *(r = -0.10)*	-1.434*** *(r = -0.07)*	-1.868*** *(r = -0.09)*	-3.618* *(r = -0.18)*	-2.612* *(r = -0.13)*	-2.594* *(r = -0.13)*
Education	-1.140*** *(r = -0.06)*	0.738*** *(r = 0.04)*	-2.280** *(r = -0.11)*	-0.741*** *(r = -0.04)*	-0.350*** *(r = -0.02)*	-1.099*** *(r = -0.06)*
Employment	2.733* *(r = 0.14)*	1.334*** *(r = 0.07)*	1.684*** *(r = 0.08)*	0.984*** *(r = 0.05)*	2.862* *(r = 0.14)*	2.809* *(r = 0.14)*
Position in Household	-0.188*** *(r = -0.01)*	-1.278*** *(r = -0.06)*	-1.288*** *(r = -0.06)*	0.940*** *(r = 0.05)*	1.436*** *(r = 0.07)*	2.561* *(r = 0.13)*
Monthly income	-5.230* *(r = -0.26)*	-1.566*** *(r = -0.08)*	-8.024* *(r = -0.40)*	-1.969** *(r = -0.10)*	3.230* *(r = 0.16)*	1.563*** *(r = -0.08)*
Size of Household	4.584* *(r = 0.23)*	1.542*** *(r = 0.08)*	4.733* *(r = 0.24)*	1.490*** *(r = 0.07)*	-0.494*** *(r = -0.02)*	0.563*** *(r = 0.03)*

* $p < 0.01$ | **$P < 0.05$ | ***$p > 0.05$
Effect size: r = 0 10 (small); r = 0 30 (medium); r = 0 50 (large)

3.3.2 Awareness of key water service provision policies

Figure 3.4 shows the respondents' awareness with policy instruments used to guide the development of water services in South Africa. A majority of the respondents (88%) are not aware of the existence of the Water Service Act (1997), with more than half of the respondents (54%) not aware of the existence of the FBWS policy.

Are you aware of the existence of the Water Service Act of 1997?	Are you aware of the existence of the Basic Water Services (FBWS) policy?

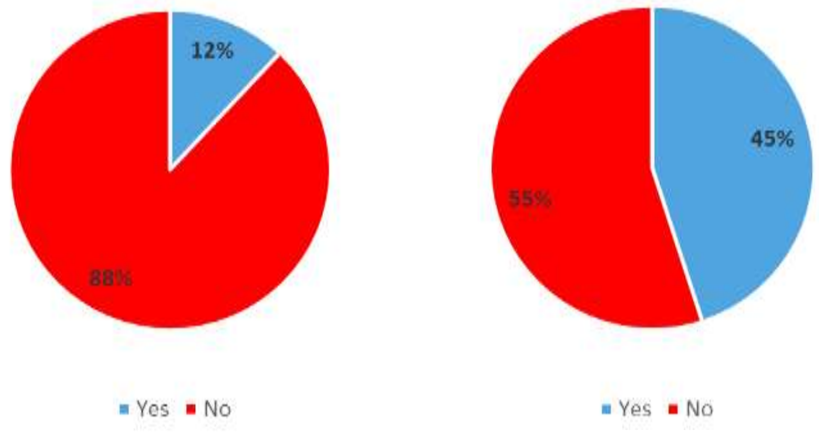

Figure 3.4 Households awareness with water policy instruments

3.3.3 Satisfaction rating of basic water services standards

Figure 3.5 shows the difference in median satisfaction rating of FBWS standards across the water schemes. In all the water schemes, the households were satisfied with the FBWS standards. Overall, the households were satisfied with the FBWS standards of distance (78.7%), quality (69.7%), reliability (77.5%), flow rate (95.0%), water quality (94.9%) and cost (94.5%). This is an indication that proper implementation of the FBWS policy can result high household satisfaction with the improved water services provided

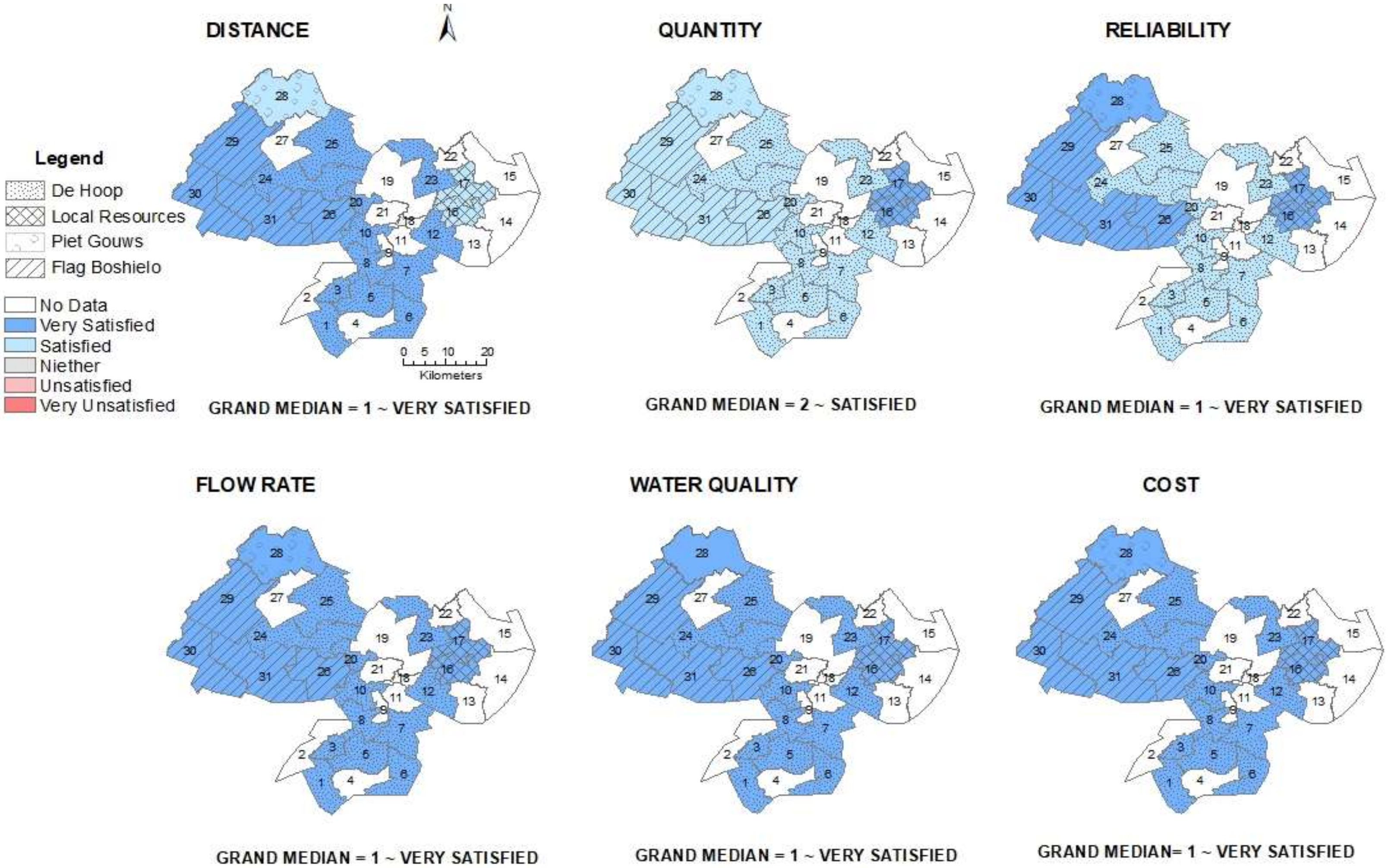

Figure 3.5 Households' satisfaction rating of Free Basic Water Services (FBWS) policy in each water schemes in Makhudutamaga Municipality

3.3.4 Satisfaction rating of water services provided

Figure 3.6 shows the percentage of satisfaction ratings with regards to water services provided. A majority (62.0%) of the households reported that they were satisfied with the return distance they walk from their households to an IWS to collect water. Most (61.6%) of the households reported that they were satisfied with the quantity of water they collect per day from the IWS. More than half (56.3%) of the households reported that they are not satisfied with the reliability of IWS. Most (52.7%) of the households were satisfied with the flow rate of water discharged from the IWS. With regards to the water quality, more than half of the households (45.2%) reported being unsatisfied with the water quality discharged from the IWS. The households (58.8%) reported that they were unsatisfied with payment for water. The payment of water was attributed to the cost of water when the government provided IWS were not operational.

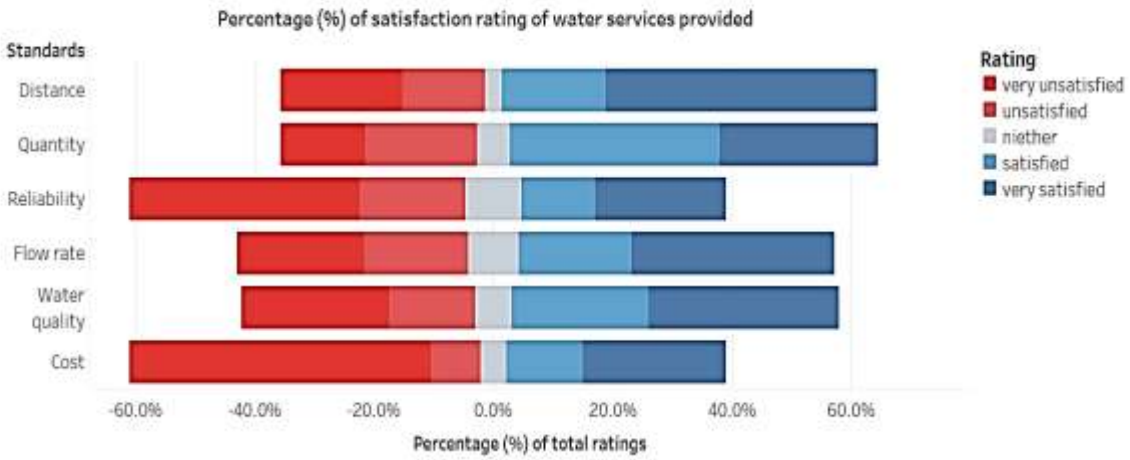

Figure 3.6 Satisfaction rating of water services provided in Makhudutamaga municipality

The results indicate that there was no statistically significant difference across the water schemes for reliability and flow rate. However, there was a statistical significant difference for distance, quantity, and water quality. Figure 3.7 show the medians difference of the water schemes computed. In PG, the households are not satisfied with the quality of water and distance. This is because the water discharged is salty which compels households to travel long distances to access water from other IWS. Unreliability of water services is a common challenge in all the water schemers. In LR, households are satisfied with the cost of buying water. This maybe because they have been buying water for a long time

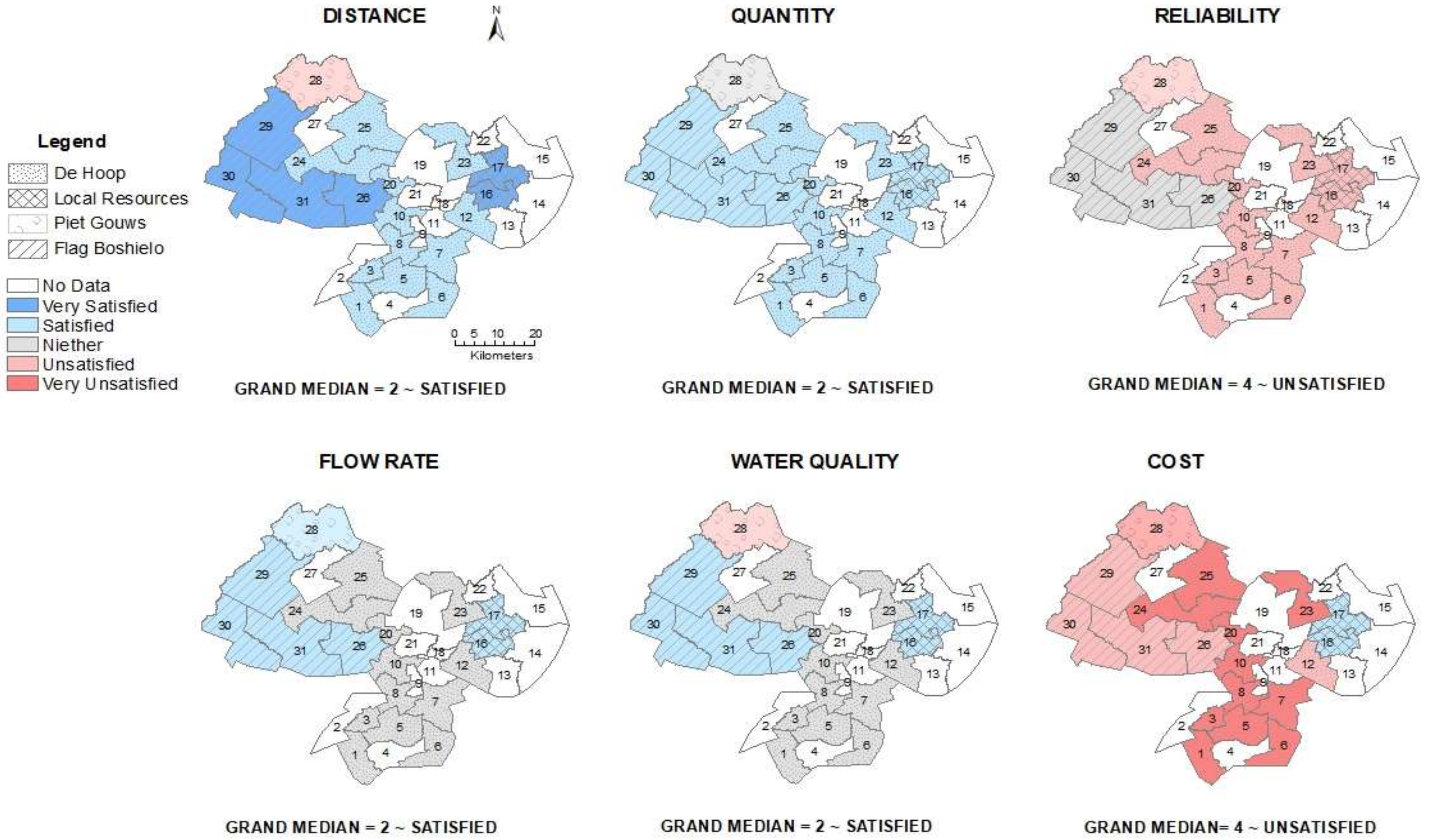

Figure 3.7 Households' satisfaction rating of water services provided in each water schemes in Makhudutamaga Municipality

3.3.5 Correlation of household satisfaction rating of water services provided

Table 3.4 shows the correlation of FBWS standards computed using Spearman's rho. The results indicate a medium to a strong correlation between FBWS standards based on household satisfaction ratings ($p < 0.01$). This was conducted to understand if the level of satisfaction of one FBWS standard had an influence on the level of satisfaction of the other standards.

Table 3.4 Correlation matrix of FBWS standards based on satisfaction ratings

Standards	Distance	Quantity	Reliability	Flow rate	Quality	Cost
Distance	1	0.542**	0.462**	0.310**	0.266**	0.225**
Quantity		1	0.439**	0.444**	0.448**	0.357**
Reliability			1	0.428**	0.162**	0.146**
Flow rate				1	0.527**	0.339**
Quality					1	0.632**
Cost						1

** p < 0.01 | **P < 0.05 | ***p > 0.05*
r = 0 10 (small correlation); r = 0 30 (medium correlation); r = 0 50 (large correlation)

3.3.6 Proposed changes to Basic Water Services standards

Appendix E, Figures 12.1, 12.2 and 12.3 show proposed changes to only three FBWS standards (distance, quantity and reliability). No changes were proposed for flow rate, water quality and cost. The respondents (33.6%) recommended a return distance of 100 meters from the household to the IWS instead of 200 meters. With regards to the quantity of water per day per capita, the respondents (32.3%) recommended 50 liters (i.e., 2 by 25 litres bottles) per capita per day instead of 25 litres per capita per day. In terms of reliability, respondents (30.3%) recommend that IWS should be operational every day of the year instead of being operational 98% of the time throughout the year. This can be challenged in line with the constitutional human right to water for all. However, if the recommendation was to be effected, it would put serious pressure on the WSP as already there are indications that there is a challenge with reliability.

3.3.7 Safety

Figure 3.8 shows the responses of the respondents with regards to safety when walking to and collecting water at any water point. More than half of the respondents (53%) did not feel safe when walking to a water point from their homes. Similar results were observed when it comes to when they are collecting water from a water point. Appendix E, Table 12.1 and Table 12.2 shows the reasons provided for feeling safe and not safe.

Do you feel safe walking from your home to the water point?	Do you feel safe when collecting water from the water point?

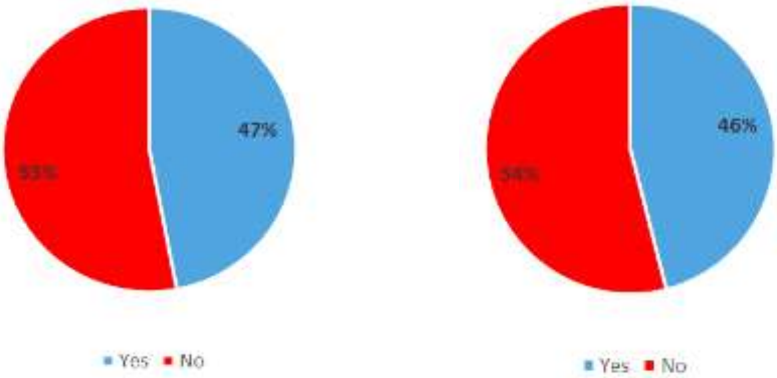

Figure 3.8 Percentage of responses to safety questions

3.4 Discussion

This section presents a discussion of the results presented in section 3.3. It starts with a discussion regarding the use of socio-demographic characteristics as a predictive indicator of households' access to improved water services. This is followed by a discussion of the households' awareness with regards to policy instruments used to guide planning and management of water services provision and the perceptions of households with regards to FBWS policy standards and improved water services provided in the study area. Lastly, a discussion regarding the safety of water users from a security perspective when accessing water IWS is presented.

3.4.1 Socio-demographic characteristic indicative of access to improved water services

The research explored socio-demographic characteristics indicative of the households' access to improved water services provided in the study area. The difference in gender does not have an influence on households access to improved water services. This is because both men and women satisfaction rating regarding water services provided was not significantly different. This is contrary to literature which indicates that in rural areas, women carry the burden of water collection (Abebaw *et al.*, 2010). As a result, men are not very much aware of the water-related issues in households. However, this could mean that both men and women are involved in water-related issues such as the collection of water and addressing challenges relating to water shortages at both the household and community level. The presence of most of the IWS in the households and their proximity to the households could have motivated men to get involved in household water-related issues.

The location of IWS with recommended distance may also explain why the older age group was more satisfied with the improved water services compared to the younger age group. Some of the older age groups indicated that "things are better than the olden days when we used to collect water in the river almost every day". This was an indication that despite the current challenges regarding water services provided, they were appreciative of the improvements from rudimentary or unsafe water sources to IWS, which were located in or in close proximity to the households. The younger age group preferred pipe water in the house - "just like in the cities" "it is a burden to collect, carry, warm and manually empty the water from the washing basin, especially in winter". Therefore, although the results presented by age groups is important, it must be used caution as an indicator of households using improved water services, because of the differences in views with regards to improved water services.

The caution above also applies to education because better-educated groups were less satisfied with aspects of water services compared to less-educated groups'. This is contradictory to other studies that found that households with better-educated people are most likely to have access improved water services compared to those with less educated people (Abebaw *et al.*, 2010; Koskei *et al.*, 2013; Adams *et al.*, 2016). The findings of this study also suggest that because the people are living in the same area, both the better- and less educated are experiencing the same level of water service.

When assessing satisfaction with respect to the wealth of the household, which constitute employment and monthly income of the household, it was found that they were more indicative of access to improved water services. The results of the research concurs with studies that found that wealthier households experienced an improved water service. This is because wealthier households can invest in improving water service by (i) drilling a borehole in the dwelling to supply water, (ii) connect standpipe in the dwelling from a communal main pipe or pull a hosepipe from a nearby communal pipe to collect water in storage tanks (Adams *et al.*, 2016; Adams, 2018). However, this can have its limitations as the results indicated that as the household size increases, satisfaction decreased. Therefore, depending on the size of the households, those that are categorized as wealthier households may later have difficulties in accessing water. This is because larger households require larger volumes of water, which cannot be catered for by basic water services. This is supported by a study conducted by Adams (2018), which found that larger households access less water in liters/capita/day. However, the trends discussed regarding socio-demographic characteristics and satisfaction ratings did not indicate a strong relationship. Therefore, it should be used with caution when using them as predictive indicators of households experiencing improved water services in the study area.

3.4.2 Household awareness and perceptions with policy instruments and water services provided

Most of the respondents were not aware of the policy instruments employed to guide planning and management as well as benchmark improved water services. This is because there were no known awareness programmes focused on educating people about the policy instruments at the various administrative levels. This was not asked by the project but came out during discussions with respondents. The nonexistence of such programmes created a gap for people to liberally make an assessment of the improved water services based on their expectations and water needs. This was worsened by the fact that people held the view that "water is abundant and should be provided for free". The statement that water should be provided for free can be linked to when and how the FBWS policy was implemented. The

FBWS policy was implemented in mid-2002 when South Africa was at the verge of local municipality elections. Its implementation was strategic in the sense that it was used by the governing party at the time for political gain. At the time, people were led to believe that water will be provided for free (Muller, 2008). This was perpetuated without sharing the details regarding the level of water service that will be provided for free (Muller, 2008). This provides an explanation as to why close to half of the respondents indicated that they were aware of the FBWS policy. The implementation of the policy by the governing party was noble and aligned to the attainment of the human right for water despite other motives. The challenge came when people were not properly educated about the level of water service that would be provided for free after the policy was implemented. This, as a result, creates a mismatch of the level of water service that can be provided for free and people's expectations. Consequently, in recent years it has resulted in service delivery protests in parts of SDM, as reported by Alexander (2010); Netswera (2014). The protest were to express dissatisfaction with the water services provided.

To address the misunderstanding, the WSP should educate people about the policy instrument employed to guide development and management as well as benchmark improved water services. This will ensure a common understanding with regards to the level of improved water services that should be provided for free. As a result, the communities will benchmark their experience of the improved water services provided based on what is stipulated in the policy instruments. This is provided that the policy instruments are properly implemented as it has the potential to contribute to reduced protests expressing their dissatisfaction with water services as well as the attainment of human rights for water.

In support of the above, with regard to proper implementation of the FBWS policy. The research benchmarked household's satisfaction with water service standards stipulated in the FBWS policy. This was done to achieve two things; (i) to educate respondents about the FBWS standards so that they can later rate the water service provided, and (ii) to understand their satisfaction with regards to the FBWS standards in order to propose a review of the policy. Overall, people were able to understand FBWS standards because it was explained to them when asked to rate their satisfaction with each standard. An overwhelming majority of the households were satisfied with the FBWS policy standards. The high satisfaction can be attributed to households reported that they would appreciate getting water services according to the FBWS policy. This is because, according to their own assessment, they do not think that the water services provided comply with the FBWS policy. As a result, it could have influenced their rating of the FBWS standards because they were coming from the point of having less to have the hope of getting something more, which may have presented a limitation in the study.

Despite the satisfaction of households with FBWS policy, amendments to distance, quantity, and reliability were proposed by a small proportion of the households. The proposed amendments to standards of quantity and reliability comply with the WHO (2010) guidelines. Regardless of the proportion of the households, it would be beneficial to align the FBWS policy with international standards. The review of the policy would only be beneficial if properly implemented to ensure the attainment of the SDG target for water and human right.

The study benchmarked households' satisfaction with water services provided to understand if they perceive the improved water services to comply with FBWS policy standards and identify areas of improvement. A positive relationship was evident in the satisfaction rating of the improved water services based on FBWS standards. This means an increase in the satisfaction rating of one aspect of the water services resulted in an increase in the satisfaction rating of all other aspects. Therefore an indication that the satisfaction rating of improved water services was based on a holistic experience of the water services within the boundaries of the FBWS standards. With regards to benchmarking of improved water services provided, it was found that most of the households were 'satisfied' with the distance they walked from their households to access improved water services. Through observation, a majority of the households had standpipes connected in the dwellings and others accessed communal standpipes located in close proximity to the households. The results of the research are consistent with studies conducted in rural communities in South Africa, which found that more than 90% of households accessed water within 200 m (Jagals, 2006; Majuru *et al.*, 2012), therefore complied with the FBWS standard for distance. This researcher learned through discussion with the community members that some of the standpipes connected in the dwellings were connected without the authorization of the WSP. It was observed that some households connected hosepipes that extends from communal standpipes into their dwellings to fill water in the container for storage. Other households walked to communal standpipes to collect water using containers which they transported using wheelbarrows. Therefore, the high satisfaction with regards to the distance walked to access improved water services was evident that households were satisfied with the situation regarding physical access to IWS.

The research linked the high satisfaction with distance with the satisfaction of households with the quantity of water collected. This is because studies conducted by Jagals (2006); and Fan *et al.* (2013) found that a decrease in the distance walked to access improved water services resulted in an increase in the quantity of water collected. This was the result in the study area where most of the households indicated that they were 'satisfied' with the quantity of water collected from IWS when operational. It was observed that most of the households collected large volumes of water in containers for storage. This was as a result of not having piped water in the house and unreliability of improved water service, which posed a health risk (Zerah, 2000; Majuru *et al.*, 2012). The health risks posed by storage of water in containers and unreliability of improved water services has been elaborated in literature (Zerah, 2000; Jagals, 2006; Majuru *et al.*, 2011; Majuru *et al.*, 2012). For example; studies reported contamination of water stored in containers as a results of poor handling and contamination of pipes that supply water to a standpipe as a result of regular interruption (Zerah, 2000; Majuru *et al.*, 2012). Some households reported that sometimes they run out of the water at the time when improved water services would be out of service. To address this, they had to buy water from neighbours with boreholes or water tankers. With most of the households unsatisfied with the cost of buying water, they were at risk of resorting to unsafe water sources (Shaheed *et al.*, 2014; Patunru, 2015; Sambo *et al.*, 2018). Some households indicated that they collected water from the river, and the water purchased from the water tankers was collect in the river. When asked, they indicated that they were not aware of any outbreak of waterborne diseases in recent years in the communities. When they did not have clean water for drinking and cooking, they boiled and added bleach in water suspected to be unclean to disinfect the water. However, despite the safety concerns with regards to the storage of water and the unreliability of improved water services, households were satisfied with the quality of water supplied.

The unreliability of improved water services is a crucial challenge that needs to be addressed in the study area. This is because most of the households were unsatisfied with the reliability of improved water services. Some households reported that improved water services could go for a week to 3 months without discharging water, with the extreme being more than a year without discharging water. The results were consistent with the literature, which indicate that the existence of IWS within the recommended distance does not automatically translate that they are providing a water service as most of them were unreliable and not operational (Shaheed *et al.*, 2014; Martinez-Santos, 2017). The reasons provided for the unreliability of IWS coincide with studies conducted in rural communities in South Africa. The major causes of the unreliability of the improved water services were reported to be; (i) electric pumps used to pumps water from the small reservoir to the communal and connected standpipes connected in dwelling were stolen (Sambo, 2015; Sambo *et al.*, 2018), (ii) water pipes burst and were not attended in time (Sambo *et al.*, 2018), (iii) communal standpipes were vandalized with brass pipes stolen and sold for cash (iv) lack of proper O&M of IWS (Rietveld *et al.*, 2008; SDM, 2019), (v) water scarcity as a result of poor rainfall (SDM, 2019). It is for these reasons that improved water services were perceived not to comply with the FBWS standards.

Households were 'satisfied' with the flow rate. The design of the water system can provide an explanation with regards to the satisfaction of households with flow rate. The water systems could have been designed in such a way that the water pressure was made to be high, taking into consideration future connections and population growth. This also provides an explanation as to why even when households connected standpipes in their dwellings without authorization, the flow rate did not decrease to an unsatisfactory level. However, more research regarding this would need to be done to have an elaborative understanding.

3.4.3 Safety

The FBWS policy considers safety in terms of water quality. However, there are safety concerns when it comes to leaving the household to collect water at a given water source, which needs to be taken into consideration when planning to provide water services. Therefore, questions were asked to the household regarding how safe it is when walking from the household to the water sources and while collecting water. The research included nearest IWS and other water sources used in the event water is not discharged from the IWS to highlight safety issues in the study area.

A majority of the respondents did not feel safe when walking from their households to collect water and while collecting water from a given water source. The major reason for them not to feel safe were; (i) water source is far, (ii) village is not safe, (iii) there are rapists and thieves at the river, and (iv) water is sometimes supplied at night. Most of those that did not feel safe were female household representatives, age-wise, a majority were adults (31-40 age group), and the elderly (50+ age group). Respondents that reported to feel safe were those that regularly collected water from standpipes connected in the dwellings and those that regarded the water source not to be located far from the households. This highlights the importance of ensuring that households have reliable improved water services at a distance stipulated in the FBWS policy to ensure their safety when accessing water.

3.5 Conclusion and Recommendations

This study assessed household satisfaction with FBWS policy standards and improved water services provided in the study area. Households were satisfied with FBWS standards. However, they were unsatisfied with the reliability of the improved water services provided and the cost of buying water. The fact that households had access to an IWS did not translate to households being satisfied with the water services provided. As a coping measure, households were compelled to buy water and they were unsatisfied with the cost. This is a clear indication that the socio-economic benefits of having physical access to improved water services are overestimated. IWS fail due to a focus on providing more of them rather than maintaining the existing. As a result, when aspects of the improved water services prevent/limit access of a particular IWS, households were compelled to walk long distances to collect water. It is important to note that women and elderly people did not feel safe when walking from their households to collect water and while collecting water from water sources that were far from their households. However, there is a need to conduct an investigation of the factors that contribute to water users not feeling safe as a result of using a particular water source and how it influence water access. Such information can be useful in planning and designing of improved water services.

The recommendations of this study are as follows;

(a) The WSP should properly implement the FBWS policy. Proper implementation of the FBWS address the issues with reliability of improved water services and contribute to high household satisfaction.
(b) The WSP should develop programmes to educated households about the policies used to guide water services provision. This will help to manage communities' expectations and reduce protest action demanding services delivery.
(c) The WSP should adopt the findings of this study to inform decision-making about aspects of the water services that need improvement as well as identification of households that are unsatisfied with aspects of the water services provided.

3.6 Limitations of the study

The following are understood to be limitations of the research;

(a) The study lacks the time component, where the perceptions of the households with regards to FBWS policy and improved water services provided are monitored over time (5 years, 10 years, or 15 years) to highlight changes in satisfaction. This could not be done due to the limited time of the research and lack of baseline information. However, the results of this research can be used as baseline data for future research. The use of such an approach would help to understand some of the key issues that result in households being satisfied and unsatisfied with the improved water services provided.
(b) The study only focused on perceptions (qualitative); therefore, it did not quantitatively benchmark water services with FBWS standards. A combination of both qualitative and quantitative approach would bring about an understanding with regards to the link between the level of improved water service provided according to FBWS standards and perceptions of households in the study area.

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4. USING AS A SET OF INDICATORS TO ASSESS GEOGRAPHICAL INEQUALITIES IN SUSTAINABLE ACCESS TO IMPROVED WATER SERVICES A RURAL MUNICIPALITY IN SOUTH AFRICA

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Abstract

Monitoring of sustainability of improved water services can contribute to enhanced public health, livelihoods, and wellbeing as well as fulfil the human right to access to water. However, the aspects that contribute to sustainable access to improved water sources are not monitored by water service providers (WSP), which has resulted in rural communities not experiencing intended water services. The study employed a set of indicators based on the South African Free Basic Water Services (FBWS) policy standards (*e.g.* distance, reliability and cost) to assess inequalities in access to improved water services in Makhudutamaga Local Municipality (MLM) in Limpopo province in South Africa. A survey questionnaire was employed to collect qualitative and quantitative data from 396 households in 39 settlements to inform the set of indicators. The results indicated that the water services did not comply with aspects of FBWS standards. In addition, there were statistical differences in access to improved water services across the water schemes for distance [H(3) = 61.33, p = 0.00], quality [H(3) = 72.83, p = 0.00], flow rate [H(3) = 20.12, p = 0.00], and quality [H(3) = 17.21, p = 0.00] and no statistical difference for reliability [H(3) = 1.37, p = 0.712]. Key to this was the unreliability of the improved water services which could go out of service for 2 to 3 weeks, 4 time in 3 months, and in some cases beyond a year. In conclusion, there were inequalities in sustainable access to improved water services across the water schemes.

As a result, different aspects of the water services provided did not comply with the FBWS standards across the water schemes. It is recommended that the WSP adopt the set of indicators employed in this study to monitor inequalities in sustainable access to improved water services to ensure compliance with FBWS standards.

Keywords: free basic water policy, water service indicators**,** improved water sources**,** rural water supply

4.1 Introduction

Sustainable access to improved water services contributes to enhanced public health, wellbeing, and livelihoods as well as fulfil the human right for access to water (Kayser *et al.*, 2013; Wutich *et al.*, 2017). In the context of this study, sustainability refers to improved water services constituting sufficient, affordable, reliable, and continuous supply of potable water daily (Lestera and Rhiney, 2018). In South Africa, improved water services are provided by Improved Water Sources (IWS), which are considered to be sustainable (for examples of IWS, *cf.* Figure 2.1). This is the reason why through the Sustainable Development Goals (SDG), the target is to attain universal access to IWS by 2030 (WHO/UNICEF, 2019). Substantial progress in terms of the attainment of universal access to IWS has been made. However, there is a global debate regarding the figures representing the attainment of universal access to IWS and intended improved water services provided over their useful life which influence water access in rural communities (Martinez-Santos, 2017).

Sustainable access to improved water services is being debated because of how progress in the attainment of universal access to IWS is being monitored. This is because only IWS provided to a certain proportion of the population is monitored, with the assumption that they are providing improved water services over their useful life. Multiple aspects of sustainability (*e.g.* physical accessibility, quantity, reliability, water quality, and affordability) that reflects the level of improved water services provided over time are not monitored. In addition to this, relevant national and sub-national data representing geographical inequalities in access to improved water services remains a challenge. The result of this is that people reported to be using IWS may not be experiencing the intended level of improved water services over their useful life. This can influence access to improved water services, posing a threat to public health, livelihoods, and wellbeing of rural communities (Pullan *et al.*, 2014; Martinez-Santos, 2017). The use of "have" and "have not" approach is only useful in identifying and communicating trends in IWS provided (Kayser *et al.*, 2013), and does not reflect the level of improved water service provided. This is because researchers have reported failures of IWS as a result of one or multiple aspect(s) that define water service provision (Hoko and Hertle, 2006; Rietveld *et al.*, 2008; Majuru *et al.*, 2012; Martinez-Santos, 2017; Sambo *et al.*, 2018). However, this is not captured in the current monitoring system, as it does not account for the dynamic nature of water services provision. It is, therefore, crucial to adopt a practice to monitor multiple aspects that define sustainable access to improved water services to ensure the intended water service over the useful life of the IWS. Kayser *et al.* (2013) recommend the use of a set of indicators that monitor sustainable access to improved water services to overcome the shortcoming presented by the current indicator. The indicators should take into consideration aspects such as physical accessibility, quantity, reliability, water quality, and affordability (cost) (Kayser *et al.*, 2013).

Water services frameworks adopted at global and national levels can provide a set of indicators to monitor sustainable access to improved water services over the useful life of IWS (Kayser *et al.*, 2013). The use of a set of indicators to monitor access to improved water services is not recent; it was first introduced in 1991 by Lloyd and Bartram (1991) with the view that increased coverage in access to IWS should also reflect the levels of water services provided. Lloyd and Bartram (1991) then proposed a surveillance strategy in the form of a framework based on a set of indicators to monitor progressive improvement in water services. The strategy proposed 5 indicators; coverage, continuity, quantity, sanitation risk, and cost to monitor the levels of water services and was piloted in Peru (Lloyd and Bartram, 1991). As a result of its robustness, it was later adopted by the World Health Organisation (WHO) guidelines for drinking water quality (WHO, 2008). In 1996, a simplified version of the 5 indicators was proposed by Bartram (1996). Over the years, other water services frameworks were developed by Feachem and Cairncross (1983); DWAF (2002); UNCESCR (2002); Renwick *et al.* (2007); Moriarty *et al.* (2011). However, they are not used as indicators to monitor sustainable access to improved water services due to the resources required to collect data to inform the indicators (Giné-Garriga *et al.*, 2013). In an attempt to address the gap, researchers have demonstrated the use of a simplified set of indicators to monitor the sustainable access to improved water services (Bartram, 1996; Rietveld *et al.*, 2008; Bartram *et al.*, 2014; Sambo, 2015; Emenike *et al.*, 2017; Kulinkina *et al.*, 2017; Molinos-Senante *et al.*, 2019). Some researchers employed 2 indicators, with some using a maximum of 5 indicators. Their research made interesting findings, which lead them to conclude that the "have" and 'have not" approach does not correctly capture the reality on the ground with regards to the levels of improved water services provided in rural communities.

South Africa developed and adopted a water service policy aimed at attaining "sufficient water for all," as stated in its constitution (DWAF, 2002). The Free Basic Water Services (FBWS) policy guides Water Service Providers (WSP) with regard to the level of improved water service to be provided for free to everyone in South Africa (DWAF, 2002). The standards contained in the FBWS policy with regards to distance, quantity, reliability, flow rate, quality, and cost are shown in Table 5.2. Despite the existence of the FBWS policy, the binary categorisation of households reported to be using IWS is still in use to monitor progress in attainment of universal access to improved water services. This however, does not reflect the inequalities in access to improved water services provided.

In monitoring sustainable access to improved water services for the formulation of evidence-based policies as well as planning, development, and management of water services, it is essential to understand inequalities in access to improved water services at different administrative levels (e.g. national, provincial, district, and so on). This can also aid the process of identification and prioritisation of vulnerable communities experiencing poor water services (Giné-Garriga *et al.*, 2013). As a result, the targeted intervention can be formulated and implemented to assist communities that are most at risk. This can be achieved with indicators that are Easily measurable at the local level, Accurately defined, Standardised and compatible with data collection elsewhere, Scalable at different administrative levels and Yearly updatable (EASSY) (Jimènez Fdez de Palencia *et al.*, 2009).

This study sought to address the existing gap concerning the use of a set of indicators outlined in the South African FBWS policy to assess inequalities in access to improved water services provided. The indicators are considered to be EASSY, simplified, cost-effective, and robust, and the results of the study are expected to demonstrate that. This, as a result, can contribute to the debate regarding the use of a set of indicators to monitor sustainable access to improved water services over the useful life of IWS. Furthermore, it can present a snapshot of inequalities in access to improved water services provided in the study area.

4.2 Material and Methods

This section contextualises the study area and explains the approaches employed in sampling and data collection. It further explains the approaches used for different benchmark aspects of water services provision as well as approaches used to analyse collected data for reporting purposes.

4.2.1 Study area

This study was conducted from November 2019 to February 2020 in Makhudutamaga Local Municipality (MLM), which falls under the jurisdiction of the Sekhukhune District Municipality (SDM) in Limpopo Province in South Africa (*cf.* Figure 3.1). Chapter 3, sub-section 3.2.1, presents a detailed description of the study area. MLM was chosen as the study area due to the fact that it is mainly rural, with the majority of the population unemployed and experiencing high water services backlog as reported by SDM (2019). It was, therefore, the view of the researcher that some of the findings and proposed solutions of this study can aid in making a comparison with other rural municipalities or even aid in addressing similar challenges experienced by the municipalities.

4.2.2 Research methodology

The study employed a mixed method approach combined with Water Point Mapping approach (WPM) (explained in detail in section 2.2.2) to address the objectives of this research. In this regard, the researcher employed a survey questionnaire approach to collect information to access improved water services according to FBWS standards (distance, quantity, reliability, flow rate, and cost). A detailed explanation of sampling and data collection approaches employed in this study are presented in Chapter 3, sub-section 3.2.

Therefore, a detailed summary of the approaches employed for sampling, data collection, and analysis are presented in the following sections.

4.2.3 Sampling and data collection

Stratified random sampling was employed to sample settlements and households that were statistically representative of the entire study area (Kadilar and Cingi, 2003). The researcher used the population of all the settlements, and households due to a lack of data to identify households using IWS. Raosoft ® (Raosoft, 2019), an online sample size calculator was used to compute statistically representative settlements (population (*N*): 156, confidence interval (*CI*): 95% and margin of error (α): 5%) and households (population (*N*): 64769, confidence interval (*CI*): 95% and margin of error (α): 5%). Sample sizes of 39 and 382 were computed for both settlements and households, respectively. For comparison purposes, the proportional allocation of sampled settlements and households was conducted according to water schemes (*cf*. Table 4.1). Random selection was employed to select settlements equivalent to the computed sample sizes.

Table 4.1 Stratified random sampling in the study area

No.	Population (*N*)	Calculated sample size (*n*)	Water scheme Proportional allocation (%) (*n*)	Water scheme Actual surveyed (n)
1.	Settlements (156)	39	De Hoop (62.0%) (28) Flag Boshielo (24.0%) (10) Local resource (8.0%) (2) Peter Gouws (6.0%) (3)	De Hoop (28) Flag Boshielo (10) Local resource (2) Peter Gouws (3)
		Total (*n*)	39	39
2.	Households (64769)	382	De Hoop (62.0%) (237) Flag Boshielo (24.0%) (92) Local resource (8.0%) (31) Peter Gouws (5.6%) (22)	De Hoop (62.1%) (246) Flag Boshielo (24.2%) (96) Local resource (8.1%) (32) Peter Gouws (5.6) (22)
		Total (*n*)	382	396

A modified 8-step approach by Cant *et al.* (2005); Fink (2009) was employed to design a survey questionnaire used to collect data in the sampled settlements and households (*cf*. Figure 3.3). The survey was designed to collect quantitative and qualitative information regarding the demographics of the households and indicators of distance, quantity, flow rate, reliability, quality, and cost. Sub-section 4.2.4 presents an indicator specific explanation of how the data to inform the indicators was collected.

In the design of the survey questionnaire, the questions and statements were phrased in a manner that they were not offensive to the respondents. The available time the respondents had to participate in the survey was considered. As a result, the administration of the survey questionnaire did not take more than 15 minutes of the respondents' time. This was considered not to have disturbed the daily routine of the respondents especially that no prior arrangements were made with the households. The questions were designed to be as simple and quick as possible, however not compromising on the quality and integrity of the data. The initial survey questionnaire was piloted in 20 households. Upon piloting, minor adjustments were effected on the survey questionnaire.

The research recruited and trained two local enumerators to assist with the administration of the survey questionnaire. The use of enumerators reduced the time and budget it could have taken to cover all the households by the researcher. It was also advantageous because it was faster since it was easy to locate most of the settlements. The settlement which the enumerators resided was not part of the settlements surveyed. This was not by choice but by random selection. The survey questionnaires were administered from 9h00 in the morning to 16h00 in the afternoon. The researcher preferred to administer the survey to heads of households, however, this was not always possible because at the time of the survey some of them would be out (*e.g.* working), and if available, some of them would nominate someone in the household to represent the household. For quality assurance, during the administration of the survey, the research would conduct regular checks of the survey questionnaire completed by the enumerators. The regular checks helped to immediately address any emerging issues that may have compromised the quality of the data. The administrated survey questionnaire collected relevant information to respond to the objectives of the research.

4.2.3.1 Measurement of level of water service

The South Africa FBWS standards for distance, quantity, reliability, flow rate, water quality, and cost were employed as indicators to track inequalities in access to improved water services provided through IWS in the study area. Table 4.2 shows indicators and how they were measured for tracking purposes (DWAF, 2002). The data used to assess improved water services was collected through the administration of surveys to household representatives. This is because an exact measure of the indicators could not be conducted due to the large geographical area that the researcher had to cover within a limited budget and time. However, if this study was conducted in 2 or 3 settlements, an exact measure of the indicators could have been conducted. It is worth noting that the majority of IWS were not operational during the time of the surveys, therefore if the researcher had to wait for the IWS to be operational to be able to collect data, then that would have prolonged the duration of the study resulting in an increased budget. Therefore, the data collected for each indicator was based on the estimation of the households. The approach used is cost-effective and straightforward, as well as allows for the collection of rich and reliable data regarding monitoring data on sustainable access to improved water services. The data collected gives a snapshot of the level of improved water service provided by the WSP in the study area. The following sections describe how data for each indicator was collected and measured.

4.2.3.2 Distance

Following Majuru *et al.* (2011); Majuru *et al.* (2012) and Martinez-Santos (2017) the distance was measured as the reported return distance walk by respondents from the household to collect water from an IWS. The use of distance as an indicator to measure water access has long been used by researchers (Majuru *et al.*, 2011). The use of only distance as an indicator of water access assumes that the availability of an IWS at a recommended distance from the households automatically means that it is accessible and providing an intended quality of water services (Martinez-Santos, 2017). This is not factual because IWS fail; for example, it can fail as a result of system inadequacies, poor quality water, and dry out of water source (small reservoir or borehole) (Sambo *et al.*, 2018). Therefore, for distance, respondents were asked to select the estimated return distance walked from predetermined responses. The use of predetermined responses was helpful because, during piloting, some respondents struggled with estimations. However, predetermined responses aided the respondents to make a more accurate estimation of the distance.

4.2.3.3 Quantity

Quantity of water collected was measured as the amount of water collected per capita per day. Adams (2018) state that the quantity of water used in a household by individuals varies widely based on gender, age, breastfeeding, and physical activity. The FBWS standards recommends 25 liters/capita/day, which is expected to be used for primary water needs such as drinking, cooking, and hygiene. Kayser *et al.* (2013) state that if the quantity of water collected in liters/capita/day falls below 5 litres, it is evident of a public health concern. However, the quantity of water collected at an IWS does not necessarily indicate how the water is used. Wutich *et al.* (2017) recommend direct observations of collection and usage as the most realistic and reliable measure of the quantity of water used. However, the authors warn that it is hugely time-intensive when a large number of households are to be covered and can result in biases if observations lead to behavior change. As a result, the approach used by Majuru *et al.* (2012) where respondents reported the number of 25 litre bottles filled per visit and frequency of water collected in a day, was preferred and used.

Table 4.2 Benchmarks indicators of Free Basic Water Services (FBWS)

No.	Indicator	Definition	Data collected/measure
1.	Distance	• Not more than 200 m	Return distance walked from household to IWS
2.	Quantity	• 25 litres/capita/day	Volume of collected
3.	Reliability	• Should at least have a downtime of not more than 2 days in 3 months (98% reliably)	Number/percentage of breakdowns in 3 months
4.	Flow rate	• Minimum discharge rate of 10 l/min (0.16l/s)	The time it takes to fill 25 Litres
5.	Quality of water	• Suitable for human consumption (perceived water quality)	Taste Odor Colour
6.	Cost	• Free	Affordability of water

Following Majuru *et al.* (2012), respondents were asked to indicate water usage by the households for drinking, cooking, bathing and washing of clothes. The quantity of water collected in liters/capita/day was determined by dividing the total amount of water collected per day with the number of people in the household. However, it is worth noting that IWS in the study area were not always providing water. As a result, the quantity of water collected was divided by the estimated average number of days when water was not available from IWS to determine the quantity of water collected in liters/capita/day.

4.2.3.4 Reliability

The reliability was measured as the number of days the IWS was not providing water, as reported by households. This is because IWS have been reported to fail due to a number of challenges indicated by Harvey and Reed (2004); Hoko and Hertle (2006); Rietveld *et al.* (2008); Guardiola *et al.* (2010); Clasen (2012); Kayser *et al.* (2013); Shaheed *et al.* (2014); Sambo (2015); Kulinkina *et al.* (2017); Sambo *et al.* (2018). The FBWS standards recommends reliability of 98%, which translates that IWS should not be out of service for at least two days in three months. The respondents were asked, on average, how many days in three months do IWS not provide water. The number of days when IWS was not providing water was then divided by the number of days in 3 months (90 days) and multiplied by 100 to get a percentage.

4.2.3.5 Flow rate

The flow rate was measured as the amount of time it takes to get a certain quantity of water in litres. Flow rate is significant because it determines how long water users take collecting water from an IWS. This also has the potential of discouraging water users from collecting the required quantity of water. The respondents were asked to estimate the amount of time, in minutes it takes the IWS to fill a 25 litres bottle (Majuru *et al.*, 2012). The fill time was divided by 25 litres to give a flow rate of litres per minute (l/min) and converted to litres per second (l/s).

4.2.3.6 Quality

Water quality was measured in terms of perceived taste, colour and odour of the water as observed by the respondents. This is because people understand water quality in terms of organoleptic properties such as the clarity, colour (cleanliness and brightness), smell and composition (dirt/foreign particulates in the water) of the water (Espinosa-García *et al.*, 2015; Coetzee *et al.*, 2016). These are considered the primary water quality indicators because they can deter households from using IWS (Emenike *et al.*, 2017). The study did not assess the chemical water quality because the study area was too vast for the research to conduct the assessment within the available time and budget. However, it is worth exploring in future research.

4.2.3.7 Cost

The cost of water was measured as the affordability of water resulting from direct and indirect use of IWS. The affordability of water is commonly measured as a percentage of the total income of the household. The percentages vary based on stakeholders; however, internationally, the United Nations Development Program recommends no more than 3-5% of the total income of the households (Scanlon, 2004). The water collected from IWS in MLM was for free due to the fact that there were no water meters installed, and the WSP has an obligation to provide improved water service according to the FBWS standards. Therefore, the cost of water recorded includes the cost of water when IWS were not operational.

4.2.4 Data analysis

SPSS® (version 25) was employed to capture data and calculate descriptive statistics for all items and cross-tabulations. Kruskal-Wallis test at alpha (α) = 0.05 and confidence interval (CI) = 95% were employed to compare the median scores difference across the water schemes. For all the tests, the cut-off for statistical significance was set at $p < 0.05$, which is recommended by Field (2009).

4.3 Results

This section presents the results of the survey questionnaire regarding the level of improved water services provided assessed based on the FBWS standards in the different water schemes that cut across the study area.

4.3.1 Distance

There was a statistically significant difference in the return distance walked from households to collect water from IWS across the water schemes [H(3) = 61.33, p = 0.00]. Figure 4.1 shows a map of the study area representing geographical inequalities in return distance walked from households to IWS across the water schemes.

A majority of the households walked a return distance of between '1 - 100 meters' (*cf.* Appendix G; Table 13.1). With most of the households walking between '2 – 5 minutes' to collect water from IWS (*cf.* Appendix G; Table 13.2).

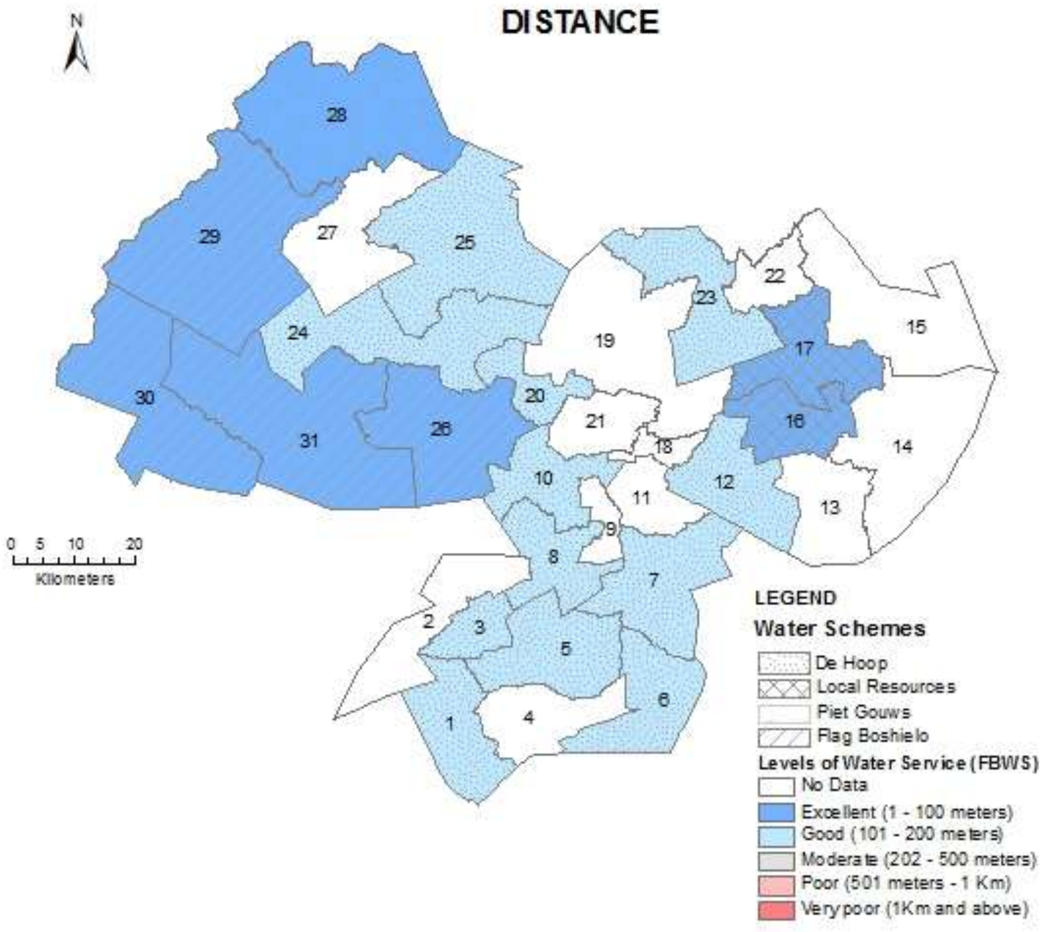

Figure 4.1 Map of the categorised distance improved water services in MLM.

4.3.2 Quantity

There was a statistically significant difference in the calculated quantity of water in liters/capita/day collected by households with an overall median quantity of 48.4 liters/capita/day [H(3) = 72.83, p = 0.00]. The post hoc test indicated a statistically significant difference between DH and FB, and DH and LR. When unreliability of improved water services was factored in, using average computed period IWS were out of service (10.5 days, midpoint of 2 – 3 weeks) (*cf.* Section 5.3.3), the quantity of water collected decreased substantially by an average of 90.5% in all the water schemes. Figure 4.2 shows inequalities in quantities of water collected in the water schemes.

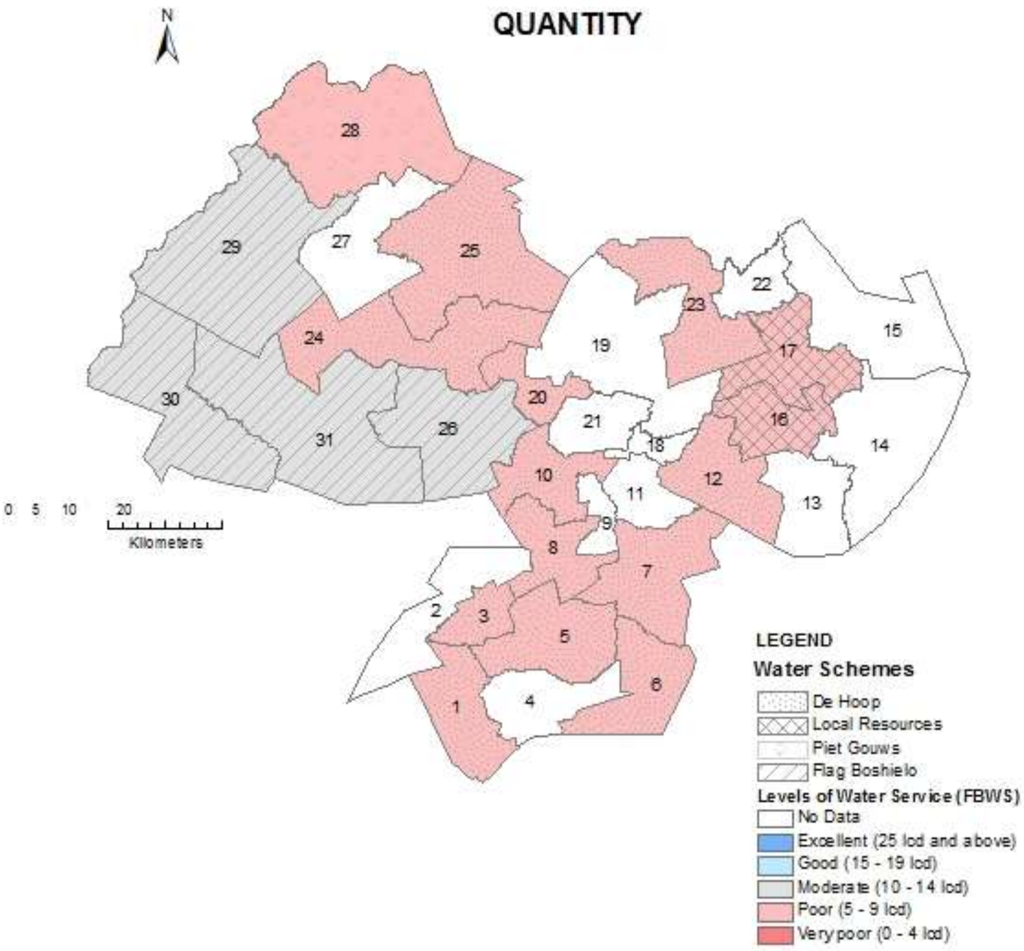

Figure 4.2 Map of the categorised quantity of water improved water services in MLM

There was no statistically significant difference in the quantities of water used daily for domestic purposes [H(3) = 3.104, p = 0.376], with a statistically significant difference with water used for cooking [H(3) = 4.60, *p* = 0.006], bathing [H(3) = 8.41, *p* = 0.038] and washing [H(3) = 10.96, *p* = 0.012] across the water schemes. For cooking, the difference is between DH and FB, and FB and LR, and for bathing, the difference is between DH and FB and PG and FB, and for washing it is between FB and LR.

There was a statistically significant difference in the combined water used for domestic, cooking, bathing and washing [H(3) = 11.05, *p* = 0.011], and without washing [H(3) = 11.74, *p* = 0.008] across the water schemes. With washing included, the difference is between FB and LR, and without washing the difference is between DH and FB and FB and LR. However, there was no statistical difference [H(3) = 0.74, *p* = 0.52] across the water schemes in the percentage of the decreased quantity of water when washing was not included. The quantity of water collected in liters/capita/day decreased by an average of 49.4% across the water schemes. On a monthly basis (calculated using 30 days) taking into consideration unreliability of improved water services, the average water collected was 1204.4 liters/household/month with no statistical difference [H(3) = 4.27, *p* = 0.234] in the quantity of water collected by households per month across the water schemes.

Most of the households collected water 1 to 3 times a day (*cf.* Appendix G; Table 13.3) and most of the households collected water 1 day during weekdays (*cf.* Appendix G; Table 13.4). The majority of the households did not collect water on weekends (74% - 100%) across the water schemes (*cf.* Appendix G; Table 13.5).

4.3.3 Reliability

There was no statistically significant difference in the number of times IWS were out of service in the last 3 months across the water schemes [*H*(3) = 1.37, *p* = 0.712]. There was also no statistically significant difference across the water schemes in the average period IWS was out of service [H(3) = 6.10, *p* = 0.107]. The IWS were out of service for a median period of 2 – 3 weeks without supplying water in 3 months. This meant that the IWS did not supply water for a minimum of 48 days and a maximum of 72 days in 3 months. The longest median period where IWS did not supply water across the water schemes was 1 month [H(3)

= 7.36, p = 0.061]. Figure 4.3 shows the geographical inequalities in the reliability of the improved water services provided across the water schemes. It is based on the mid-point (10.5 days) of the median period (2 – 3 weeks) IWS were out of service in 3 months multiplied by the number of times (4) they were out of service in the last 3 months. Therefore, the reliability of the improved water services was computed to be 53.0% in all the water schemes. This indicated as a serious challenge with the improved water services provided.

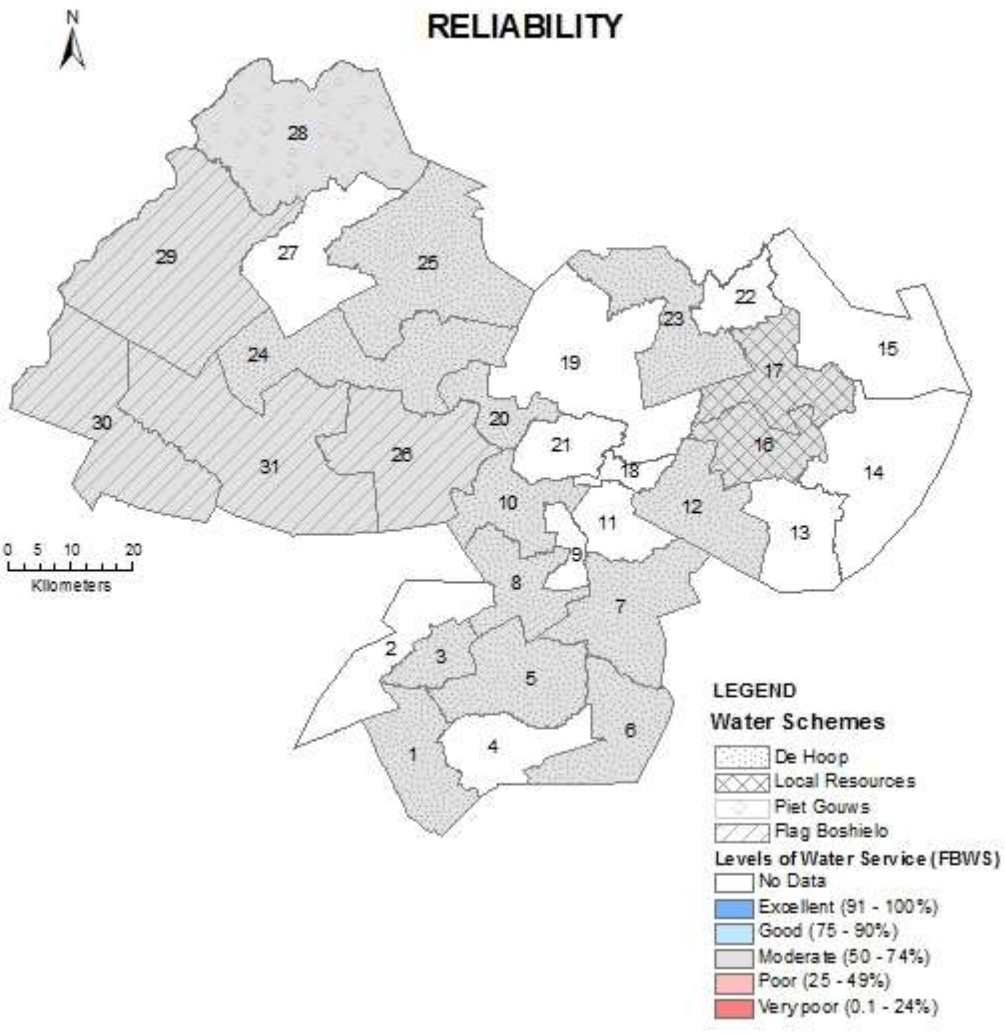

Figure 4.3 Map of the categorized reliability (%) of improved water services in MLM.

Most of the households reported that community leaders (45.1%), community members, government, and political community/ward leaders were responsible for ensuring there is water supply (*cf.* Appendix G; Figure 13.1). The majority of the problems related to water supply were reported to be; (i) IWS takes long time to supply water, (ii) poor water quality , and (iii) poor alternative water sources (*cf.* Appendix G; Figure 13.2). Other households (31.9%) did not comment regarding problem relating to water supply

4.3.4 Flow rate

There was a statistical significant difference in the flow rate across the water schemes [H(3) = 20.12, p = 0.00]. The overall median flow rate was 0.14l/s, which was below the FBWS standard. Figure 4.4 shows the inequalities in flow rate of improved water services provided in the water schemes. The flow rate is below the FBWS standard. The majority of the IWS in the different water schemes fall with the 1 – 5 minutes to fill a 25 liters water bottle (*cf.* Appendix G; Table 13.6).

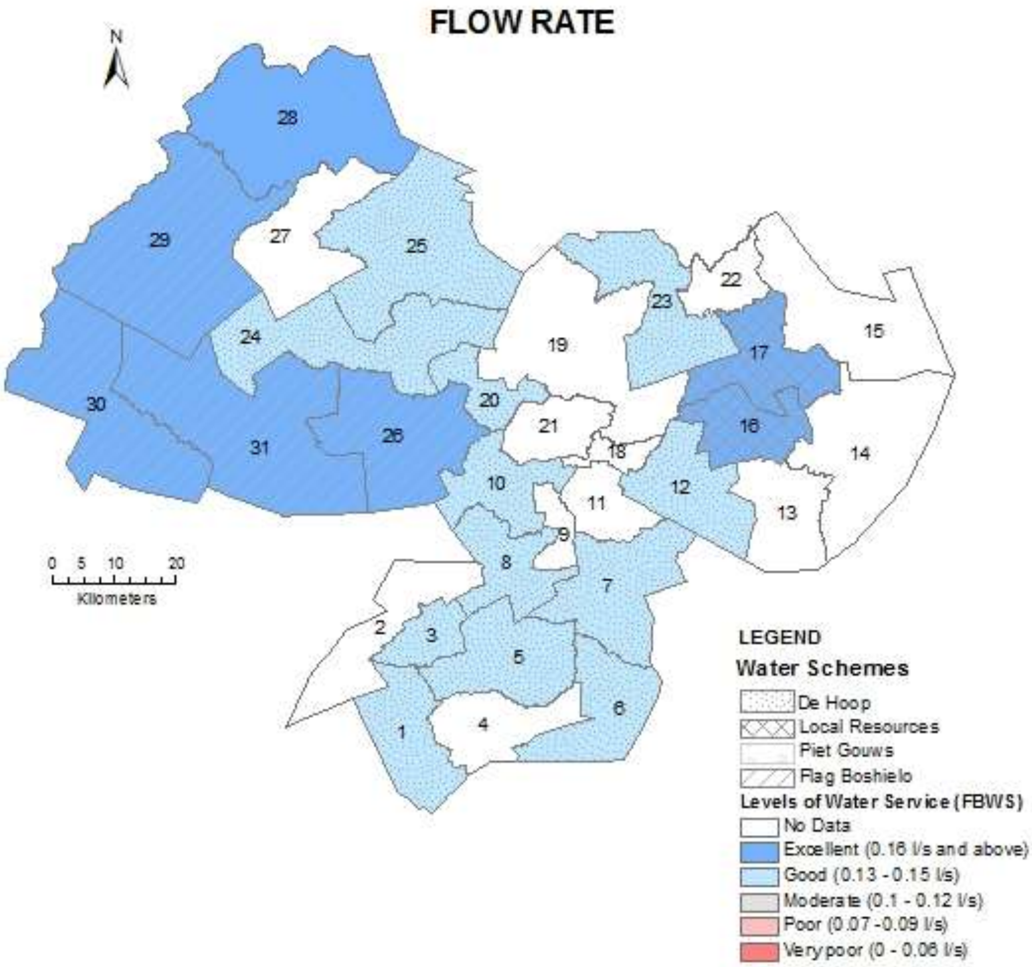

Figure 4.4 Map of the categorized flow rate of improved water services in MLM

4.3.5 Quality

There was statistically significant difference [H(3) = 17,29, *p* = 0.00] in the taste [H(3) = 17,29, *p* = 0.00], and odour [H(3) = 13,77, *p* = 0.00], and no significant difference in median scores for odour [H(3) = 6.44, *p* = 0.09] of water across the water schemes. There was a statistically significant difference in taste between DH and PG, BF and PG, and LR and PG. There was a difference in odour between DH and BF, and DH and LR. Figure 4.5, Figure 4.6 and Figure 4.7 shows the inequalities of water quality in terms taste, odour and colour of water supplied through IWS across the water schemes.

A descriptive analysis of the overall households' perceptions in terms of taste (61.4%), odour (84%) and colour (86%) of water indicate that the water quality was 'good' (*cf.* Appendix G; Figure 13.3, Figure 13.4, and Figure 13.5).

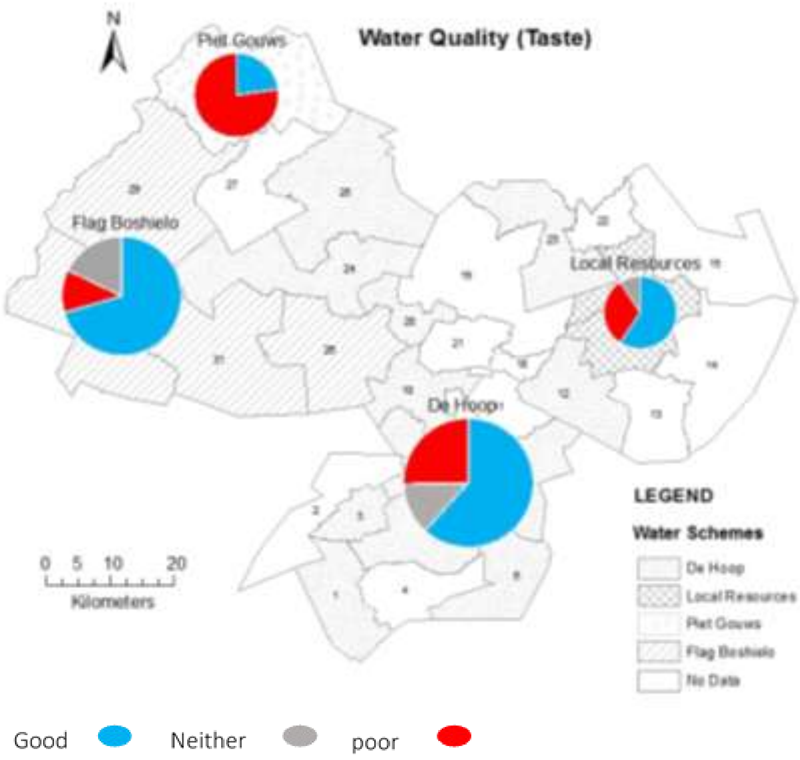

Figure 4.5 Map of water quality rating in terms of taste in MLM

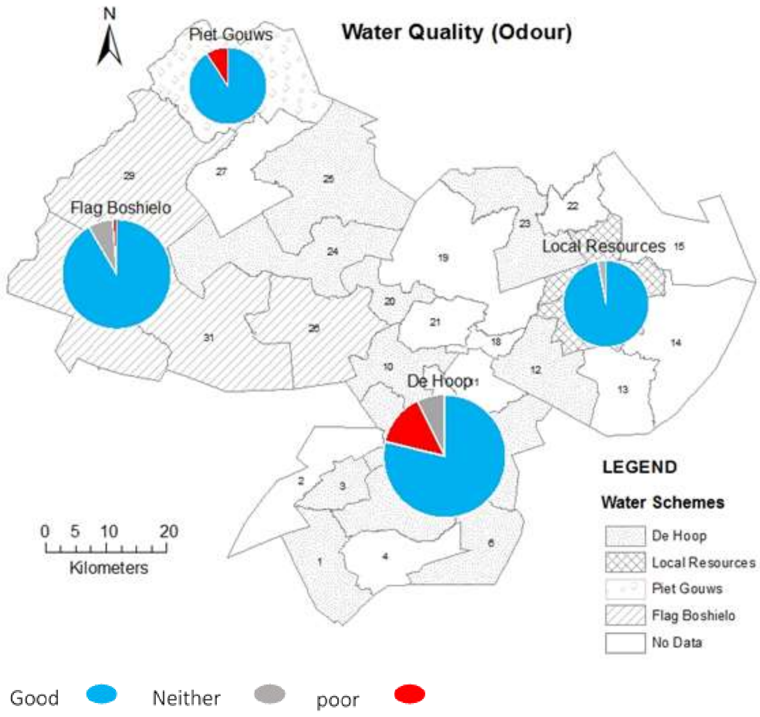

Figure 4.6 Map of water quality rating in terms of odour in MLM

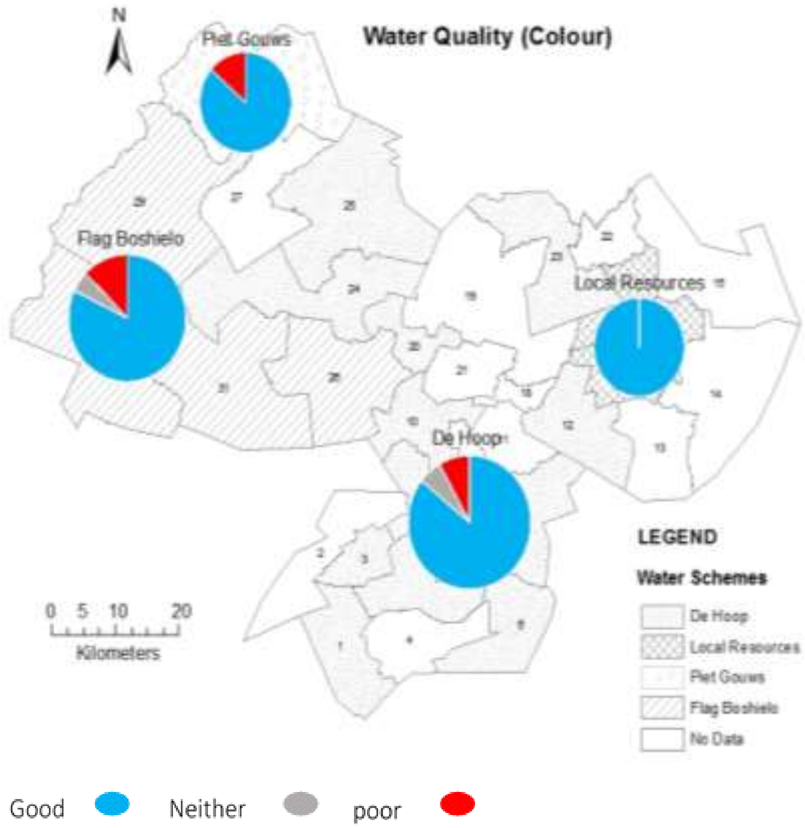

Figure 4.7 Map of water quality rating in terms of colour in MLM

4.3.6 Cost

Most of the households reported that the cost of buying water to supplement water collected from IWS was unaffordable (*cf*. Figure 4.8). Appendix G; Figure 13.6 shows the percentage of households and how much they pay for water. Few households paid R10 to R20 per month as a contribution to purchase electricity for an electric generator that pumped water to the standpipes connected in the dwellings. Other households (5.6%) paid R10 – R50 per month to community members that had boreholes in their dwellings to collect 75 liters of water per day (3 * 25 liters bottle), some (10.2%) paying an extra R2 – R5 per bottle if in need of more water. Household (62.8%) paid R30 – R1000 for different tank sizes (100 – 5000 liters) of water collected from the river.

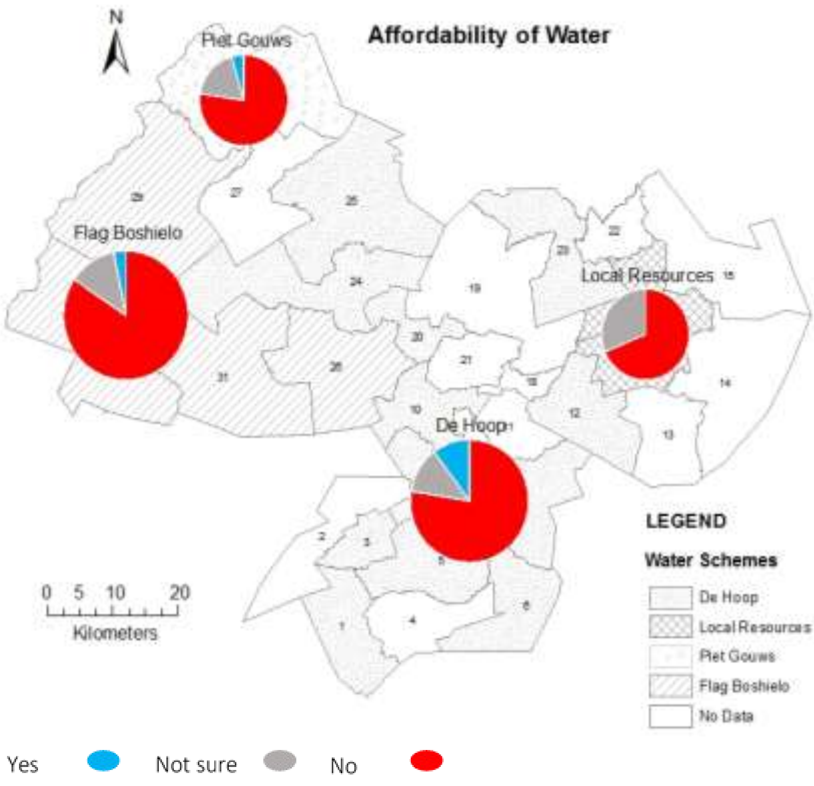

Figure 4.8 Map of affordability of water in MLM

4.3.7 Alternative water sources

A majority of the households used rivers (65.7%) and boreholes (16.9%) as alternative water sources in the study area (*cf.* Appendix G; Figure 13.7). Most of the households (96.5%) do not consider alternative water sources to be safe (*cf.* Appendix G; Figure 13.8).

4.4 Discussion

This section discusses results of this study presented in Section 4.3. A thematic approach is used to discuss the results to bring about an in-depth understanding of aspects that influence sustainable access to improved water services in the study area. However, it is noted that the sustainability aspects are not independent of each other and are interconnected; hence Section 4.5 presents a summary of the discussion with an attempt to show the interconnectedness of the sustainability aspects of improved water services in the study area.

4.4.1 Distance

There were inequalities across the water schemes in distance walked by households to access improved water services. The improved water services provided across the water schemes complied with the FBWS standard for distances. The fact that the majority of the households walked between 2 – 5 minutes to access IWS is an indication that they accessed improved water services in their dwellings or nearer to their households. It was observed that most households had standpipe connected in the dwellings, or their households were located in close proximity (1 m to 200 m) to communal standpipes. This is supported by the IDP report that states that 75% of the households have access to standpipes in their dwellings or have access to communal standpipes within 200 m from the households (SDM, 2019). Majuru *et al.* (2012) and Coetzee *et al.* (2016) found similar results in studies conducted in rural municipalities of South Africa, where most of the households walked not more than 200 m to access improved water services. This was beneficial to the households because literature indicates that children living in households that accessed water not more than 500 m were 34% less likely to get infected by water-related diseases (*e.g.* diarrhea) compared to those whose water source was over 500 m (Gorter *et al.*, 1991).

4.4.2 Quantity of water collected and used

There were inequalities across the water schemes in the quantity of water collected in liters /capita/day from the improved water services. Households collected quantities of water above the FBWS standard of 25 liters/capita/day. The fact that households did not have to carry water for long distances may be one of the reasons that attributed to high quantities of water collected, as found in studies conducted by Majuru *et al.* (2012) and Bartram *et al.* (2014). This is supported by literature, and it indicates that once water is collected in the dwelling, the quantity of water collected increases significantly by one-third compared to the average water collected from a IWS outside the dwelling (Howard and Bartram, 2003). A majority of the households collected water once to thrice in a day during weekdays when IWS were operational. Most of the households did not collect water during weekends.

Key to the above is that households collected high quantities of water, which they stored in different container sizes for later use as a measure to deal with unreliability of the improved water services (*cf.* Section 5.4.2). Therefore, the quantities of water collected were depended on the water storage capacity of the households. Those with a lower water storage capacity (*e.g.* 250 liters drum) collected less water compared to those that had a higher storage capacity (*e.g.* 5000 litres tank). The practice of storage of water posed potential health risk to the households. A study conducted by Majuru *et al.* (2011) and Majuru *et al.* (2012) found that water collected from IWS and stored in containers by rural households was contaminated and of unacceptable drinking quality as a result of improper storage. This is contradictory to the results of a study conducted in rural communities of Pakistan, which found that storing water supplied by IWS in containers was the most protective level of service with limited health benefits derived from just collecting water from an IWS (Van der Hoek, 2002).

When the unreliability of IWS was factored, the quantities of water collected in liters/capita/day decreased substantially by 95%. This indicated that the water services provided did not comply with the FBWS standard for quantity. Furthermore, the household collected 79.9% less water compared to the FBWS standard of 6000 liters/household/month, also an indication that the improved water services were not compliant with the FBWS policy. This was not consistent with with literature which indicate that households with standpipes in their dwellings collect not less than 5000 liters/household/month (Luna *et al.*, 1992), which was not the case in this study. The reason for this can be the unreliability of improved water services.

The results discussed in the above paragraph are based on calculations of the reported quantities of water collected when IWS were operational. In order to understand the household's water use, they were asked to estimate the quantities of water used per day for domestic, cooking, bathing, and washing clothes. The estimated quantities of water used was then divided by the size of the households to get quantities of water used in liters/capita/day. An average of 50.1 liters/capita/day of water was used, with 49.4% of the water used for washing clothes. This is in agreement with literature that indicates that households that mostly use standpipes in the dwellings use 50 liters/capita/day (Howard and Bartram, 2003). A majority of the households washed their clothes on weekends. This is despite most households indicating that they did not collect water on weekends. This meant that households collected more water on weekdays for washing clothes on weekends. This also indicated that the recommended 25 liters/capita/day is sufficient on a normal day where there is no washing of clothes.

4.4.3 Reliability

There were no inequalities in the reliability of improved water services provided across the water schemes. The reliability of improved water services provided was below the recommended standard stipulated in the FBWS policy. On average, IWS were not operational for 4 times for 2 – 3 weeks in 3 months, Majuru *et al.* (2011) found similar results in a study conducted in the rural communities of South Africa. This meant that in 3 months, IWS were not operational for a minimum average of 48 days (43% reliability) and a maximum average of 72 days (20% reliability). The longest average period IWS have being out of services was 1 month, the results agree with the results of studies conducted in the rural communities in developing countries where is was found out that the IWS can be out of service for a month or even more than a year (Hoko and Hertle, 2006; Rietveld *et al.*, 2008; Hunter *et al.*, 2009; Guardiola *et al.*, 2010; Majuru *et al.*, 2011; Majuru *et al.*, 2012; Fan *et al.*, 2013; Pullan *et al.*, 2014; Sambo, 2015; Coetzee *et al.*, 2016; Kulinkina *et al.*, 2017; Sambo *et al.*, 2018).

The major water supply issue that households raised when asked what the challenges with the improved water services provided was that ‘IWS takes long to supply water’. A majority of households indicated that it was the responsibility of the community leaders, community members, and government to ensure unlimited water supply. The fact that community members were indicated as part of the stakeholders that should ensure water supply was an indication that some community members have a sense of responsibility and ownership towards the IWS. The unreliability of IWS supports the statement made in the IDP report that water supply in the study area remains a significant challenge (SDM, 2019). It can be attributed to low rainfall (as water-scarce district) and inadequate protection of water resources on the supply side, and increasing demand as a function of population growth, as well as inadequate operation and maintenance (O&M) of critical water infrastructure, to ensure water supply to IWS (Sambo, 2015; Sambo *et al.*, 2018). In an effort to address these challenges, since 2014, the SDM implemented projects that are ongoing to extend existing infrastructure and resolve functionality and source issues with a long-term budget of ZAR 237,015,450.00 (USD 13,774,306.14) (SDM, 2019). The intended benefits of the projects to its intended beneficiaries remains to be realised (Muller, 2008; SDM, 2019).

4.4.4 Flow rate

There were inequalities in the flow rate across the water schemes. The flow rate in the water schemes is below the stipulated standard for the FBWS policy with DH being the lowest. The low flow rate can be attributed to the unauthorized standpipe connections from main communal pipes to the dwellings. This is because most of the households indicated that they installed the standpipes themselves. However, the increase in population in the settlements combined with high unreliability of IWS can also be a contributing factor. This can result in a higher than average households collecting water at the same time with all the taps open, and as a result, reduce the flow rate.

4.4.5 Water quality, cost and use of alternative water sources

The perceptions of the households regarding water quality in terms of organoleptic properties of taste, colour, and odour was used as a measure of water quality. Most of the households perceived the taste, colour, and odour of the water supplied by IWS to be 'good'. When asked, households were not aware of any water quality issues arising from the IWS that resulted in an outbreak of any waterborne diseases or mortality. The results concur with those of a study conducted in the rural municipalities of South Africa that found that most participants perceived water to be 'good' based on organoleptic properties as a measure of water quality (Coetzee *et al.*, 2016). However, because of the unreliability of IWS, households were forced to either purchase water or use UWS (Hunter *et al.*, 2009; Majuru *et al.*, 2011).

The majority of the households could not afford to buy water. They reported that the cost was "just too much" for them as most of the people in the households were unemployed, therefore rely on old-age pension grants and child support grants to sustain the household. Literature indicates that in most cases, households sacrifice budget for food to purchase water (as it is essential), which in turn can contribute to under-nutrition (Cairncross and Kinnear, 1992). However, it was a different case for those that could not afford to make the sacrifice because of an already heavily constrained budget. As a result, they resorted to collect water from the river and other water sources, in which a majority have indicated that they are unsafe. This coincides with literature that rural households are forced to use UWS as a result of the unaffordable cost of water and unreliability of IWS (Smiley, 2013; Sambo, 2015; Giné-Garriga *et al.*, 2018; Sambo *et al.*, 2018). This, as a result, poses a severe health risk to households. This is why the cost of water should not prevent people from accessing sufficient, reliable, and safe water for their basic use (Martinez-Santos, 2017).

4.4.6 Summary

The study proves that the use of the "have" and "have not" approach in monitoring access to improved water services is not a suitable measure of sustainability. The results indicated that across the water schemes, most households accessed improved water services within the recommended distance of 200m. However, the improved water services did not meet the stipulated standards of FBWS policy of quantity, reliability, flow rate, and cost. Furthermore, there were inequalities in aspects of access to improved water services across the water schemes. This, as a result, impacted the households negatively, as the cost of buying water was unaffordable for most, and those that could not afford used alternative water sources (*e.g.* rivers) that were considered to be unsafe for human consumption by most households. This posed a potential health risk to them as well as affected their livelihoods.

4.5 Conclusion and Recommendation

A set of indicators were used to benchmark improved water services based on FBWS standards in the 4 water schemes in the study areas. There were inequalities in sustainable access to improved water services based on the set of indicators derived from the FBWS policy standards. As for complies with FBWS policy, aspects (*e.g.* reliability, quantity and cost) of the water services did not comply resulting in patchy access in water access posing a threat to wellbeing and livelihoods of rural communities. Therefore, the set of indicators employed by this study can be used to monitor inequalities in sustainable access to improved water services. The indicators are suitable to be used at different administrative levels from national down to the settlements to assess inequalities in sustainable access to improve water services. The indicators are considered to be EASSY, simplified, cost-effective, and robust. However, the cost component of the indicators is yet to be explored when they are used at a community level as it will result in an increase in the households to participate in the survey increasing cost. This, however, presents an opportunity to explore other sampling methodologies that can result in reduced statistical representative sample of households reducing cost. The representation of the water services data using the indicators at different geographical scales can be used to inform focussed planning, monitoring and management of improved water services as well as prioritisation of high-risk groups according to identified areas of improvement. Furthermore, suppose the data is used appropriately, it can contribute to the formulation of evidence-based strategies and direct investments to problem areas to ensure sustainable access to improved water services.

It is the recommendation of the study that;

(a) WSP should adopt the set of indicators employed in this study monitor sustainable access to improved water services to ensure that they are providing the intended water services.
(b) WSP should address the unreliability of improved water services to ensure intended water services according to the FBWS policy. The fact that most of the households

have access to IWS within the recommended distance, the water quality is perceived to be good, and the flow rate is not that bad, it is a plus for the WSP, and once unreliability is resolved households will experience the intended water services.

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5. SYSTEMS ANALYSES OF COMPLEX INTERACTIONS OF CATEGORICAL FACTORS INFLUENCING SUSTAINABLE ACCESS TO IMPROVED WATER SERVICES IN A RURAL MUNICIPALITY IN SOUTH AFRICA

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Abstract

It is essential to understand the complex interactions of the factors that influence sustainable access to improved water services provided by improved water sources (IWS) because it contributes to enhanced public health, wellbeing, and livelihoods. However, there is limited use of approaches that capture the complex interactions of the factors resulting in a coherent understanding of the synergies and trade-offs of how they influence sustainable access to improved water services in rural communities. The study sought to investigate and analyse the complex interactions of factors that influence sustainable access to improved water services in Makhudutamaga Local Municipality in Limpopo Province in South Africa. Key informant interviews were employed as a qualitative research approach to collect qualitative explanatory information using developed semi-structured questions. A systems approach (network analysis) was employed as a quantitative research approach to analyse the qualitative explanatory information collected. As a result, two (2) networks representing the complex interactions of the factors were generated. Three (3) thematic communities were identified in the network to allow for a thematic analysis of the network. The 'long-term sustainability' thematic community was found to be more critical than 'water availability' and 'institutional arrangements and funding' thematic communities. Limited budget, limited/no water supply, and improper operation and maintenance (O&M) were critical

problem areas in the networks that influenced sustainable access to improved water services. In conclusion, the study investigated and analysed the complex interactions of factors that influence sustainable access to improved water services resulting a coherent understanding of the factors. It is therefore recommended the findings should be adopted by the relevant authorities responsible for water services provision to inform planning and management as well as strategies to address challenges identified to ensure sustainable access to improved water services in the study area.

Keywords: complex systems, network approach, sustainable water services, categorical factors

5.1 Introduction

Sustainable access to improved water services provided by Improved Water Sources (IWS) *(e.g.* standpipe connected in the dwelling or communal standpipe) in rural communities can contribute to enhanced public health, wellbeing and livelihoods (Giné-Garriga, 2015; Giné-Garriga *et al.*, 2018; Sambo *et al.*, 2018). However, there remains a substantial proportion of the rural population without access to improved water services (WHO/UNICEF, 2019). With those that are reported to have access to improved water services experiencing services related issues which influence water access negatively (Martinez-Santos, 2017). The literature reviewed indicates that the situation on the ground culminates from factors that are technical, social and institutional that influence sustainable access to improved water services, which are documented in detail by Clasen (2012), Flores Baquero *et al.* (2013), Kayser *et al.* (2013), Shaheed *et al.* (2014), Giné-Garriga *et al.* (2015), Martinez-Santos (2017) & Adams (2018).

The factors that influence sustainable access to improved water services are well documented in the literature. However, the compartmentalised analysis of the factors could be a contributing aspect of the reason the situation is as it is on the ground. This is because the factors are interconnected and interact, therefore complex in nature, supported by Harvey and Reed (2004) and Sambo *et al.* (2018). The conventional approaches employed in the analysis of the factors do not capture their complex interactions to provide a coherent understanding (Sambo, 2015; Giné-Garriga *et al.*, 2018). The understanding of the factors in the manner that they are analysed does not yield sustainable solutions. There is a need to understand the complex interactions of the factors. Such an understanding can contribute to enhanced public health, wellbeing and livelihoods (Giné-Garriga, 2015; Giné-Garriga *et al.*, 2018; Sambo *et al.*, 2018). It can also result in targeted interventions that include evidence-based policies and proper planning and management of improved water services to ensure sustainability. Consequently, this raises a need to explore appropriate approaches that capture and provide a coherent understanding synergies and trade-offs resulting from the complex interactions of factors that influence sustainable access to improved water services provided in rural communities (Giné-Garriga, Requejo, Molina and Pérez-Foguet 2018).

There have been efforts to employ appropriate approaches with the potential to inform interventions targeted towards the attainment of universal access to improved water services. These efforts focused on addressing specific challenges related to IWS coverage, water service level and prioritisation of high-risk communities (Rietveld *et al.*, 2008; Cohen and Sullivan, 2010; Flores Baquero *et al.*, 2013; Giné-Garriga *et al.*, 2013; Luh *et al.*, 2013; Giné-Garriga, 2015; Sambo, 2015; Kulinkina *et al.*, 2017; Molinos-Senante *et al.*, 2019). These resulted in enhanced availability and access to up-to-date and reliable information as well as promoted dissemination and use of the information to inform evidence-based policies and proper planning and management of improved water services (Giné-Garriga *et al.*, 2018). The approaches provide valuable information that contributes to sustainable access to improved water services. However, when the results derived from the approaches are used in isolation, they provide a somewhat compartmentalised perspective centred on specific aspects (*e.g.* physical accessibility or functionality) of water service provision. As a result, the approaches provide some level of understanding with regards to sustainable access to improved water services but do not provide a coherent understanding of the complex interaction of factors.

In an attempt to address the gap, various researchers have employed approaches that interlinked two or more categorical factors in studies that addressed factors that influenced sustainability access to improved water services. Categorical factors refer to factors that influence sustainable access to improved water services, categorised as social, environmental, institutional, economic, and technical factors, explained in detail by Graciana and Nkambule (2012) and Sambo (2015) (*c.f.* Chapter 2, Section 2.2). The literature reviewed indicated contradicting results in terms of main factors that influenced the sustainable access to improved water services (Macus and Onjala, 2008; Graciana and Nkambule, 2012; Sambo, 2015; Giné-Garriga *et al.*, 2018; Sambo *et al.*, 2018). For example, Macus and Onjala (2008) found that sustainable access to improved water services depended on economic and institutional factors. Contrary to this, Graciana and Nkambule (2012) found that economic and institutional factors were less critical than technical and social factors. The contradicting results are indicative that the factors may vary depending on the location of the study. The limitation of the approaches employed was that the factors' interactions were not quantified. Giné-Garriga *et al.* (2018) proposed Object-Oriented Bayesian Networks (OOBN) as an approach to quantify the complex interactions of Water Sanitation and Hygiene (WaSH) factors. The results of the study indicated that the OOBN approach has the potential to accommodate the complex interactions of WaSH factors. However, they concluded that there is a need to improve the model in order to simplify it by lowering the number of nodes (factors) of some categories without losing critical information. In addition to this, they indicated that the software used requires a highly qualified person to use, which is a major drawback. In rural municipalities where there is limited technical capacity (Sambo *et al.*, 2018), it makes the adoption of such an approach a challenge.

It is against this background that the research finds a network analysis approach suitable to capture the complex interactions of factors that influence sustainable access to improved water services in rural municipalities (Sambo *et al.*, 2018). It is because of its simplicity regarding data collection and analysis that makes it adaptable in a rural setup (Sambo *et al.*, 2018). The network approach has the potential to capture the interactions of different and unlimited number of categorical factors based on their cause-effect relationship. These include; technical, social, institutional, economic, and environmental factors (Harvey and Reed, 2004; Graciana and Nkambule, 2012; Fan *et al.*, 2013; Spaling *et al.*, 2014). The approach has been employed in different disciplines, including social sciences, management and agriculture (Wasserman and Faust, 1994; Freeman, 2004; Fairweather, 2010; Bezuidenhout *et al.*, 2013). However, there has been limited use of the approach in the water sector, mainly rural water supply.

The graphical nature of the network (‘spider-web’ like) allows for easy and systematic analysis of the complex interactions of factors. The *nodes* in the network represent factors, and the *lines* represent the linkages of the factors with each other (Milojeviă, 2014). The nodes' size can represent the intensity of the relation of nodes with other nodes (Wasserman and Faust 1994, Milojeviă 2014), thus allowing identification of critical areas to focus interventions in order to address challenges. The lines can be used to represent the direction of the linkages of nodes with other nodes. The direction of the linkages is useful in analysing the flow of the interactions leading to critical nodes in the network (Bezuidenhout *et al.*, 2013). The closeness of the node as a result of the linkages aids in understanding their relation. This, combined with the community structure approach, can be used to identify thematic communities in the network to enhance understanding of the network (Bezuidenhout *et al.*, 2013). As a result, in the context of rural water supply, this can provide a coherent understanding synergies and trade-offs resulting from the complex interactions of the factors that influence outcomes regarding IWS coverage and water service levels in different settings (*e.g.* district, municipality, community, etc.).

The study sought to addresses the gap concerning the coherent understanding of the complex interactions of factors that influence sustainable access to improved water services in a rural setup. The objective of the study was to investigate and analyse the complex interactions of the factors that influenced sustainable access to improved water services using an approach that captures their complex nature. It is expected that the results will highlight the critical factors resulting from their complex interactions that influence access to improved water services providing a coherent understanding of the factors.

5.2 Material and Methods

This section contextualizes the study area and explains the research process and methods employed to attain the objectives of this study.

5.2.1 Study area

The study was conducted in June 2020 in Makhudutamaga Local Municipality. Chapter 3, sub-section 3.2.1, presents a detailed description of the study area.

5.2.2 Research approach

A mixed-methods approach was employed to investigate and analyse the complex interactions of the factors influencing sustainable access to improved water services provided in the study area. Table 5.1 and Table 5.2 show a summary of the research procedure employed to attain the research objective. Key informant interview method was employed as a qualitative research approach to collect qualitative data on factors that influence sustainable access to improved water service. The research preferred the key informant interview method because it allowed for collecting rich and reliable explanatory qualitative data, supported by Bezuidenhout *et al.* (2013). In this regard, semi-structured questions were formulated to collect relevant explanatory qualitative information. Semi-structured questions were preferred over close-ended questions because of their flexibility with regards to allowing for follow up questions to be asked when the interviewer did not fully comprehend the responses provided by the interviewees. The posing of follow-up questions enhanced the researcher's understanding to contextualise the interviewees' responses. The formulated questions were piloted with two people to ensure their relevance in collecting the required data. The piloting of the questions provided clarity regarding how the interviewees will understand and respond to the questions. After piloting, comments were provided by the interviewees to improve the questions to collect the relevant information in a reduced time frame. The comments were incorporated in the finalisation of the questions.

The interviewees' sampling was purposeful because it was based on their availability and accessibility at the time of the research (Sambo, Senzanje and Dhavu 2018). The researcher consulted the Sekhukhune District Municipality (SDM) to identify relevant personnel involved in the planning and managing of water services that could participate in the key informant interviews. As a result, a list of nine personnel and their contact details (emails and mobile numbers) was provided for scheduling appointments. Email and telephone calls were used to contact the identified personnel to introduce the research and request for their participation in the interviews. Consequently, appointments were secured with six personnel (interviewees) (*cf.* Appendix F, Table 14.1), the other three identified personnel were unreachable. Due to COVID-19 regulations of 2020 at the time of the study, the research was not able to conduct physical field visits to interview water service users in the study area. This is because movement was restricted to essential services, and research was not classified as essential. Hence, the interviews were conducted telephonically with the SDM personnel.

Interviewees were sent consent forms via email to give consent to participate in the interviews as per ethical research requirements (*cf.* Appendix C, Section C). The consent form, in addition to other things, solicited consent for the interviewees to be recorded. This was for the researcher to be able to refer to the recording when analysing the exploratory qualitative information provided and not to misinterpret the information. This was critical in ensuring the validity and reliability of the data. During the interviews, semi-structured questions were asked with clarity and in a manner that was not offensive to the interviewees. In this regard, the responses provided by the interviewees were clear and addressed the questions asked. This is because the interviewees responded with an understanding of the questions asked providing relevant information. In addition to recording, the researcher also noted certain issues in a journal that were emphasised by the interviewees. This was regarded as important information to aid in data analysis, especially in the identification of factors. At the end of the interviews, the interviewees were thanked for their time.

The researcher preferred to conduct physical interviews. However, telephonic interviews and interviewing six people did not compromise the quality of the data collected. Interviewing more people could have led to the high saturation of the qualitative explanatory information provided; this is supported by the experiences of Bezuidenhout *et al.* (2013) and Sambo *et al.* (2018). This was evident as interviewees reported similar issues during the interviews resulting in saturation. The interview took between 15 to 20 minutes and the data collected was sufficient to conduct a detailed analysis.

5.2.3 Data analysis and network generation

The recordings and notes of the interviews were used as a reference to identify critical factors and their linkages. The researcher preferred using both manual and computer-assisted methods to analyse the data collected to take advantage of their strengths to produce the best results, supported by Welsh (2002). Computer software is useful in organising and grouping extensive qualitative data according to specified categories to enable data analysis (Alhojailan, 2012). This was valuable because it improved the rigours analytical steps for validating the data and allowed for the data to be analysed based on the interactions of the factors at a level of a complex system (Alhojailan, 2012).

NotePad® was employed to assist with the categorisation and linking of factors. The identified factors were categorised under technical, institutional, economic, environmental, and social categories. The categorised factors were linked based on their cause-effect relationship using the first principle. The first principle referring to the linking of factors that have a direct cause-effect relationship *(e.g.* 'A' has a direct cause-effect relationship with 'B'). For example, "we are unable to repair pump because we do not have spare parts" (A); as a result, 'broken pump' links with the 'unavailability of spare parts' (B).

Table 5.1 Steps used to generate the network of factors in MLM

Stage	**Description of stages**	**Descriptive summary of actual steps taken**
Stages 1	Research method and type of data	- Key informant interviews were employed for data collection. - Qualitative explanatory data was collected.
Stages 2	Data collection instrument	- Semi-structured questions were developed and piloted with two people to check for relevance. - After piloting, revisions were made to the questions and then finalised.
Stages 3	Identification of Stakeholders	- Stakeholder selection criteria were developed - Stakeholders were identified from a list of personnel working at the Sekhukhune District Municipality – Infrastructure Water Services division (SDM-IWS) based on the selection criteria. - Interviews with identified personnel were scheduled using email and telephone.
Stages 4	Data collection	- The interviews were conducted telephonically. - The interviews were recorded and notes made in a journal.
Stages 5	Categorisation	- Statements regarding factors that affect sustainable access to improved water services were identified - The factors were coded. - The coded factors were allocated to representative categories - Factors were linked based on their direct cause-effect relationship using the first (1st) principle. -
Stages 6	Data analysis and display	- The linked factors were loaded on computer software (Pajek®) for processing. - The energy transformation technique was applied to the data to generate a network. - Centrality approaches relating to interconnectedness and closeness were applied to the network. - Thematic communities were identified in the network (for steps taken, *cf.* Table 2). - The final network was generated (*cf.* Figure 1). - Density visualisation was applied to the network (*cf.* Figure 2) to identify problem areas.

The data processed in Notepad® was exported to Pajek® (Version 5.09) (Batagelj and Mrvar, 1998). Pajek® is a computer software that was employed to process the data to generate the network. The computer software is a powerful tool for processing interconnected factors to generate networks (Batagelj and Mrvar, 1998; Milojeviă, 2014). The Kamada Kawai energy transformation (Kamada and Kawai, 1989) was applied to the factors to generate the network. The network was generated based on the diversity, interconnectedness, and closeness of the factors (nodes). To quantitatively analyse the generated network, the centrality approaches were applied to the network. The Degree Centrality (DC) approach determines the nodes' interconnectedness based on the direct cause-effect relationship (Zhang and Luo, 2017). This allows for the identification of critical nodes in the network. The larger the node's size compared to other nodes, the more critical it was in the network. The Betweenness Centrality (BC) approach determines the number of times a node lies in the shortest path between nodes (Zhang and Luo, 2017). The approach allowed for the identification of nodes that influenced the flow of the network. The Closeness Centrality (CC) approach uses a score to determine the 'closeness' of a node to other nodes in the network (Zhang and Luo, 2017). The approach allowed for the identification of nodes that influenced the whole network. For the identification of thematic communities, the Louvain method (Blondel *et al.*, 2008), a community structure method, was applied to the network. The thematic communities were identified based on the nodes' coherence and diversity. The density visualisation approach using VosViews® (Version 1.6.5) (Van Eck and Waltman, 2010) was applied to the network to identify 'hot' and 'cold' spots (problem areas) in the network. The use of density visualisation allowed for the identification and categorisation of critical problem areas in the network.

Table 5.2 Steps employed to analyse the generated network

Stages	Description of Stage	Descriptive summary of actual steps taken
Stage 1	Reliability and validity	- The researcher checked that the network was correctly generated. - An analysis of the nodes and linkages was done, including the flow of the network. - An independent person also checked the network (SDM Operation and maintenance manager).
Stage 2	Identification of thematic communities	- Thematic communities were identified based on closely related nodes using Louvain method (Blondel *et al.*, 2008) - The coherence and diversity of the nodes was analysed to validate the communities
Stage 3	The naming of the thematic communities	- The thematic communities were delineated according to the clusters. - Based on the coherence and diversity of the nodes, the thematic communities were named

Stage 4	Review the thematic communities	-	The thematic communities were reviewed by repeating Stages 2, 3, and 4.
Stage 5	Finalise thematic communities	-	The thematic communities were finalised

5.3 Results

Thirty (30) different categories of factors (nodes) and seventy-two (72) direct cause-effect linkages (lines) were identified from the qualitative exploratory information collected through the key informant interviews (for detailed results, *c.f.* Appendix F, Table 14.2). Figure 4.1 shows an energised network depicting the complex interactions of the factors that influence sustainable access to improved water services. The energy transformation applied to the network distributed the nodes based on their association; therefore, closely related nodes were placed close to each other. The centrality approaches were applied to the network. The DC approach created different sizes of the nodes based on their interconnectedness with other nodes. Larger nodes represented critical points in the network that raised opportunities for improvements. Complementary to critical points, problem areas were identified using density visualisation of the network (*c.f.* Figure 5.2). The red, yellow, and green colours shown in Figure 4.2 represent high, medium, and low-density areas, respectively. High-density areas represent critical problem areas in the network. For example, in Figure 5.2, the area marked (A) represents a high-density area. Furthermore, community structure method identified three (3) thematic communities (grey shaded areas) in the network (*c.f.* Figure 5.1). The thematic communities were identified as; ‘water availability,’ ‘institutional arrangements and funding’, and ‘long-term sustainability’.

The nodes representing limited budget, limited/no water supply, limited staff capacity, improper operation and maintenance (O&M), and limited specialised staff are the top five (5) critical points in the network. These critical points are located in areas categorised as critical problem areas based on density visualisation. For example, in Figure 5.2, the area marked C is a critical problem area representative of factors to do with O&M and capacity of staff responsible for O&M.

The critical problem areas are useful to bring attention to certain key nodes in the network and not just one node. However, it is important to understand the in-degree (leverage) and out-degree (KPI) that the different nodes have in the network. For example, the limited budget has the highest leverage and low KPI, and limited/no water supply has the lowest leverage, but the high KPI. This means that a limited budget causes an effect to a majority of the nodes connected to it, and limited or no water is an effect of the majority of nodes connected to it. Improper O&M also has an effect on the majority of the nodes connected to it, which include limited budget, limited staff capacity, and limited specialised staff. Therefore, understanding the leverage and KPI of nodes helps to understand their role in the network.

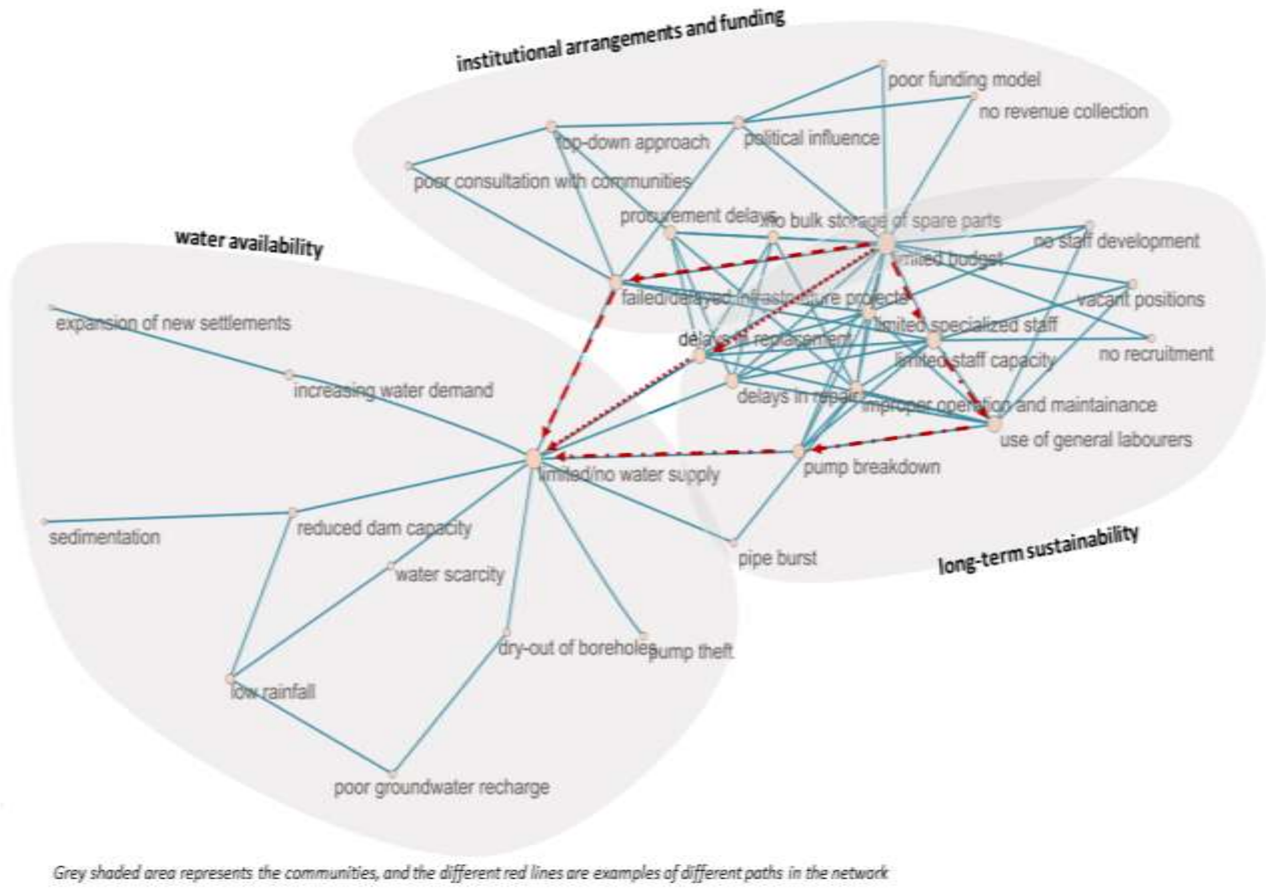
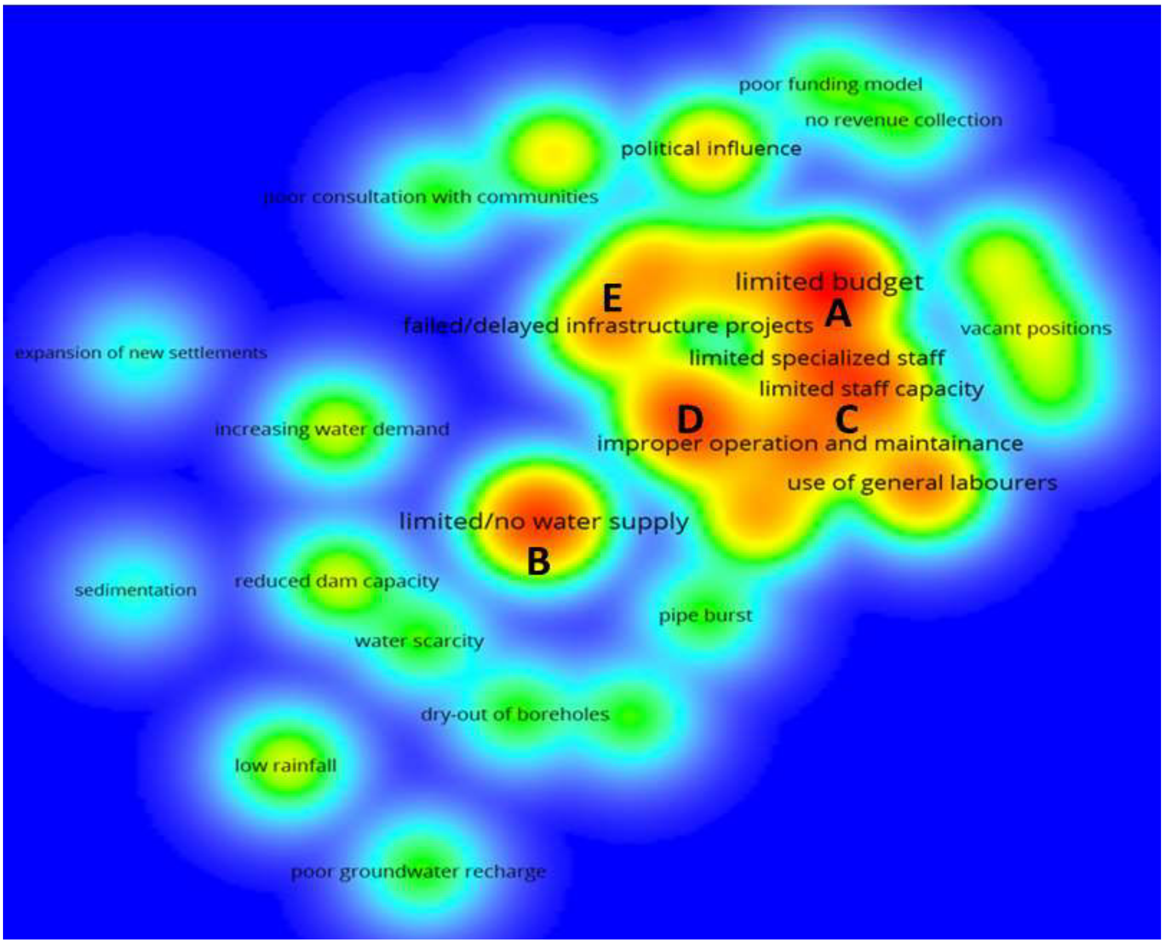


Figure 5.1 Energised network of factors affecting provision of Free Basic Water Services (FBWS) in Makhudutamaga municipality

The role of nodes in the network can be further understood using the BC and CC. This allows for a detailed analysis of the nodes and the network. Limited or no water supply has the highest BC and CC. This means that it has a strong influence on the flow of the network, and it is best placed compared to other nodes to be influenced or to influence other nodes. In this case, as shown by the red arrows in Figure 5.1, the flow of nodes leads to limited or no water supply, and it is influenced by most nodes. The limited budget also has high BC and DC, it influences the flow of the network as most of the nodes are influenced by it, and its influence results in limited/no water supply; therefore, it is an influencer in the network. Based on this, the flow of the network is from left to right.



The alphabets A, B, C, D and E represent priority problem areas in descending order

Density level: High Medium Low

Figure 5.2 Density visualization of the network

It is also important to understand the role of the nodes in the linkage of thematic communities identified in the network. The nodes in the ‘institutional arrangements and funding’ and ‘long-term sustainability’ thematic communities are more closely related compared to those in the ‘water availability’ community. The ‘water availability’ thematic community is separated at a noticeable distance from the other thematic communities. However, as indicated by BC and DC, the critical node in ‘water availability’ has a strong influence on the flow of the network. This is because it is influenced by the nodes within the thematic community and in the other thematic communities. Limited or no water supply is central to the connection with other thematic communities, and limited budget is central to the linkage of 'institutional arrangements and funding' and 'long-term sustainability' thematic communities. This again indicates the importance of the two nodes in the network.

5.4 Discussion

The networks depicted the complex interactions of factors that influence sustainable access to improved water services in the study area. The network consists of thematic communities resulting from the diversity, interconnectedness, and close association of the factors. It highlights the importance of analysing the factors' interactions at the level of a complex system and not in isolation, providing a coherent understanding of the factors. The sub-sections below present a discussion of the critical aspects and thematic communities of the network.

5.4.1 Institutional arrangements and funding

The challenge in the 'institutional arrangement and funding' thematic community is the failure (delayed/abandoned) of water infrastructure projects aimed at supporting water services provision. Within the thematic community, the challenges are due to political influence, top-down approach, and the lack of consultation with beneficiary communities. This is because, at a political level, especially during elections, communities are promised projects that are expected to address their water challenges (Muller, 2008). However, these projects can either be started and not completed or completed but with no water supply. Some projects fail because of limited budget', which is a critical factor within the 'long-term sustainability' thematic community and the network. The factor is influenced by a poor funding model used to fund investment in the development of water infrastructure and O&M. The fact that WSP does not collect water tariffs worsens the situation with regards to the availability of budget to fully support water service provision. The WSP depend on grants provided by the Department of Water Affairs and Sanitation (DWAS) and the Municipality Infrastructure Grant (MIG) to support water services provision. The equity-share model guides the allocation of the grants, which in most cases, does not consider the situation in the communities but considers the population served by the respective municipality. This results in challenges that affect the long-term sustainability of improved water services.

5.4.2 Long-term sustainability

The limited budget allocated for investment in new water infrastructure projects and O&M is a challenge faced by the WSP within the 'long-term sustainability' thematic community. This has resulted in a number of challenges that compromised the sustainable access to improved water services. The WSP operates with limited capacity to fulfil its mandate of water provision in the communities because it is short-staffed and has limited staff with specialised skills required to conduct proper O&M. This is even though the WSP through the assistance of external service provides having developed a comprehensive O&M strategy (*e.g.,* community water supplier mater plan) aligned to achieve the objective of the Water Supply Development Plan (WSDP) and IDP as well as to attain universal water access. The over-reliance on external service providers on issues to do with the development of strategies, infrastructure projects, and O&M is perhaps one of the reasons the budget allocated to the WSP is constrained. External service providers tend to take advantage of the situation and charge 'ballooned' fees for their services. However, because of the constrained budget, there are key vacant positions and the focus is on recruiting general labours that are not trained in doing the specialised work of O&M. This resulted in O&M being one of the critical challenges that influence sustainable access to improved water services. Ruiters (2013) states that in a situation where the budget is constrained, O&M is sacrificed over the development of new water infrastructure projects, which is what is being done by the WSP. The combination of constrained budget and limited staff has resulted in delays in the repair, replacement, and maintenance of critical water infrastructure (*e.g.* broken-down/stolen electric pumps), supported by findings of research study conducted in the study area by Hofstetter *et al.* (2020) . This has contributed to communities experiencing limited/no water supply.

5.4.3 Water availability

The challenge of limited or no water supply is not only resulting from improper O&M but also to do with water availability. The fact that the study area is located within a water scare district with low rainfall makes it challenging for the WSP to provide water services that meet the water demand of its residents. The annual rainfall received is not sufficient to replenish surface and groundwater sources. Many boreholes have been reported to have dried-out, and dam capacities are reducing (Sambo *et al.*, 2018; SDM, 2019). Population growth that has resulted in the expansion of residential areas in the communities has made the work of the WSP challenging. It is estimated that the annual average increases in population and households are 1.6% and 2.0%, respectively (SDM, 2020). The WSP is grappling to keep up with providing services due to that from 2008 to 2018, the number of households estimated to be using improved water services decreased with an annual average of 1.6% (SDM, 2020). It is estimated that the combined developed and undeveloped surface and groundwater sources will not meet the water demand by 2045 (SDM, 2020) - provided that there are no water infrastructure issues. However, 47% of the potential surface and groundwater sources have been developed, and the remainder is yet to be developed (SDM, 2020). The interviewees indicated that the challenge is worsened by traditional authorities that do not consult them when establishing new residential areas. As a result, the new residential areas are not included in the planning of the WSP. However, expectation once established is that the WSP should provide them with water services. This is problematic for the WSP as they are struggling to clear the water backlog, and it is increasing annually, as reported in the IDP report (SDM, 2020).

5.4.4 Summary

The network approach indicates the importance of capturing the complex interactions of complex factors that influence sustainable access to improved water services. The centrality of factors and the formation of communities within the network is key to the identification of critical problem areas. The thematic communities consist of different categories of factors and are linked by critical factors. This, as a result, indicates the importance of the factors in ensuring sustainable access to improved water services. The limitation in the available budget is a critical factor that influences sustainable access to improved water services. This is because it results in reduced investment in the development of new water infrastructure and improper O&M. As a result, communities experience limited or no water supply, which is also caused by scarce water resources, *visa-viz* population growth. However, given more than half of the potential surface and groundwater resources are not yet explored. Addressing the issues with limitations in the budget can result in the development of critical water infrastructures in priority areas and proper O&M. This, as a result, is expected to result in the long-term sustainability and access of improved water services.

5.5 Conclusion and Recommendation

The study investigated and analysed the complex interactions of the factors that influence sustainable access to improved water services. Critical factors that influence sustainable access to improved water services were identified as a result of their complex interactions. It resulted in a coherent understanding of the factors, providing a clear picture of the context where factors interact to influence an outcome regarding water service provision. Limited budget, limited/no water supply and improper O&M were some of the critical factors/problem areas that have a more significant influence on sustainable access to improved water sources. However, most of the issues culminated from the limited budget. Therefore, identification of the critical factor allowed for the development of targeted interventions that can contribute to sustainable access to improved water services.

It is recommended that the relevant authorities responsible for water services provision adopt the findings of the study to inform planning and management as well as strategies contributing to sustainable access to improved water services and improvement of rural livelihoods.

5.6 Limitations of the study

The limitations of the study are as follows;

(a) COVID-19 lockdown restriction and time constrain did not allow the researcher to include community members in the key informant interviews. As a result, the findings of the research are not representative of the community perspective. However, interviewing more people could have resulted in saturation of the information provided. This can be explored in future research.

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6. A FRAMEWORK TO IMPROVE SUSTAINABLE ACCESS TO FREE BASIC WATER SERVICES IN MAKHUDUTAMAGA LOCAL MUNICIPALITY, SOUTH AFRICA

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Abstract

Sustainable access to improved water services is vital to enhance wellbeing, public health and livelihoods of rural communities. However, a vast proportion of the rural population still do not have sustainable access to improved water services. This is because of a number of challenges that include lack of current and reliable information to inform planning, monitoring and management as well as formulation of targeted interventions. This study responded to the identified gap with regards to availability of reliable information to inform decision making. It illustrate the use of a monitoring framework to inform decision-making in addressing water services issues at the local context. Survey questionnaires and key informant interviews were employed to collect qualitative and quantitative data. The results of this study indicate that the illustrated framework can be used to address water services challenges in the local context. The monitoring framework covers aspects of making data available, data analysis and use of the data to inform formulation of targeted interventions. Increased budget, improved institutional capacity, community participation and improved monitoring were identified as some of the targeted interventions that can contribute to sustainable access to improved water services. It was concluded that the proposed framework is suitable for use at the level of the water service provider (WSP). The recommendation is for WSP to adopt the proposed framework complementing existing systems.

Keywords: decision-support, framework, local planning, monitoring, improved water services

6.1 Introduction

The right to sufficient water for all is stated in the constitution of South Africa was key to conceiving and implementing of the Free Basic Water Services (FBWS) policy. The FBWS policy was in response to the need to provide its citizens (mostly in rural communities) with water to meet their basic water needs (DWAF, 2002). This is because, after 1994, it was realized that most people residing in the former homelands were without sustainable access to improved water services to meet their daily water needs (Muller, 2008). However, implementation of the FBWS policy has had challenges. This is evident from the recent estimates that indicate that a vast proportion of the rural communities still lack sustainable access to improved water services provided by improved water source (IWS) (*e.g.* standpipe connected in dwelling or communal standpipe) (Muller, 2008; Statssa, 2016; SDM, 2020).

In an attempt to ensure sustainable access to improved water services, in the early 2000s, the South African government began a process of decentralization of powers and functions of water services provision to local government. The rationale for decentralization was that local municipalities have an information advantage over a centralised government regarding local needs and priorities (Steiner, 2007). This, as a result, would inform planning, management and evidence-based strategies to ensure equitable resources allocation as well as improve public participation and accountability (Steiner, 2007). Despite the outline benefits of decentralization, there have been challenges with regard to water services provision in rural communities. These challenges include weak institutional capacities and limited resources to effectively provide improved water services (Blair, 2000; Crook, 2003; Devas and Grant, 2003; Jiménez and Pérez-Foguet, 2011; Giné-Garriga *et al.*, 2015). This is worsened by the lack of current and reliable information systems capable of describing the situation on the ground with regard to the level of water services provided in rural communities (Giné-Garriga *et al.*, 2015).

A reliable information system is crucial to holding WSPs accountable for the level of water services provided in rural communities. To achieve this, there is indeed a need for an innovative decision support framework to bring about accountability and equitable resources allocation (Blair, 2000; Devas and Grant, 2003). The decision support framework should be supported by availability and accessibility of current and reliable information to identify challenges with water services provision and communities at risk at various administrative scales or levels as well as improve transparency in budget allocation procedure and monitor progress (Giné-Garriga *et al.*, 2018). Unfortunately, information is not always available in rural communities, and even when available, there is limited evidence that it is appropriately used to inform decision-making. Giné-Garriga *et al.* (2015) states that decision-making is influenced by political will combined with poor institutional capacities disregarding available information, a point that is also supported by Hofstetter *et al.* (2020). This results in poor targeting of high risk communities and deviation of investments earmarked to support water services provision.

It is against this background that this study sought to address the gap that exist with regard to the lack of current and reliable information in the local context to inform planning, monitoring and decision-making. The study demonstrates making available reliable and current data to use to inform formulation of targeted interventions to address issues that hinder water services provision in a rural communities. The objective of this study was to propose and illustrate a monitoring framework to guide decision-making in management, monitoring and planning of improved water services with a policy implication. The results of this study, if adopted are expected to contribute to sustainable access to improved water services in the study area. It is worth noting that in his that was study conducted in the study area, Sambo (2015) proposed site-specific best management practices to address causes of failure of IWS and unimproved water sources. The proposed monitoring framework is advanced compared to best management practises as the proposed targeted interventions are informed by linking household perceptions of the water services with an assessment of the level of water services complemented by an investigation and analysis of complex factors that influence sustainable access to improved water services.

6.2 Material and Methods

6.2.1 Study area

The study was conducted in the 4 water schemes that cut across the Makhudutamaga Local Municipality (MLM). The water schemes are De hoop (DH), Flag Boshielo (FB), Local

Resources (LR) and Piet Gouws (PG). A detailed description of the study area is presented in Chapter 3, sub-section 3.2.1.

6.2.2 Research approach

A cyclic stepped approach was adopted to attain the objective of this study (*cf.* Figure 6.1). The approach takes into account the availability of relevant, current and reliable data that supports comprehensive understanding of water services provision in rural communities. A comprehensive understanding of water services provision results in identification of challenges that present an opportunity for improvement of the water service (Giné-Garriga *et al.* (2015). It is therefore crucial to present the results in a manner that is simple and understandable to intended users of the information to enhance their understanding of water service provision for effective decision-making(Giné-Garriga *et al.*, 2013). In the context of this study, decision-making involves the use of relevant, current and reliable data to inform formulation of targeted interventions in addressing challenges that result in an outcome of water services provision. Table 6.1 shows a summary of the actions taken in each step of the approach from data collection to formulation of target interventions to contribute to sustainable access to improved water services in the study area.

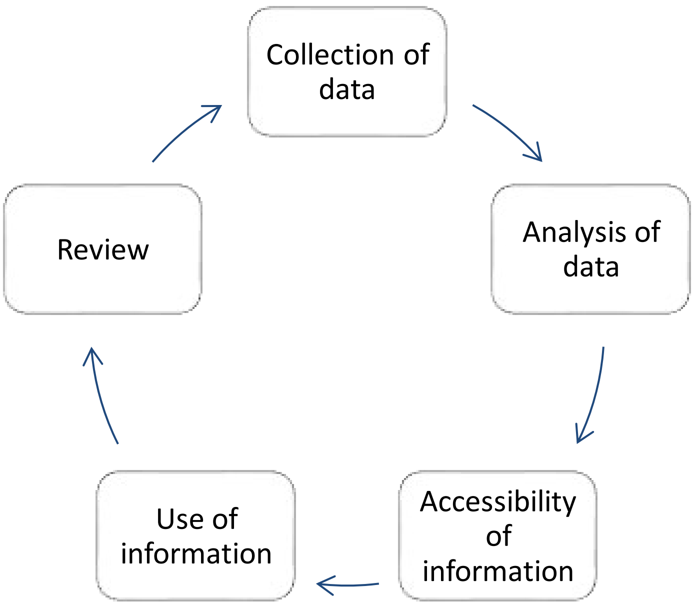

Figure 6.1 Steps of the monitoring framework

Table 6.1 Summary of the actions taken to illustrate application of the monitoring framework

No.	Step	Action taken
1.	Data collection	• Administrated household surveys to collect data on household (user) perception regarding water service and level of water services (*cf.* Chapter 3 and 4). • Conducted key informant interviews to collect data on factors that influence sustainable access to improved water services (*cf.* Chapter 5).
2.	Analysis of data	• Employed statistical methods to analyse household surveys data (*cf.* Chapter 3 and 4). • Employed systems approach to analyse key informant interview data (*cf.* Chapter 5)
3.	Accessibility of information	• Employed maps to presented results of the household surveys using a 5 point Likert scale (*cf.* Chapter 3 and Chapter 4). • Employed network approach to present the results of the key informant interviews (*cf.* Chapter 5) • Employed a risk approach to link household surveys and key informant interviews results to flag challenges with the improved water services provided posing risk in terms of water access in the water schemes.
4.	Use of information	• Employed a matrix approach to propose targeted interventions for the identified challenges based on the information
5.	Review	• Review of the steps (1, 2, 3 and 4) taken to ensure that the information is applied correctly to proposed targeted interventions that will result in the expected outcome.

Data collection: The step involves making available relevant, current and reliable data to bring about a comprehensive understanding of the water service provision from the perspective of the water users (households), water service level and Water Service Provider (WSP). A survey questionnaire was administrated to collect data on household perceptions as a feedback mechanism of their experience using improved water services provided according to the Free Basic Water Services (FBWS) policy standards (for detailed explanation, *c.f.* Chapter 3, section 3.2). A second survey questionnaire was administrated to collect data to inform a set of indicators (*e.g.* distance, quantity and cost) derived from the FBWS standards, which are representative of the level of water services provided (for detailed explanation, *cf.* Chapter 4, section 4.2). To get a complete picture of the situation on the ground it was essential to look beyond data on household satisfaction and water services level and integrate a broader view of water services provision, supported by Giné-Garriga *et al.* (2013). To attain this, key informant interviews we conducted at the level of the WSP to collect data on factors that influence sustainable access to improved water services in the study area (for detailed explanation, *cf.* Chapter 5, section 5.2). As a result, data on institutional, social, technical and environmental factors that influence sustainable access to improved water services was collected.

Data analysis: Descriptive (*e.g.* cross-tabulations) and inference (*e.g.* Kruskal-Wallis) statistical approaches (*cf.* Chapter 3 and Chapter 4) were employed to analyse the qualitative and quantitative data of both survey questionnaires to derive estimates and ranges. The systems approach (network analysis) was used to analyse the qualitative data collected from the key informant interviews to identify critical factors that influence sustainable access to improved water services in the stud area.

Accessibility of information: This step involved presenting the results in a manner that is simple and understandable to the intended users. Maps (*cf.* Chapter 3 and Chapter 4) were used to present statistical estimates and ranges based on the classifications shown in Table 6.2. A risk assessment approach was used to reclassify the classifications of the household satisfaction and water services level based on identified risk (*cf.* Table 6.2). The use of maps and classifications to present the results allowed for the identification and prioritisation of aspects of the water services provision and water schemes experiencing challenges. In support of this, the critical factors that influence sustainable access to improved water services were presented using a network (*cf.* Chapter 5, section 5.3). The sizes of the nodes in the network made it simple to identify critical factors that influence water access.

Use of information: a matrix approach was employed to link identified challenges, risk level, proposed interventions and expected outcomes.

Review: the step involves the review of previous steps (1, 2, 3 and 4) taken to verify that the information was properly applied to proposed targeted interventions that will result in the expected outcome.

Table 6.2 Classification of improved water services

No.	Water user classification	Water services level classification	Risk classification
1.	Very satisfied	Excellent	Low
2.	Satisfied	Good	
3.	Neither	Moderate	Medium
4.	Unsatisfied	Poor	High
5.	Very unsatisfied	Very poor	

6.3 Results

This section presents a brief situation analysis of water services provision issues in the study area from the perspective of the water user (households), water service level, and WSP. From the results, challenges that influence sustainable access to improved water services were identified and interventions were proposed with expected outcomes. The focus is to illustrate a monitoring framework that can be used at the level of the WSP to inform monitoring, planning and formulation of targeted interventions with a policy implication.

6.3.1 Situation analysis

Table 6.3 shows the risk classification in the study area based on households' satisfaction with the improved water services provided according to the FBWS standards. There was low-risk in terms of households' satisfaction with the return distance walked and the quantity of water collected, except in PG. In PG, there was high-risk in terms of households' satisfaction with the return distance walked to access improved water services. The high-risk in the distance can be linked to the medium-risk in terms of households' satisfaction with the quantity of water collected. This is because when households walk long distances to access water from improved water services, the quantity of water collected decreases as the distance walked increases, as supported by Howard and Bartram (2003). However, this can also be linked with the high-risk in satisfaction in the reliability of the improved water services, which can also be linked to high-risk in satisfaction with the cost of buying water. Surprisingly, in LR, the households' satisfaction with the cost of buying water was low-risk.

The results provide feedback in terms of households' experience of the improved water services provided and flag potential areas of improvement to increase household satisfaction. However, it is important to link household satisfaction with water service level to identify mismatches and aspects of the improved water services that require improvement to comply with the FBWS standards.

Table 6.3 Water scheme risk assessment based on household satisfaction

FBWS indicators	Water schemes			
	De Hoop (DH)	*Flag Boshielo (FB)*	*Local Resource (LR)*	*Piet Gouws (PG)*
Distance	*Low*	*Low*	*Low*	*High*
Quantity	*Low*	*Low*	*Low*	*Medium*
Reliability	*High*	*Medium*	*High*	*High*
Flow rate	*Medium*	*Low*	*Low*	*Low*
Quality	*Medium*	*Low*	*Low*	*High*
Cost	*High*	*High*	*Low*	*High*

Table 6.4 shows the risk classification based on FBWS standards as indicators of the level of improved water services provided in the study area. The results indicate that in terms of distance, the risk was low in all the water schemes. However, this was contrary to the results of the households' satisfaction were distance was high-risk in PG. This was attributed to the water is salty discharged from IWS resulting in households walking long distances to access alternative water sources. This was an indication that simply being provided with an IWS within the recommended distance does not automatically translate that households' are experiencing intended service as certain aspects of the water services can change over time. In terms of quantity, households were at high-risk as they do not collect the recommended quantity of water in litres/capita/day when reliability of the improved water services is

factored. However, this does not correlate with the results of the households' satisfaction. It can be attributed to the fact that households were satisfied with the quantity of water collected when IWS were operational as they filled water in tanks, drums and containers for later use. However, when factoring in reliability of the improved water services, the quantities of water collected decreased dramatically, which is what is reflected in Table 6.4. This as results has compelled households to buy water. The cost of buying water was a high-risk in all the water schemes. This was contrary to the households' satisfaction with cost of buying water which was low-risk.

The results provide useful information that can be used to understand aspects of water services provision that require improvement and identify water schemes at risk requiring urgent attention. However, this is not enough to address the water services provision challenges as it only tells you of what is going wrong with the service and areas at risk. Therefore, understanding factor that influence sustainable access to improved water services can help address the water services challenges.

Table 6.4 Water scheme risk assessment based on benchmarking of water services

FBWS indicators	Water schemes			
	De Hoop	*Flag Boshielo*	*Local Resource*	*Piet Gouws*
Distance	*Low*	*Low*	*Low*	*Low*
Quantity	*High*	*High*	*High*	*High*
Reliability	*High*	*High*	*High*	*High*
Flow rate	*Medium*	*Medium*	*Medium*	*Medium*
Quality	*Medium*	*Low*	*Low*	*High*
Cost	*High*	*High*	*High*	*High*

The results of an investigation of the factors that influence sustainable access to improved water services indicated that limited budget, limited/no water supply, improper O&M, and failed water infrastructure projects are some of the critical factors resulting in water services not to comply with the FBWS standards. These critical factors are not standalone; they interact with other factors resulting in an outcome of water services provision.

6.3.2 Proposed targeted interventions

The last step of the monitoring framework is the formulation of targeted interventions. Table 6.5 shows the proposed targeted interventions derived from the results presented in the sections above. Given the dynamic nature of water-related issues, the proposed interventions can periodically be reviewed based on the availability of current, relevant and reliable data to inform decision-making.

Table 6.5 A matrix of challenges, risk level, interventions, and expected outcomes

Item	Challenges	Risk	Proposed interventions	Responsibility	Expected outcome
1.	Limited budget	High	• Review the funding model to respond to the situation on the ground-based on monitoring information • Improve budget allocation to respond to the new water infrastructure needs and operating and maintenance • Implement minimal fixed water tariff of 3% of the household income to support operation and maintenance (O&M), supported by World-Bank (2011) • Reduce over-reliance on external service providers and build internal capacity	• Water service authority • Water services provider • Department of Water Affairs and Sanitation	• An adequate budget that responds to new water infrastructure needs and operation and maintenance of existing water infrastructure inform by current data.
2.	Limited/no water supply	High	• Targeted investment in the development of 57% of the undeveloped surface and groundwater sources • Implement a programme to educate communities about available water resources and efficient use of water to manage expectation to reduce service delivery protest • Develop and implement a reasonable participatory water rationing strategy • Improve communication with traditional authorities on issues related to the expansion of residential land and water service provision to support planning	• Water service authority • Water services provider	• Increased availability of water to cater for the communities • Improved reliability of the improved water services • Efficient use of water with an understanding that water is a scarce natural resource • Community expectations managed and water service provision protests eliminated as a result of the understanding level of water services that can be provided with available water resources
3.	Improper operation and maintenance of infrastructure	High	• Recruit competent staff with the relevant qualification and skills to support O&M activities • Build capacity of existing staff (e.g. general labours) to support O&M activities • Procure commonly needed spare parts to support proactive maintenance	• Water service authority • Water services provider	• Improved internal capacity to conduct O&M • Reduce reliance on services provides improving efficiency • Improved reliability of the improved water services • Affordable cost of water as households would not be forced to buy water

Item	Challenges	Risk	Proposed interventions	Responsibility	Expected outcome
4.	Failed water infrastructure project	High	• Involve communities in the identification of water-related challenges and planning and implementation of the water projects • Manage political influence by implementing a community-centred approach in planning and implementation of water infrastructure projects	• Water service authority • Water services provider • Traditional leadership • Political representatives	• Increased participation of communities in planning and implementation of water infrastructure projects. • Increased community sense of ownership of the water infrastructure • Increased success rate of water infrastructure projects
5.	Poor communication between WSP and communities	High	• Develop and implement an effective participatory communication strategy to facilitate communication between Water Services Provider (WSP) and communities	• Water service authority • Water services provider • Traditional leadership	• Improved communication between WSP and communities
6.	Monitoring and planning	High	• Develop and implement a monitoring and planning strategy that guides collection of water services provision data based on Free Basic Water Services (FBWS) standards and allows for prioritization of communities based on risk to formulate targeted interventions	• Water service authority • Water services provider	• Monitoring based on FBWS standards which reflect the level of water services provision • Planning based on current and reliable data • Strategies and policies review based available and accessible empirical data

6.4 Discussion

The proposed targeted interventions are suitable to address the challenges that influence sustainable access to improved water services in the study area. This is because the proposed interventions are practical in nature and are presented in a manner that can be understood by decision-makers who are in most cases non-technical and solution and action orientated. The packaging of the proposed interventions is to promote their uptake at the level of the WSA and WSP in the study area, as discussed below.

6.4.1 Limited budget

The limited budget is a critical aspect that can be addressed by conducting a review of the funding model that guide investments in water infrastructure projects and O&M. The current grant-based model which the WSP is heavily reliant on does not respond to the situation on the ground concerning water services provision, and it is unsustainable; this is supported by Muller (2008). The WSP needs additional income streams to be sustainable and deliver on its mandate of water services provision according to the FBWS policy. For example, the review should consider the introduction of a minimum water tariff charge of 3% of the total income of the household, supported by World-Bank (2011). A minimum water tariff of ZAR 50 per household (based 3% of the average pension grant of R 1 800 in South Africa) multiplied by the population of households (around 62000) would generate an additional income of around ZAR 3.1 million per month (theoretical and assuming high compliance), which is equivalent to ZAR 37.2 million annually. The additional income from the minimum water tariff can be utilized to reduce the O&M backlog. However, payment of water tariffs has the potential of making the communities demand a higher level of improved water services or even resist paying for water, supported by Van Houtven *et al.* (2017). Therefore, the determination of the minimum water tariff should be conducted through a participatory approach that involves the communities to encourage a high level of compliance when it is eventually implemented.

6.4.2 Operation and maintenance

In addition to funding, the WSP should invest in the development of its staff capacity, more specifically on the filling of vacant positions and training of existing staff responsible for O&M. Training of staff would improve internal institutional capacity to properly conduct O&M and reduce over reliance on external services providers that charge exorbitant fees for work done, this is supported by Hofstetter *et al.* (2020). This should be supported by the procurement of spare parts in line with the developed O&M strategy to support proactive maintenance. Commonly used spare parts should be stored in bulk in a secured place to reduce delays in repairs. The use of spare parts should be recorded to have an updated record of available stock to know which spare parts need to be ordered on time and reduce theft. Addressing these issues associated with O&M is expected to enhance the reliability of improved water services, ensuring continues water supply.

6.4.3 Limited/no water supply and communication

Water supply is not only dependent on O&M, but it is also a factor of available water resources *vis-a-viz* demand. There is little the WSP can do to change the water scarcity situation, which is a national challenge. However, programmes targeted at educating communities about the management of available water resources and efficient use of water can go a very long way in managing their expectations and service delivery protests, this is also supported by a study conducted by Hofstetter *et al.* (2020) in the study area. Additionally, communication between WSP and traditional authorities should be improved by holding meetings to discuss water related issues which include expansion of residential land *vis-a-viz* water services provision and a water rationing strategy. The meetings should be held in line with the jointly developed communication strategy/plan to ensure participation. However, new residential developments should be provided with improved water services. This can be achieved through investment in the development of the undeveloped surface and groundwater sources. Developing the water resources should be implemented in a sustainable manner striking a balance between water-demand and the environment.

6.4.4 Failed water infrastructure project

The development of water resources means new water infrastructure projects which require a budget and often as a result of political influence to score political mileage, as reported by Sambo *et al.* (2018) and Hofstetter *et al.* (2020). Political influence should be managed at all cost by engaging communities about their water-related issues and involve them in the planning and implementation of water infrastructure projects. It will result in demand-driven water infrastructure projects managed and monitored by communities to ensure their success. The politicians should be involved in mobilizing funds to support demand-driven water infrastructure projects which have a greater chance of success.

6.4.5 Monitoring and planning

However, success comes with accountability, which means there will be a need to monitor the level of water services to implement corrective measures and inform planning and management. Consistent monitoring of the aspects of improved water service will ensure that plans and policies are reviewed based on current and reliable information. This is expected to result in sustainable access to improved water services fulfilling the constitutional human right to sufficient water for all.

6.5 Conclusion and Recommendation

The study illustrated the use of the proposed monitoring framework from data collection to using the available information to formulated target interventions in addressing issues with water services provision in the study area. The information derived from the use of the framework if used appropriately can contribute to sustainable access to improved water services. This is because it allows for assessment of improved water services and identification of challenges from the perspective of the water user, water services level, and WSP. The information from the assessment and identified challenges can inform planning and monitoring as well as the formulation of targeted interventions that are practical for use in the local context resulting in investment in water infrastructure projects and O&M. However, there is a need to demonstrate the use of the proposed monitoring framework at a community or ward level. This will yield more focused results that can be used to address challenges at the respective level. However, it would still be a struggle to address the challenges if the issues with the WSP are not addressed before moving to a low level. There is also a need to explore ways in which the monitoring framework can be institutionalised at the level of WSP to complement existing internal systems and capacity.

It is recommended that the proposed framework should be practically piloted and if suitable, adopted by the WSP to support decision-making in addressing challenges with water services provision.

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7. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

In summary, the focus of the study was to assess inequalities in sustainable access to improved water services in the study area. In addition, investigate and analyse the complex interactions of the factors that influence sustainable access to improved water services to propose site-specific targeted interventions. To achieve this, an assessment of households' satisfaction with Free Basic Water Services (FBWS) policy standards and water services provided was conducted. The assessment brought about an understanding of households' satisfaction with the FBWS standards and water services provided to identify potential areas of improvements with the policy and water services. To enhance understanding concerning water services provision in the study area, the FBWS standards were used as a set of indicators to benchmark sustainable access to improved water services. The information derived from the households satisfaction and bechmarking reflected inequalities in sustainable access to improved water services. However, the information did not provide reasons as to why the situation with regard to water services provision was as it was in the study area. Therefore, an investigation of the factors that influenced sustainable access to improved water services was conducted to bring about a coherent understanding of the situation in terms of water services provision. The information generated from the assessments and investigation informed the formulation of targeted intervention. Therefore, the steps employed by the study illustrate a monitoring framework that can be used at both the Water Services Authority (WSA) and Water Services Provider (WSP) level to support decision making.

7.2 Conclusions

It was concluded that households were satisfied with the FBWS policy standards and aspects of the water services provided. The high percentage of households satisfied with the FBWS policy standards is indicative of the policy's relevance and if properly implemented, can result in high household satisfaction with the water services provided. However, the households' satisfaction with improved water services provided indicated that the FBWS policy was not properly implemented. The assessment flagged potential areas of improvement with aspects of the water services regarding reliability and cost of buying water. The fact that households have access to IWS did not translate that households' were satisfied with the improved water service provided. In most cases, a consistent benefit derived from an improved water service is having it within the recommended distance, as was evident in the study area.

To have an enhanced understanding of water services provision, there was a need to also benchmark improved water services provided according to FBWS standards. A set of indicators derived from the FBWS standards were used to benchmark improved water services in the study area. Aspects (*e.g.* quantity, reliability and cost) of the improved water services provided did not comply with the FBWS standards. And there were inequalities in sustainable access to improved water services across the water schemes. As a result, some households were experiencing patchy access to water. The information derived from the assessment of households' satisfaction and level of water services provide is useful to understand improved water services coverage and identification of communities within a certain geographical area that are at risk.

To have a coherent understanding of the water services provision in a broader view, it was necessary to investigate and analyse complex factors that influence sustainable access to improved water services. Limited budget, limited/no water supply and improper O&M were critical factors/problem areas that had a more significant influence on sustainable access to improved water services. Most of the factors culminated from the limited budget. The identification of the factors resulted in a coherent understanding of the factors, providing a clear picture of the context where factors interact to influence an outcome regarding water services provision.

The last stage of this study illustrated the use of information in a monitoring framework to inform planning and monitoring, and formulation of targeted interventions. The proposed monitoring framework was suitable for use by decision-makers at the level of the WSP involved in planning, management and monitoring as well as the formulation of strategies. The information derived from the use of the framework, if used appropriately, can contribute to sustainable access to improved water services. This is because it allows for the identification of challenges from the perspective of the water user, water services level, and

WSP. The identifications of challenges allows for the formulation of targeted interventions that are practical for use in the local context resulting in investment in water infrastructure projects and O&M. However, there is a need to demonstrate the use of the proposed framework at a community or ward level. This will yield more focused results that can be used to address challenges at the respective level. However, it would still be a struggle to address the challenges if the issues with the WSP are not addressed. There is also a need to explore ways in which the monitoring framework can be institutionalised at the level of WSP to complement existing internal systems.

7.3 Recommendations

The recommendations of the study are as follows;

(a) WSP should use a set of indicators to track water services provided through IWS to ensure that they are providing the intended water services. The information derived from the set of indicators regarding water service provided can be used for the planning and management of IWS as well as inform policies and prioritization of high-risk groups.

(b) WSP should address the unreliability of IWS, which results in reduced water services. The fact that most of the households have access to IWS within the recommended distance, the water quality is perceived to be good, and the flow rate is generally acceptable, it is a plus for the WSP, and once unreliability is resolved households will experience the intended water services.

(c) For the WSP, they should use the proposed targeted interventions to address challenges that influence sustainable access to improved water services in the study area.

(d) Proposed monitoring framework should be piloted at the level of the WSP and if found to be practical, should be adopted by the WSP to support decision-making in addressing challenges in water services provision. However, the adoption of the framework would also involve an assessment of the institutional mechanisms used by the WSP to explore how they can complement each other.

7.4 Future Research Needs

The research made future research recommendations as follows;

(a) Conduct similar studies in other local municipalities in the district that is focused at community level instead of main water scheme with a chemical water quality assessment included.
(b) A review of the current funding models to explore innovative ways the WSP can increase its revenue to support investment in water infrastructure projects and O&M.
(c) Assessment of communities' willingness to pay for an improved water services to support O&M.
(d) Assessment of available water resources to propose an equitable water rationing strategy.
(e) Investigation of factors that influence household satisfaction of the water services provided.
(f) Investigate the factors that makes water users not to feel safe when waking from the households to collect water and collecting water from improved water sources and unimproved water sources.

7.5 The Originality of the Study

The originality of the study is attributed to the following;

(a) The study assessed the perceptions of households to understand their satisfaction with the FBWS standards. As assessment of household satisfaction of all the FBWS standards in one study has not been conducted in South Africa.
(b) The study assessed the perception of households to understand their satisfaction with the level of water services provided. The assessment of improved water services using all the FBWS standards in one study has not been conducted in South Africa.
(c) The study used a set of indicators to access inequalities in sustainable access to improved water services. The use of all the FBWS standards as a set of indicators to assess inequalities in sustainable access to improved water services has not been conducted in South Africa.

8. APPENDIX A: GATEKEEPS LETTER

SEKHUKHUNE
District Municipality

Private Bag X8611 Groblersdal 0470, 3 West Street Groblersdal 0470
Tel : (013) 262 7300, Fax: (013) 262 3688
E-Mail : sekinfo@sekhukhune.co.za

Enq: S P LEKGORO
REF: SK4/1/1/1/1

Mr. Calvin Sambo
University of Kwazulu Natal
Bioresources Engineering
School of Engineering

Dear Mr. Sambo

This letter serves to confirm that you are allowed to do a research project which will contribute to the body of knowledge in the area of discipline Water Resource Management.

The Municipality will be happy if you can privilege it with the copy of the Dissertation after completion of your studies so that we can concentrate on research findings and recommendations.

This will be beneficial to more than 1 Million People of the District.

Hoping that you find the above in order

Yours Fa[redacted]

DIRECTOR: CORPORATE SERVICES
Mr. S P LEKGORO
Date: 9/10/2018

9. APPENDIX B: ETHICAL CLEARANCE LETTER

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

16 January 2020

Mr Doctor Calvin Sambo (208514293)
School of Engineering
Howard College Campus

Dear Mr Sambo,

Protocol reference number: HSS/0863/018D
Project title: Investigating inequalities in improved water sources coverage using developed indicator(s) in selected rural municipalities of South Africa

Approval Notification — Expedited Application

In response to your application received on 25 November 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted FULL APPROVAL.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

This approval is valid for one year until 16 January 2021.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

Yours sincerely,

[redacted]

Professor Urmilla Bob
University Dean of Research

/ms

Cc Supervisor: Professor O Mutanga & Dr A Senzanje
cc Acting Academic Leader Research: Professor Akshay Saha
cc School Administrator: Ms N Dlamini

Humanities & Social Sciences Research Ethics Committee
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** [illegible] / [illegible]
Website: www.ukzn.ac.za

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10. APPENDIX C: SURVEY INSTRUMENTS (CONSENT FORM, HOUSEHOLD SURVEYS (A), WATER POINT INFORMATION (B) AND KEY INFORMANT INTERVIEWS (C)

DECLARATION OF CONSENT

PROJECT TITLE: INVESTIGATING INEQUALITIES IN IMPROVED WATER SOURCES COVERAGE USING DEVELOPED INDICATOR(S) IN SELECTED RURAL MUNICIPALITIES OF SOUTH AFRICA

RESEARCHER

Full Name: Calvin Sambo
School: Engineering
College: Agriculture, Engineering & Science
Campus: Pietermaritzburg
Proposed Qualification: PhD
Contact: 0834775609
Email: calvinsambo@gmail.com

SUPERVISOR

Full Name of Supervisor: Dr A Senzanje
School: Engineering
College: Agriculture, Engineering & Science
Campus: Pietermaritzburg
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Email: senzanjea@ukzn.ac.za

HSSREC RESEARCH OFFICE

Full Name: Prem Mohun
HSS Research Office
Govan Bheki Building
Westville Campus
Contact: 0312604557
Email: mohunp@ukzn.ac.za

I, **Calvin Sambo**, Student no. **208514293** am a PhD student, at the School of Engineering, at the University of Kwazulu Natal. You are invited to participate in a research project entitled: INVESTIGATING INEQUALITIES IN IMPROVED WATER SOURCES COVERAGE USING DEVELOPED INDICATOR(S) IN SELECTED RURAL MUNICIPALITIES OF SOUTH AFRICA. The aim of the study to map geographical inequalities in improved water access using developed indicators that incorporate sustainability aspect of IWS, and analyse the complex interactions of the factors that affect water access.

Basically the research has different components, and the component I would like your assistance with is on assessing your satisfaction as a water user with the benchmark indicators used for basic water services. Indicators referring to a measure of a certain aspect of water services provided. Basic water services referring to water services provided to meet you minimum water needs for drinking, food preparation and personal hygiene. I guarantee that your responses will not be identified with you personally. Your participation is voluntary and there is no penalty if you do not participate in the study. Please sign on the dotted line to show that you have read and understood the contents of this letter. The questionnaire will take approximate 10 minutes to complete.

DECLARARTION FOR CONSENT

I…………………………………………………………………………………………(Full Name) hereby confirm that I have read and understand the contents of this letter and the nature of the research project has been clearly defined prior to participating in this research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

Participants Signature……………………………………………………………………………………

Date……………………………………………………………………

Tsebišo semmušo ya tumellano

Leina la Projeke: Nyakišišo ya tekatekano ya mehlodi ya meetsi a hlekilego ka bophara, re šomisa maswao a maemo a godimo mebasepaleng ya selegae ya afrika borwa.

MONYAKISISI

Leina: Calvin Sambo
Sekolo: Entsenere
Lefapa: Temo, Entšenere le saense
Khamphase: Pietermaritzburg
Thutelopelo: PhD
Kgokaganyo: 083 4775609
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MOLAODI

Leina:
Sekolo: Entsenere
Lefapa: Temo, Entšenere le saense
Khamphase: Pietermaritzburg
Kgokaganyo: 0332606064
Imeile: senzanjea@ukzn.ac.za

OFISI YA DINYAKIšIšO YA HSSREC

Maena ka botlalo: Prem Mohun
Ofisi ya HSS ya dinyakišišo
Moagong wa Govan Mbeki
Khamphaseng ya westville
Khokaganyo: 0312604557
Imeile: mohunp@ukzn.ac.za

Ke nna Calvin Sambo, nomoro yaka ya boithuto ke 208514293. Ke moithuti wa PhD lefapeng la entšenere yunibesiting ya Kwa Zulu Natal. Le amengwa go tšea karolo go projeke ya pukwana ya nyakišišo e bitšwago:

Nyakišišo ya tekatekano ya mehlodi ya meetsi a hlekilego ka bophara, re šomiša maswao a maemo a godimo mebasepaleng ya selegae ya afrika borwa.
Maikemišetšo a boithuto jona kego nyakišiša tekatekano ya khumano ya tlhweko ya meetsi re šomiša maswao a maemo a godimo a nalego dikokwane tše swarelelago tša dihlodi tsa meetsi a hlekilego (mehlala: meetsi a dipaepe le ago boriwa). Re tswela pele re sekaseka boima jwa mekgwa ye e amago khumanego ya meetsi a.

Ka bokopana, pukwananyakišišo ye e leka go ka humana ditsela tšago hwetša meetsi a hlwekilgo lego kwišiša mabaka ka moka a thibelago khumanego ya meetsi mebasepaleng ya selegae ya Afrika Borwa. Goya ka ditlamorago tša dinyakišišo tše, maele a tlo fiwa mafelo a humanego a nale bothata jwa khumano ya hlweko ya meetsi lego ka rarolla mathata a bona. Ge le dumela go tšea karolo mo dinyakišišong tše, ke tshepiša gore dikarabo tša lena gadi tlo amanywa le maina a lena. Go tšea karolo mo dinyakišišong tše ke ka boithaopo fela. Ga gona kotlo ye le tla e fumanago ge o kgetha go se tšeye karolo mo. O kgopelwa go saena mo methalong ya ka fase go bontšha gore le badile le go kwišiša tše di ngwadilego mo lengwalong le. Diputšišo di tlo tšea tekano ya metsotso e lesome fela.

Tsebišo semmušo ya tumellano

Ke nna ………………………………………….(Maina ka botlalo) ke dumela gore ke badile lego kwišiša lengwalo le, le tšeo di nyakegago mo projekeng di hlalošitšwe ka tsela ye bonolo pele ke tšea karolo mo go yona.
Ke kwišiša le gore ke nale maatla a go tšwa mo projekeng ye nako engwe lengwe ge ke ikwa ke sa hlwele ke nale kganyogo ya go tsea karolo.

Tshaeno ya Motšeakarolo…………………………..
Letsatsi………………………..

SECTION A: HOUSEHOLD SURVEYS

A. GENERAL INFORMATION

Date: ………………………………………………………………………………………

Ward No: ………………………………………………………………………………………

Water Point ID: ………………………………………………………………………………………

B. Demographics

1)	Gender:	[ ] Female	[ ] Male	
2)	Age group:	[ ] 18-30 [ ] 51+	[ ]31-40	[ ] 41-50
3)	Level of education:	[ ] Tertiary	[ ] Secondary	[ ] Primary
		[ ] None		
4)	Employment Status:	[ ] Employed	[ ] Self-Employed	[ ] Unemployed

5) What is your position in the household?

Head of Household	1
Child	2
House Helper	3
Others	4

6) What is your estimated monthly income?

R0-500	1
R501-1000	2
R1001-1500	3
R1501-3500	4
R3501+	5

7) What is the size of your household?

2	1
3	2
4	3
5	4
Other	

C. QUESTIONS REGARDING BASIC WATER SERVICES

1. Are you aware of the existence of the Water Service Act of 1997?

2. Have you ever heard of the term basic water services?

3. Please rate your satisfaction level with regards to the benchmark indicators used by government to define basic water services (minimum water for drinking, food preparation and personal hygiene)

Benchmark Indicators	Strongly satisfied	Satisfied	Neither	Unsatisfied	Strongly unsatisfied
An operational public water point should be located within 200 meters distance from you household.					
Water point should be able to supply 25 Litres of water/person/day.					
Water point should be functional for 3 months with only 2 days down time (98% reliability).					
Water point must fill a 20 litres water bottle in 2 minutes					

Water quality should comply with the WHO water standards for human consumption.*					
Basic water is provided for free					

*provide explanations to enhance understanding

4. Which of the benchmark indicators for basic water services do you think needs amendment based on your current minimum water needs for direct drinking, food preparation and personal hygiene?

Benchmark Indicators	**To?**
An operational public water point should be located within 200 meters distance from you household.	
Water point should be able to supply 25 Litres of water/person/day.	
Water point should be functional for 3 months with only 2 days down time (98% reliability).	
Water point must fill a 20 litres water bottle in 2 minutes	
Water quality should comply with the WHO water standards for human consumption.*	
Basic water is provided for free	

*provide explanations to enhance understanding

5. Are you satisfied with the current level of water service provided in terms of?

Benchmark Indicators	**Strongly satisfied**	**Satisfied**	**Neither**	**unsatisfied**	**Strongly unsatisfied**
Distance to water point					
Quantity of water collected					
Reliability of water point					
Q Water discharged from water source					
Quality of water supplied					
Affordability of water					

6. Do you feel safe walking from you home to the water point?
    a. If yes, please explain:____
7. Do you feel safe when collecting water at the water point?
    a. If yes, please explain:____

SECTION B: WATER POINT INFORMATION

Water Point ID: ……………………………… Year of Construction: ………………….

Type of Water Point: [ ] Public tap (surface water) [ ] Public tap (underground water)

[ ] Hand-pump

Indicator	Questions/Data required	Response
Physical Access	GPS Coordinates	
	How far do you think you have walked/walk to get to the water point?	[0–100] [101 -200m] [200-500m] [500m-1km] [1km+]
	How much time did it take you/ took you to get to the water point?	
	How many times do you collect water in a day?	[Once] [two times] [three times] [if more, specify]
	How many days in a week do you collect water?	[Once] [two times] [three times] [more]
	Do you collect water during the weekends?	[Yes] [No]
Reliability	How many **days/weeks/months** did the water point not supply water?	
	After that, how long **[in days/weeks/months]** did it take before it supplied water?	
	How many times does it not supply water in 3 months?	[Once] [two times] [three times] [if more, specify]
	On average how long does it take without supplying water?	

	What is the longest time it has taken without suppling water?	
	Who is responsible for ensuring there is water supply in the settlement?	
	What are the general main problems with water supply in the settlement?	
Water Quantity	How many minutes does it take for the water point to fill a **20 litres bottle**	
	How much water do you collect per visit? **In terms of 20 litre bottles.**	
	How much water do you collect on weekdays?	**Drinking:** **Cooking:** **Personal Hygiene (bathing & washing):**
	How much water do you use in day for?	**Drinking:** **Cooking:** **Personal Hygiene Bathing:** **washing:**
	How much water do you collect during weekend?	**Drinking:** **Cooking:** **Personal Hygiene (bathing & washing):**
	When do you do washing?	[Weekend] [Weekdays] [Both]
Water Quality	What are the quality issues in terms of **taste**, **odour** and **colour** of water discharged by this water point?	**Taste:** [ ] Good [ ] Neither [ ] Bad **Odour:** [ ] Good [ ] Neither [ ] Bad **Colour:** [ ] Good [ ] Neither [ ] Bad
Affordability	How much do you pay for water?	**Communal stand pipe** **Standpipe connected in dwelling:** **Other, e.g tanker, bottled etc:**
	Is the cost of water affordable in relation to the combined household income?	

What alternatives sources of water do you use?	**Are they safe in terms of water quality?**
	Yes No

****

We have reached the end of the questions.
Thank you for your time!!!

11. APPENDIX D: CLASSIFICATION OF WATER SOURCES (WHO/UNICEF, 2018B)

Table 11.1 Classification of water sources (WHO/UNICEF, 2018)

Levels	Classification	Description
1	Safely Managed	• Water is collected from an improved water source. • Water collected in premises • Water available when needed • Water is safe for human consumption
2	Basic	• Water is collected from an improved water source. • Water collection time of not more than 30 minutes for a roundtrip, including queuing • Water is safe for human consumption
3	Limited	• Water is collected from an improved water source. • Water collection time exceeds 30 minutes for a roundtrip, including queuing • Water safety is an issue
4	Unimproved	• Water collected from an unimproved source (e.g. unprotect spring) • Water not safe for human consumption
5	Surface water	• Water collected from an unimproved source (e.g. dam, lack or river) • Water not safe for human consumption

Table 11.2 Summary of requirements for water services levels to promote health (Howard and Bartram, 2003)

Service level	**Access measure**	*Needs met*	**Level of health concern**
No access (quantity collected often below 5 l/c/d)	More than 1000m or 30 minutes total collection time	Consumption – cannot be assured Hygiene – not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 l/c/d)	Between 100 and 1000m or 5 to 30 minutes total collection time	Consumption – should be assured Hygiene – handwashing and basic food hygiene possible; laundry/ bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 l/c/d)	Water delivered through one tap on-plot (or within 100m or 5 minutes total collection time	Consumption – assured Hygiene – all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity 100 l/c/d and above)	Water supplied through multiple taps continuously	Consumption – all needs met Hygiene – all needs should be met	Very low

12. APPENDIX E: CHAPTER 3 - SUPPORTING DATA

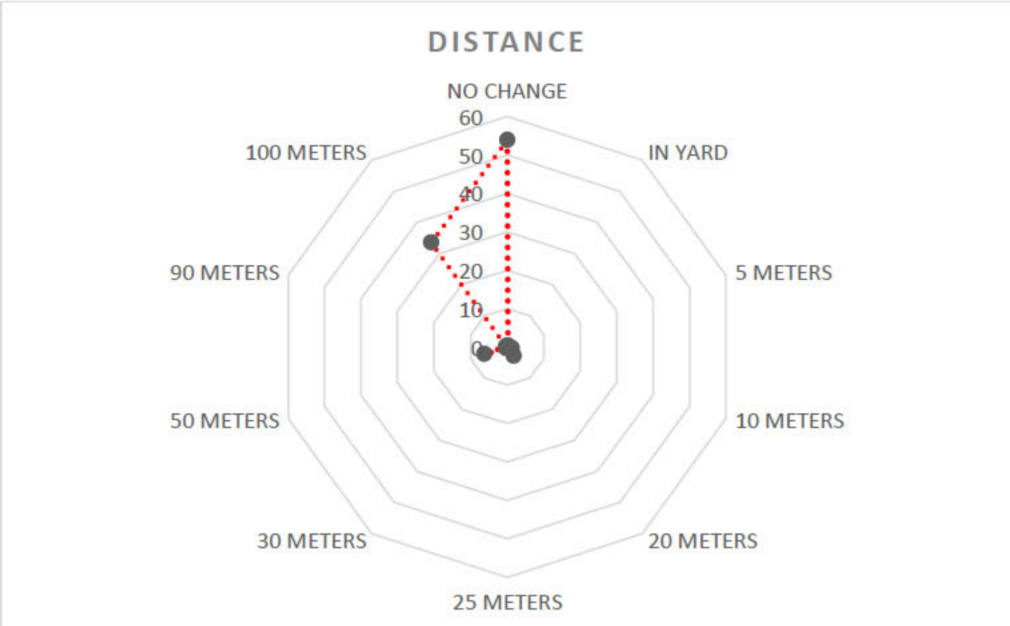

Figure 12.1 Percentage of respondents that recommend amendment to distance

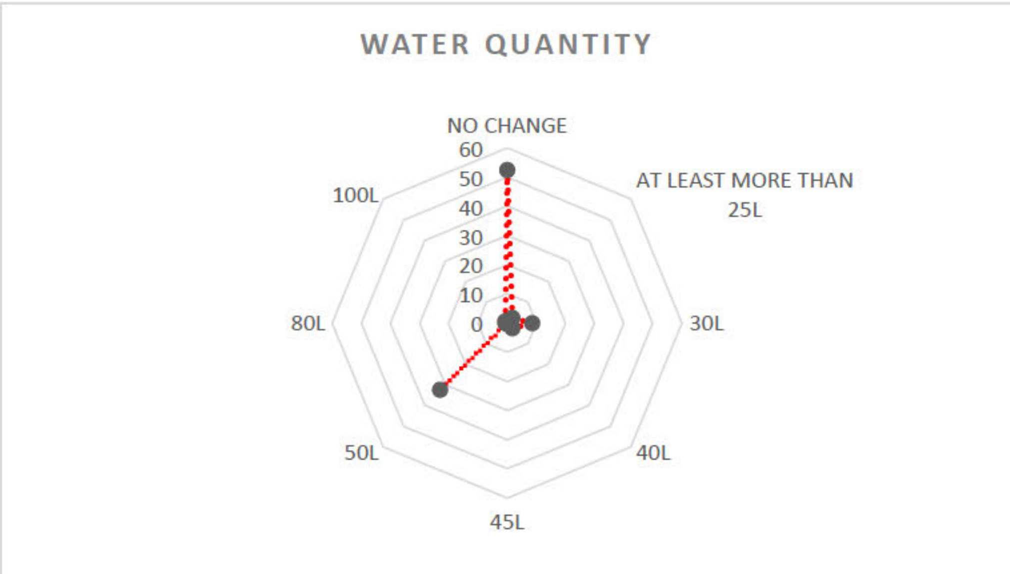

Figure 12.2 Percentage of respondents that recommend amendment to water quality

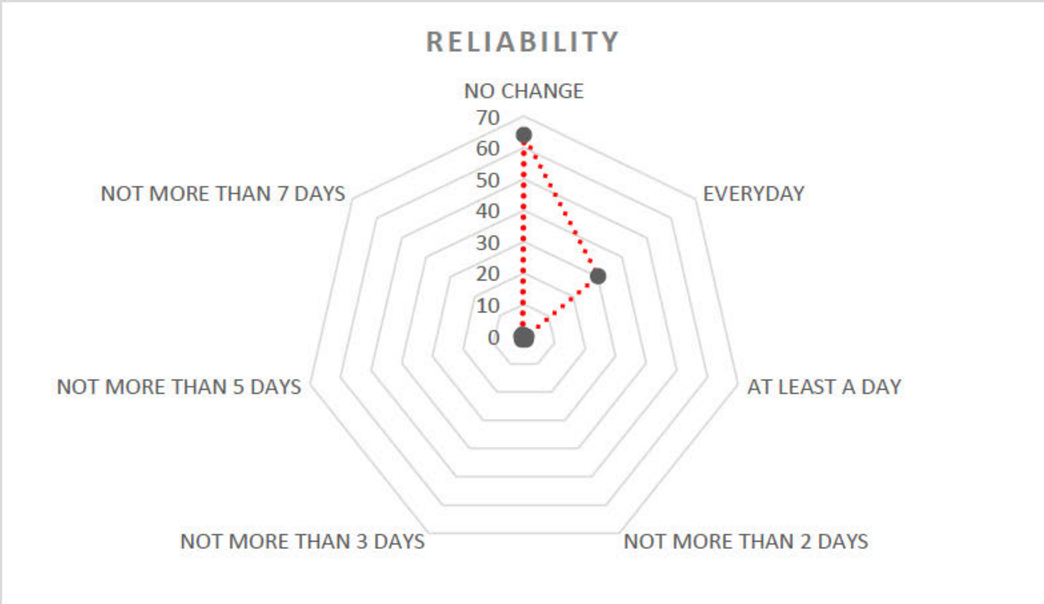

Figure 12.3 Percentage of respondents that recommend amendment to reliability

Table 12.1 Cross-tabulation of Question 6a and Question 6b

Question: Do you feel safe walking from you home to the water point?				
No.	**Responses**	**Responses**		**Total**
		No	Yes	
1.	Accompanied by children		0.3%	0.3%
2.	Collect water at the river	3.3%		3.3%
3.	No reason	37.6%	4.8%	42.4%
4.	Not far		13.9%	13.9%
5.	Not safe	5.3%		5.3%
6.	Safe during the day		0.3%	0.3%
7.	Tap in the dwelling		23.7%	23.7%
8.	Village is safe		2.5%	2.5%
9.	Village is not safe	0.8%		0.8%
10.	Wild animals	0.5%		0.5%
11.	Within village		1.5%	1.5%
12.	Water point far	5.3%		5.3%
13.	Water point not working	0.3%		0.3%
Total		**53.0%**	**47.0%**	**100.0%**

Table 12.2 Cross-tabulation of Question 7a and Question7b

Question: Do you feel safe walking from you home to the water point?				
No.	**Responses**	**Responses**		**Total**
		No	Yes	
1.	Collect water at the river	3.5%		3.5%
2.	It is safe		3.5%	3.5%
3.	Need traps in our dwellings	0.5%		0.5%
4.	No reason	40.4%	4.8%	45.2%
5.	Not far		11.1%	11.1%
6.	Not safe	1.3%		1.3%
7.	Tap in the dwelling		23.0%	23.0%
8.	Unreliable		0.5%	0.5%
9.	Village is safe		2.5%	2.5%
10.	Water is supplied at night	3.0%		3.0%
11.	Water point is within the village		0.8%	0.8%
12.	Water point is far	4.8%		4.8%
13.	Water point is not working	0.3%		0.3%
Total		**53.8%**	**46.2%**	**100.0%**

13. APPENDEX G: CHAPTER 4 - SUPPORTING DATA

Table 13.1 How far do you think you have walked/walk to get to the water point?

Distance	**Water Scheme**				**Total**
	DH	*FB*	*LR*	*PG*	
[0-100m]	48.4%	88.5%	78.1%	77.3%	62.1%
[101-200m]	37.4%	11.5%	12.5%	18.2%	28.0%
[200-500m]	8.9%	0.0%	9.4%	4.5%	6.6%
[500m-1km]	4.1%	0.0%	0.0%	0.0%	2.5%
[1km+]	1.2%	0.0%	0.0%	0.0%	0.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table 13.2 How much time did it take you/ took you to get to the water point?

Minutes	**Water Scheme**				**Total**
	DH	*FB*	*LR*	*PG*	
[0-1min]	5.3%	41.7%	56.3%	9.1%	18.4%
[2-5min]	40.2%	46.9%	21.9%	68.2%	41.9%
[6-10min]	26.8%	7.3%	9.4%	18.2%	20.2%
[11-20min]	16.7%	4.2%	3.1%	4.5%	11.9%
[21-30min]	4.1%	0.0%	6.3%	0.0%	3.0%
[31-1h]	3.7%	0.0%	3.1%	0.0%	2.5%
[1h+]	3.3%	0.0%	0.0%	0.0%	2.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table 13.3 How many times do you collect water in a day?

No. of times	**Water Scheme**				**Total**
	DH	*FB*	*LR*	*PG*	
1	48.0%	45.8%	37.5%	31.8%	45.7%
2	26.0%	32.3%	34.4%	40.9%	29.0%
3	22.8%	12.5%	25.0%	27.3%	20.7%
4	1.6%	9.4%	3.1%	0.0%	3.5%
5	1.2%	0.0%	0.0%	0.0%	0.8%
8	0.4%	0.0%	0.0%	0.0%	0.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table 13.4 How many days in a week do you collect water?

No. of days	Water Scheme				Total
	DH	*FB*	*LR*	*PG*	
1	49.6%	66.7%	50.0%	40.9%	53.3%
2	22.0%	28.1%	25.0%	18.2%	23.5%
3	22.0%	3.1%	25.0%	9.1%	16.9%
4	0.4%	2.1%	0.0%	31.8%	2.5%
5	2.8%	0.0%	0.0%	0.0%	1.8%
6	0.8%	0.0%	0.0%	0.0%	0.5%
7	2.4%	0.0%	0.0%	0.0%	1.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table 13.5 Do you collect water during the weekends?

Response	Water Scheme				Total
	DH	*FB*	*LR*	*PG*	
N	76.8%	74.0%	87.5%	100.0%	78.3%
Y	23.2%	26.0%	12.5%	0.0%	21.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

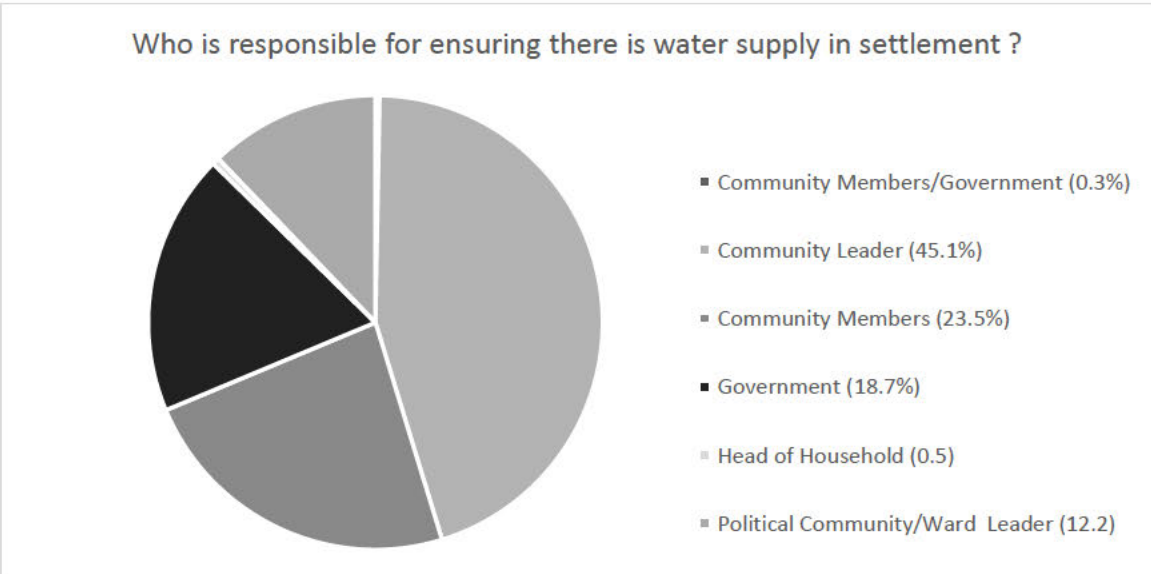

Figure 13.1 Percentage of stakeholders responsible for water supply in the settlements

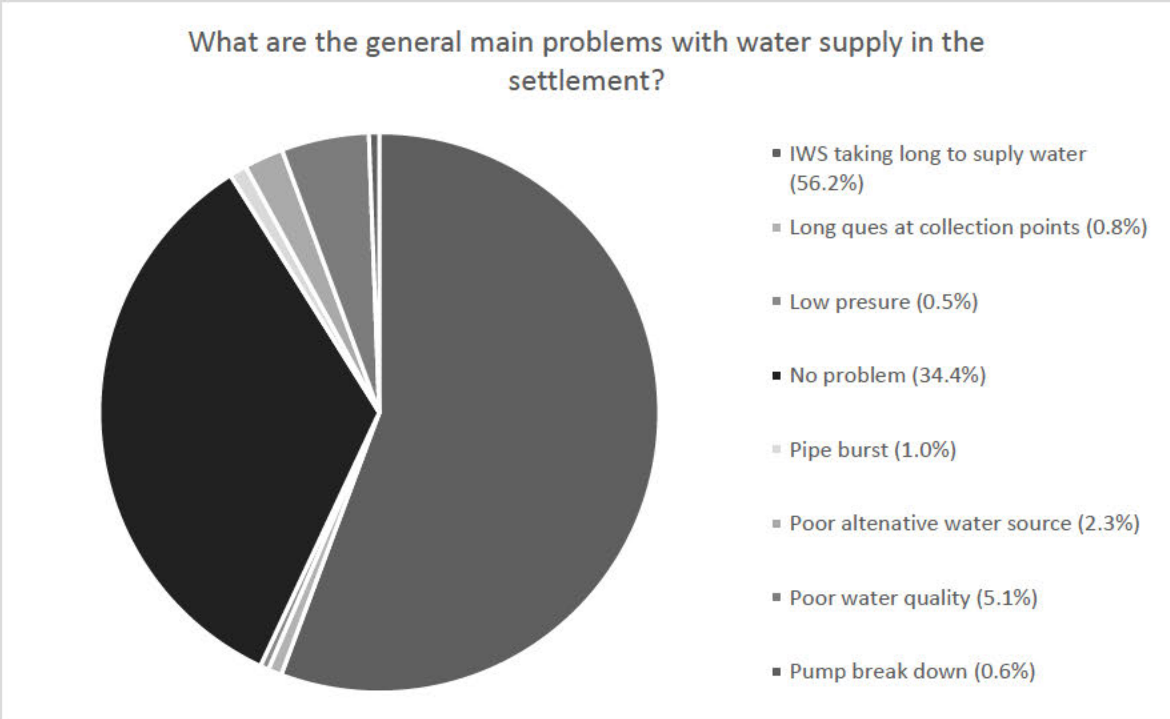

Figure 13.2 Percentage of general main problems with water supply in the settlement

Table 13.6 How many minutes does it take for the water point to fill a 25 litres bottle?

No. of days	**Water Scheme**				**Total**
	DH	*FB*	*LR*	*PG*	
1 - 5 min	74.7%	84.4%	62.6%	76.7%	76.7%
6-10 min	15.9%	15.6%	31.2%	13.6%	17.1%
11 -15 min	2.8%	0.0%	6.2%	0.0%	2.4%
16 - 20 min	3.3%	0.0%	0.0%	0.0%	2.0%
21 - 25 min	0.4%	0.0%	0.0%	0.0%	0.3%
26 - 30 min	2.0%	0.0%	0.0%	0.0%	2.0%
30 min +	0.8%	0.0%	0.0%	0.0%	0.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

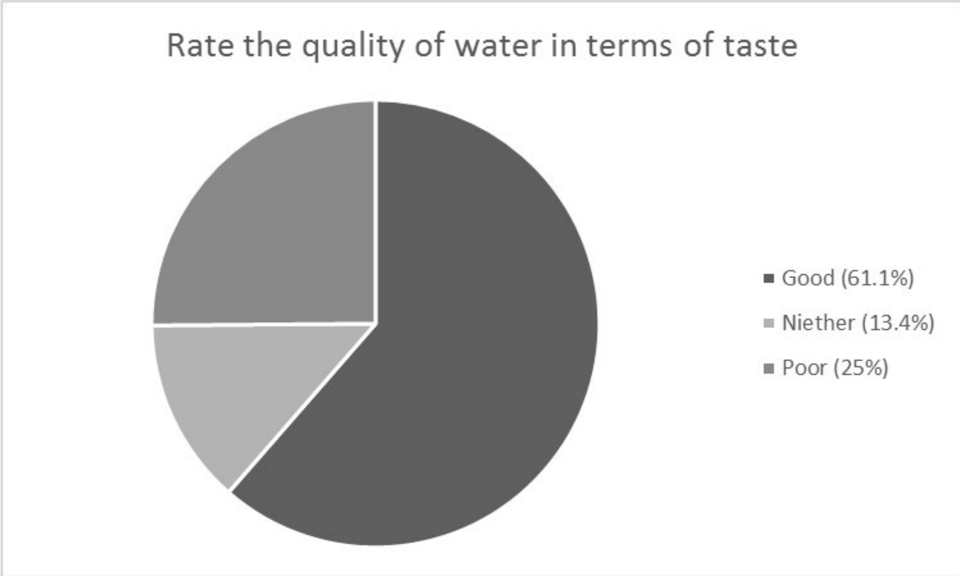

Figure 13.3 Percentage of water quality rating in terms of taste

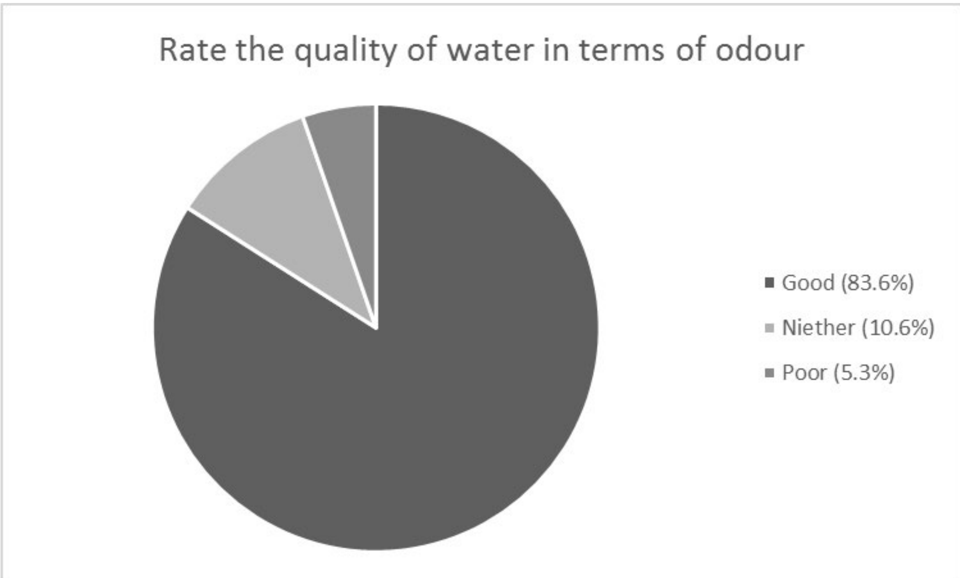

Figure 13.4 Percentage of water quality rating in terms of odour

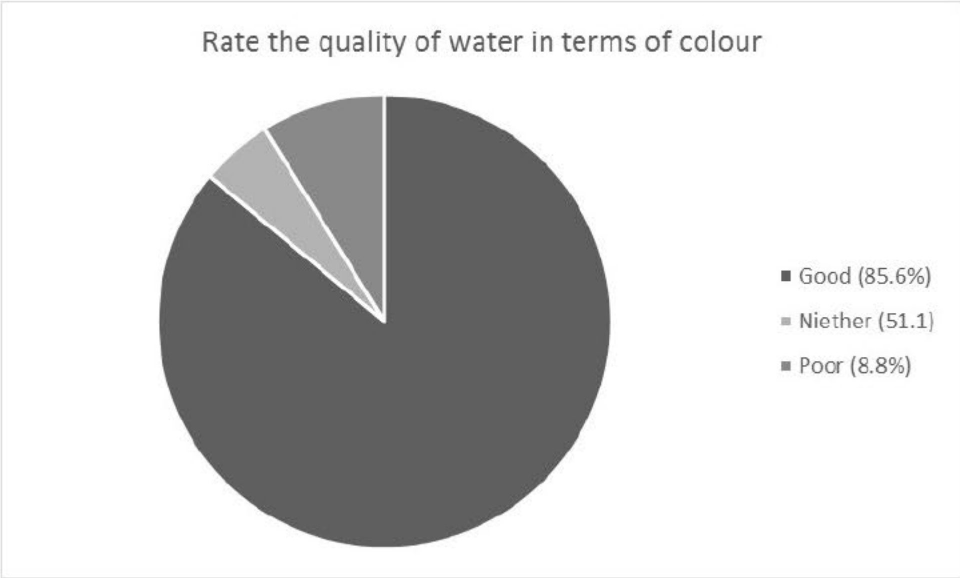

Figure 13.5 Percentage of water quality rating in terms of colour

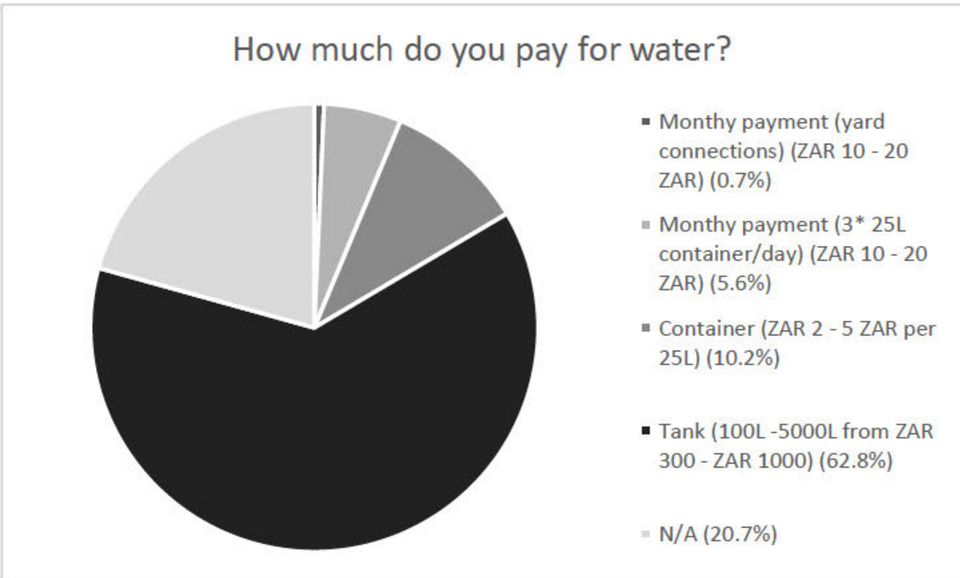

Figure 13.6 Percentage of buying water based of difference water sources

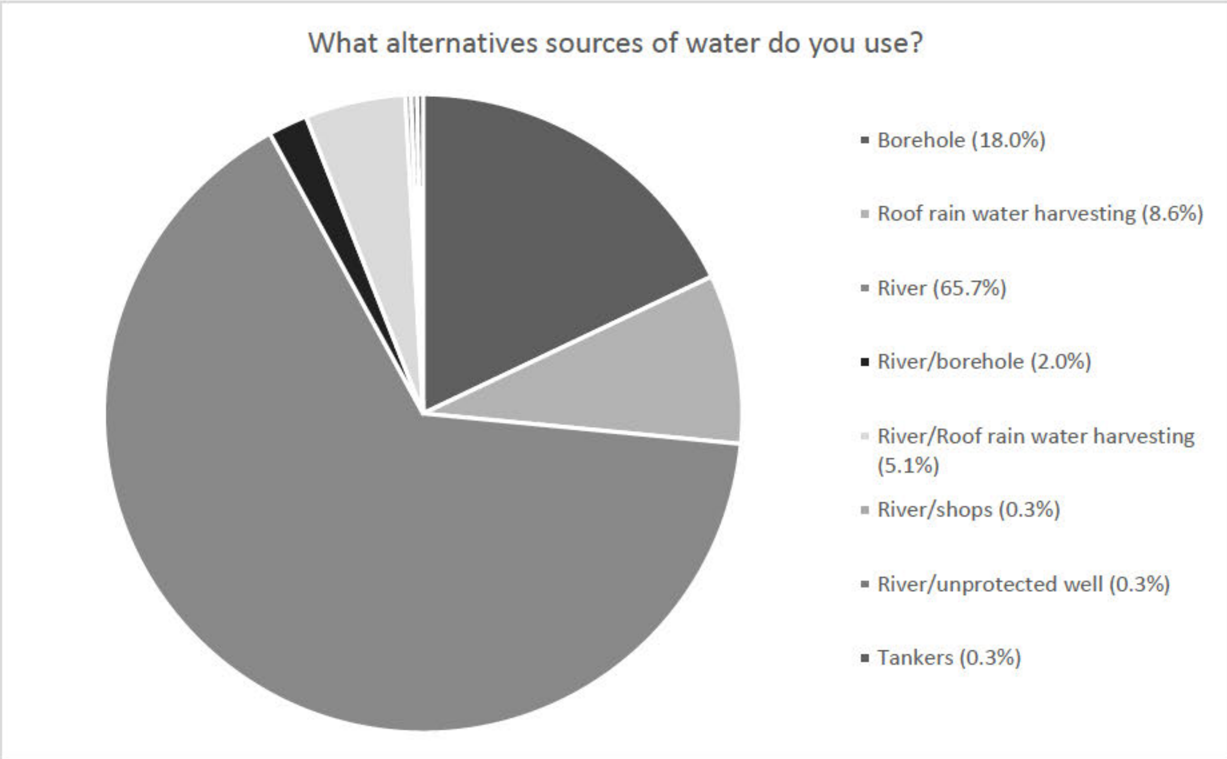

Figure 13.7 Percentage of alternative water sources used in the study area

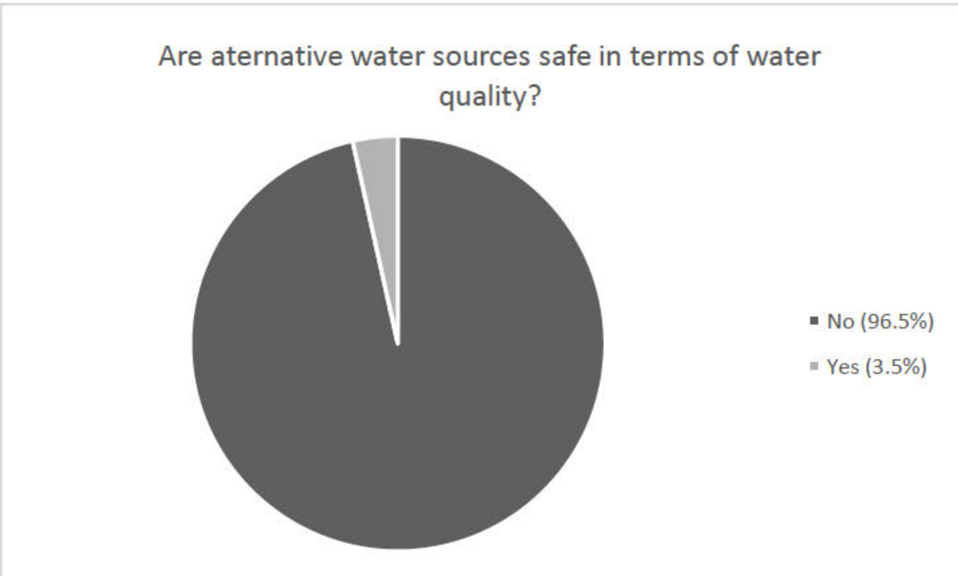

Figure 13.8 Percentage of perceptions of households in terms of alternative water sources safety in terms of water quality

14. APPENDIX F: CHAPTER 5 - SUPPORTING DATA

Table 14.1 Key informant interviews interviewees

No.	Position	No. interviewed
1.	Planning Manager	1
2.	Operation and Maintenance manager	1
3.	Depot Managers	4
	Total	**6**

Table 14.2 Characteristics of nodes in the network

No.	Factor	Category	Community	Degree Centrality	In-degree	Out-degree	Betweenness	Closeness
1	water scarcity	EV	C3	2	1	1	0 03	0 37
2	limited/no water supply	EV	C3	12	11	1	0 52	0 55
3	low rainfall	EV	C3	3		3	0 01	0 29
4	poor groundwater recharge	EV	C3	2	1	1	0 00	0 29
5	reduced dam capacity	EV	C3	3	2	1	0 10	0 38
6	dry-out of boreholes	EV	C3	2	1	1	0 06	0 37
7	top-down approach	I	C1	4	1	3	0 01	0 40
8	limited budget	E	C2	15	3	12	0 24	0 52
9	poor funding model	E	C1	2	1	1	0 00	0 35
10	Improper operation and maintenance	T	C2	8	6	2	0 04	0 45
11	no staff development	T	C2	3	1	2	0 00	0 36
12	use of general labourers	T	C2	8	3	5	0 03	0 43
13	limited specialized staff	T	C2	8	2	6	0 03	0 46
14	vacant positions	I	C2	3	1	2	0 00	0 36
15	no recruitment	I	C2	2	1	1	0 00	0 35
16	limited staff capacity	I	C2	9	3	6	0 05	0 47
17	no bulk storage of spare parts	I	C2	5	2	3	0 00	0 43
18	procurement delays	I	C2	6	2	4	0 02	0 45
19	political influence	I	C1	5		5	0 02	0 43
20	poor consultation with communities	S	C1	2	1	1	0 00	0 36
21	failed/delayed infrastructure projects	I	C1	7	6	1	0 18	0 53
22	increasing water demand	S	C3	3	1	2	0 07	0 37
23	expansion of new settlements	S	C3	1		1	0 00	0 27
24	no revenue collection	E	C1	2	1	1	0 00	0 35
25	pump theft	S	C1	2		2	0 00	0 36
26	pump breakdown	T	C2	6	5	1	0 07	0 50
27	pipe burst	T	C3	2	1	1	0 01	0 43
28	delays in repair	T	C2	7	6	1	0 09	0 52
29	delays in replacement	T	C2	7	6	1	0 09	0 52
30	sedimentation	EV	C3	1		1	0 00	0 28
	Factors: Institutional (I), Technical (T), Economic (E), Social (S), Environmental (EV) **Communities:** Institutional arrangement and funding (C1), Long-term sustainability (C2), Water availability (C3)							