



Exploring the improvement of the water infrastructure within the John Taolo Gaetsewe District Municipality

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:

DECLARATION

I, Olebogeng Asieng, declare that this research dissertation titled: Exploring the improvement of the water infrastructure within the John Taolo Gaetsewe district municipality, and the work presented in this research dissertation is both my own and generated by me from my original research. It is submitted in partial fulfilment of the requirements of the degree Master of Business Administration at the North-West University Business School. To the best of my knowledge and belief, no material previously published or written by another person, except where due references are made, is contained in this mini-dissertation.

Olebogeng Asieng.



November 2025

DEDICATION

I dedicate this mini dissertation to all those who have supported and motivated me throughout this amazing journey.

To the participants of this study—thank you for your time, insights, and inclination to contribute to this research. Your input has been important and deeply appreciated.

To my colleagues, your encouragement, collaboration, and shared wealth of knowledge have been instrumental in shaping this work. I am grateful for your support and companionship.

To my friends, your understanding, motivation, and moments of laughter have made this journey more bearable and meaningful.

To my family, your unwavering love, patience, and belief in me have been my greatest source of strength. Thank you for standing by me through every challenge and achievement.

To my immediate family, thank you for lending me your time. I know that my academic commitments often meant time away from you, missed moments, and added responsibilities on your shoulders. Your encouragement, understanding, and love have been the foundation that kept me going, even during the most challenging times. I am truly grateful for your sacrifices and belief in me.

This work is a true reflection of your collective support, and I am truly thankful.

PREFACE AND ACKNOWLEDGEMENTS

Access to clean and reliable water remains one of the most pressing challenges in many rural communities, not only in South Africa but across the globe. This mini dissertation, titled "Exploring the improvement of water infrastructure within the John Taolo Gaetsewe District Municipality," is the culmination of a journey driven by a deep commitment to understanding and addressing the systemic issues that hinder equitable water access in under-resourced areas.

The motivation for this research stems from both professional and personal experiences. As someone who has witnessed the daily struggles of communities grappling with inadequate water infrastructure, I was compelled to investigate sustainable, context-specific solutions that can drive meaningful change. This study seeks to explore innovative approaches, stakeholder collaboration, and policy frameworks that can enhance water service delivery in rural settings.

This work would not have been possible without the generous support and participation of several individuals and institutions. I would like to extend my heartfelt gratitude to all the participants who willingly shared their time, insights, and experiences. Your contributions have enriched this research and provided invaluable perspectives that form the foundation of this study.

I would also like to express my sincere appreciation to my supervisor, Dr Frans Prinsloo and co-supervisor, Dr Johan Jordaan, for their invaluable guidance, mentorship, and support throughout this research. Your insights, patience, and encouragement have been instrumental in shaping the direction and quality of this work.

Lastly, I would like to acknowledge the academic and administrative staff of North West University for their guidance and support. Your dedication to academic excellence and research has been a source of inspiration.

I hope that the findings and recommendations presented in this dissertation will, in some small way, contribute to ongoing efforts to improve water access and quality in rural communities and inspire further research and action in this critical area.

ABSTRACT

Access to reliable and safe water remains a critical development challenge in rural South Africa, particularly in arid regions reliant on groundwater. This study examines strategies to improve rural water supply systems in the John Taolo Gaetsewe District Municipality in the Northern Cape Province, where water service delivery remains unreliable despite ongoing infrastructure investments. Adopting a qualitative interpretivist paradigm, the study employs a mono-method approach comprising a literature review and semi-structured interviews with one executive from each district water service authority. Guided by an integrated economic, governance, institutional, and systems-based framework, the research identifies key systemic, operational, and financial factors that influence water infrastructure effectiveness. The findings indicate that governance weaknesses, institutional fragmentation, ageing infrastructure, and capacity constraints significantly undermine sustainable water service delivery. The study proposes strategic interventions to strengthen governance, improve infrastructure planning and maintenance, and enhance institutional coordination. By offering context-specific insights, the study contributes to the understanding of rural water supply challenges and provides practical guidance for improving sustainable and equitable water service delivery in the John Taolo Gaetsewe District Municipality and comparable rural settings.

Key terms: Integrated Water Resource Management, Qualitative Research Design, Rural Water Supply, Maintenance Management, Water infrastructure, Water service delivery.

LIST OF ABBREVIATIONS AND ACRONYMS

CAQDAS:	Computer-Assisted Qualitative Data Analysis Software
DWS:	Department of Water and Sanitation
GIS:	Geographic Information Systems
IDP:	Integrated Development Plan
IoT:	Internet of Things
IWRM:	Integrated water resource management
JTGDM:	John Taolo Gaetsewe District Municipality
NRW:	Non-Revenue Water
OECD:	Organisation for Economic Co-operation and Development
PPP:	Public-Private Partnerships
RDP:	Reconstruction and Development Programme
SDGs:	Sustainable Development Goals
SIP:	Sustainable Ibadan Project
SOS:	Safe Operating Space
SRF:	State Revolving Loan Funds
VFDS:	Variable Frequency Drives
WSA:	Water Service Authority
WSP:	Water Service Provider

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CHAPTER 1: NATURE AND SCOPE OF STUDY

1.1 INTRODUCTION

Access to safe and reliable water is universally recognised as a fundamental human right and a cornerstone of public health and socio-economic development. Despite this, global access to clean water remains uneven: an estimated 884 million people still rely on unsafe or contaminated water sources, while more than one billion suffer from waterborne diseases resulting from poor water quality (Malima *et al.*, 2022:148). These challenges are particularly acute in sub-Saharan Africa, where water scarcity is exacerbated by climate change, recurring droughts, and rapid population growth (Malima *et al.*, 2022:148).

In South Africa, the right to access sufficient water is enshrined in Section 27 of the Constitution (Republic of South Africa, 1996:28). The Department of Water and Sanitation (DWS) holds the primary mandate for ensuring equitable and sustainable water provision nationwide, while district municipalities are responsible for delivering water supply services, and provincial governments provide oversight and support (Centre for Environmental Rights, 2011:4,18). Despite this well-defined institutional framework, service delivery remains inconsistent, particularly in rural areas (Centre for Environmental Rights, 2011:15).

Rural water supply systems play a critical role in ensuring that communities have access to safe drinking water (Thsona *et al.*, 2024:2). However, in many regions, these systems are undermined by ageing infrastructure, poor design, inadequate maintenance, and slow repair processes (Rudolph & Muchesa, 2023:2). When infrastructure fails, residents are often forced to depend on unsafe alternative water sources, which pose serious health and social risks (Ishola *et al.*, 2025:6). The problem is further compounded by the rapid expansion of informal or unplanned settlements that lack the infrastructure, technical capacity, and funding necessary to sustain reliable water supply systems (Abrams *et al.*, 2021:8).

While numerous studies have examined South Africa's national and municipal water management frameworks, there remains a significant gap in understanding how water supply systems can be holistically strengthened across all operational stages—planning, governance, financing, implementation, and maintenance—within rural district contexts (Thsona *et al.*, 2024:2; Ruiters & Matje, 2015:661; Hutete & Sibanda, 2022). In particular, limited research has been conducted in extremely arid regions such as the John Taolo Gaetsewe District Municipality (JTGDM), situated on the edge of the Kalahari Desert, where rainfall is minimal and no perennial rivers are present (John Taolo Gaetsewe District Municipality, 2023:9). This geographic and climatic distinctiveness necessitates locally appropriate strategies for sustainable water provision.

The purpose of this study is to identify and address systemic gaps in the rural water supply systems of the John Taolo Gaetsewe District Municipality, from planning to operations, to develop a holistic strategy to improve water infrastructure performance and service delivery. By engaging executives through semi-structured interviews, the study aims to provide actionable insights that can strengthen governance, funding, and operational practices across the district's Water Service Authorities (WSAs), thereby supporting the DWS and associated Water Boards in achieving equitable and sustainable water access.

1.2 BACKGROUND

The United Nations (UN) adopted the 17 Sustainable Development Goals in 2015, designed to improve people's lives worldwide by 2030 (United Nations, 2018:10). The sixth SDG calls for universal access to clean water and sanitation by 2030 (United Nations, 2018:10).

According to the United Nations, the share of the world's population with access to safe drinking water increased from 70% in 2015 to 74% in 2020 (United Nations, 2022). Nonetheless, in that year, 2 billion people lacked these facilities, including 1.2 billion who lacked even the most basic amenities (United Nations, 2022). In 2020, about 8 out of 10 individuals without basic water services lived in rural areas, with around half residing in the least developed countries (CAF, 2021). Regarding drinking water targets, global coverage is projected to reach 81% by 2030, leaving 1.6 billion people without access to well-managed drinking water supplies (Sida, 2021; IFEH, 2022).

In South Africa, the number of people with access to clean drinking water appears to be improving, but some concerns persist. The DWS data for water supply show that although 96 % of South Africans have access to water supply infrastructure at the Reconstruction and Development Programme (RDP) level or higher, only 65 % have access to reliable services (Department of Water and Sanitation, 2018:5). Reliability is defined as having access to water of appropriate quality for 300 days of the year, with supply interruptions lasting no more than 2 consecutive days (Department of Water and Sanitation, 2024:199).

South Africa's Northern Cape spans 372,882 km², making it the largest province (Mzansi Mirror, 2025). In 2020, approximately 1.24 million people lived in the Northern Cape, equating to three people per square kilometre, making it the province with the lowest population density (ReadKong, 2021:1). The Northern Cape experiences a low average annual rainfall of just 281 mm, with between 45 and 55 mm falling during summer months and only about 6 mm in winter (NomadSeason, 2025). During summer, extreme heat (above 40°C) coupled with low rainfall depletes groundwater resources, increasing reliance on underground water sources (Department

of Water and Sanitation, 2024:39). The mining of diamonds, copper, and iron ore, alongside extensive farming practices such as commercial livestock and communal farming, requires substantial water (Koovarjee *et al.*, 2023:228). Irrigation from the Orange River waters the fertile land along its valley. However, 96% of the province's land is used for extensive livestock farming, with cattle dominating the savannah biome or Kalahari, while sheep and goats occupy the rest of the region, placing significant pressure on its limited water resources (Stats SA, 2020).

Unreliable water supply services in Northern Cape municipalities are driven by multiple factors, including insufficient investment, weak operations and maintenance in water utilities, ineffective ward-level collaboration among political parties, non-cost-reflective tariffs, and limited provincial capacity to address dysfunctional councils, resulting in failed municipal interventions (Helen Suzman Foundation, 2019). These challenges are compounded by inadequate technical support from national and provincial governments before such interventions (Water Research Commission, 2023:26). Additionally, the John Taolo Gaetsewe District Municipality water supply systems are characterised by a lack of infrastructure, technology, expertise, and understanding by those who manage them (Dickson *et al.*, 2015:1568). As a result, the John Taolo Gaetsewe District Municipality's existing water sources are under tremendous strain and often insufficient to sustainably supply households, schools, businesses, mines, and agricultural activities with water.

By regulating and supporting the delivery of adequate supply and sanitation, the DWS is responsible for protecting, managing, and controlling the country's water resources. The statistics given in section 1.4 confirm that the DWS is installing the required water infrastructure in the John Taolo Gaetsewe District Municipality. However, a significant challenge is whether it is relevant and/or maintained correctly. The John Taolo Gaetsewe District Municipality suffers from water infrastructure that is delayed, degrading, and failing due to poor conceptualisation and lack of deliberate design (John Taolo Gaetsewe District Municipality, 2022:59). A common cause of substandard water services in South Africa is intermittent water supply due to demand exceeding water capacity (Loubser *et al.*, 2021:7).

After recognising its shortcomings, the DWS launched projects to upgrade the water infrastructure in the John Taolo Gaetsewe District Municipality. However, water infrastructure projects in the John Taolo Gaetsewe District Municipality are expected to be completed between 2025 and 2026 (John Taolo Gaetsewe, 2022:111). These projects primarily aim to expand existing water supply infrastructure and restore decommissioned infrastructure. It is evident, however, that additional water infrastructure is needed before the completion dates.

This study examines the three local municipalities that serve as WSAs in the John Taolo Gaetsewe District Municipality: Joe Morolong, Ga-Segonyana, and Gamagara.

1.3 PROBLEM STATEMENT

Despite substantial national investment and policy interventions aimed at improving water service delivery, rural municipalities in South Africa continue to experience unreliable and unsustainable water supply. This challenge is particularly evident in the John Taolo Gaetsewe District Municipality (JTGDM), where communities face frequent supply interruptions, declining water quality, and persistent infrastructure failures. Although official statistics indicate relatively high levels of nominal access to potable water across the district's WSAs, service reliability remains poor, largely due to ageing infrastructure, inadequate maintenance, limited technical and financial capacity, and weak institutional coordination.

Performance assessments, including the Blue Drop and Green Drop programmes, consistently reveal systemic underperformance across key management areas such as technical capacity, financial management, and effluent and sludge control (Department of Water and Sanitation, 2024:18). These deficiencies not only undermine potable water quality but also contribute to excessive non-revenue water losses and increased public health risks. Furthermore, while infrastructure upgrades are ongoing, existing systems frequently fail to meet their intended design horizons, raising concerns about the long-term sustainability of current planning, governance, and operational practices.

The central problem addressed in this study is therefore not merely the presence of water supply challenges, but the absence of an integrated, effective strategy to improve the performance and sustainability of rural water supply systems within the institutional, financial, and operational context of the JTGDM.

Accordingly, the problem investigated in this study is framed by the following question:

How can governance, infrastructure planning, and operational management strategies be improved to enhance the reliability and sustainability of rural water supply systems in the John Taolo Gaetsewe District Municipality?

1.4 PRIMARY AND SECONDARY OBJECTIVES

Within the constraints of limited municipal budgets, the primary objective of this study is to evaluate the most effective methods for improving rural water supply systems in the three WSAs of the John Taolo Gaetsewe District Municipality.

The secondary objectives are:

- To investigate the governance, planning, funding, implementation, and operational factors affecting the functionality of the WSAs' water supply systems.
- To evaluate the findings and develop recommendations for improving the water supply system.
- To assess the financing process as a potential cause of project delays and to provide targeted recommendations for improvement.

1.5 RESEARCH QUESTIONS

1.5.1 Primary Research Question

How can governance, operational management, and stakeholder collaboration be optimised to improve the sustainability and efficiency of water infrastructure in the John Taolo Gaetsewe District Municipality?

1.5.2 Secondary Research Questions

- How do governance structures, leadership capacity, and institutional coordination affect the operational performance of the WSAs in the John Taolo Gaetsewe District Municipality?
- To what extent do funding constraints, budgeting practices, and financial management systems influence the reliability and sustainability of rural water infrastructure?
- What key technical and operational limitations affect the maintenance, efficiency, and lifespan of water supply systems in the JTGDM?
- How do wastewater treatment practices and environmental management shortcomings impact potable water quality and public health within the district?
- Based on the five Key Performance Areas, what targeted interventions can be implemented to improve coordination, monitoring, and sustainability in rural water service delivery?

1.6 SCOPE OF THE STUDY/DELIMITATIONS

1.6.1 Field of the study

This study falls under the field of Public Management. According to Mancosa (2019), Public Management is the task and process of managing public organisations. The objective of public management is to improve efficiency and ensure the quality of services provided by these

organisations. To realise these deliverables, public managers analyse public policy and demand the necessary course of action. Public managers may operate either internally or externally.

1.6.2 Sector/Industry/Business under investigation

This study is part of the Water Resources sector within the Civil Engineering division.

1.6.3 Geographical demarcation

The study is conducted within the district of the John Taolo Gaetsewe District Municipality in the Northern Cape province of the Republic of South Africa. Figure 1.1 shows the location of the Northern Cape and the John Taolo Gaetsewe District Municipality within South Africa, while Figure 1.2 highlights the locations of the Joe Morolong, Gamagara, and Ga-Segonyana Local Municipalities (Municipalities.co.za, 2025).



Figure 1.1: Northern Cape map showing the John Taolo Gaetsewe District Municipality (Adopted from Alamy, 2021).

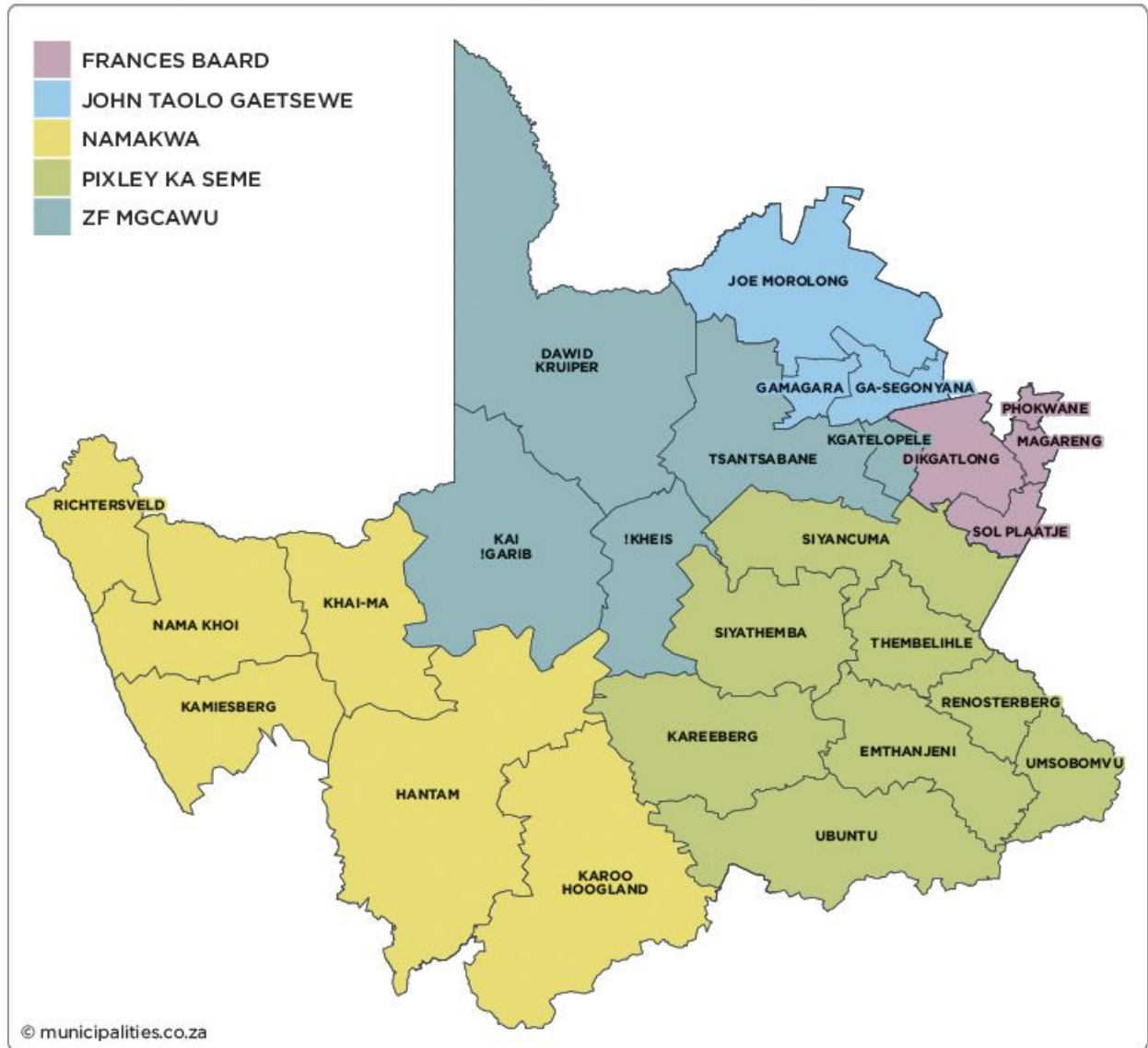


Figure 1.2: John Taolo Gaetsewe District Municipality map showing the Joe Morolong, Gamagara, and Ga-Segonyana Local Municipalities.

1.7 RESEARCH METHODOLOGY

1.7.1 Introduction

This study uses a research methodology specifically designed to meet the research objectives and questions outlined earlier. This section provides a brief overview of the research approach, design, and methods employed in this investigation.

A comprehensive and detailed account of the research methodology, including the specific techniques, data collection instruments, sampling strategy, and data analysis procedures, will be provided in Chapter 3 of this dissertation.

1.7.2 Empirical Study

This study explored the challenges and opportunities in improving rural water infrastructure within the John Taolo Gaetsewe District Municipality using a qualitative, interpretivist approach (Section 3.2.1). By engaging one executive from each of the three district water service authorities, the study aimed to generate rich, context-specific insights to inform evidence-based strategies for improving service delivery (Bearman, 2018:3).

A mono-method qualitative design was employed, combining a literature review with semi-structured interviews. The research adopted a comparative strategy to examine patterns, similarities, and differences in infrastructure management practices across the three municipalities. Data were collected at a single point in time, consistent with a cross-sectional study design, and purposive sampling ensured that participants had the relevant expertise to contribute meaningful insights (Barrett & Twycross, 2018:63). Consequently, hypothesis testing did not apply to this study.

Semi-structured interviews were designed to capture both data and participants' personal perspectives on water supply reliability, infrastructure priorities, technological innovations, financial constraints, and collaborative opportunities (George, 2020). Interviews were conducted face-to-face or virtually, with detailed notes and audio recordings used to ensure data accuracy and richness. Thematic analysis was applied to identify patterns and themes within the data, linking these insights directly to the study objectives (Braun & Clark, 2006:16-23).

To ensure trustworthiness, the study incorporated credibility, confirmability, transferability, and dependability (Korstens & Moser, 2017:2). No attempt was made to achieve traditional thematic saturation, as three elite interviewees, the most authoritative informants within their respective municipalities, were selected (section 3.2.13). Triangulation with documents strengthened the validity of the findings by incorporating multiple external data collection methods focused on the same events, complemented by various external analysis approaches (Fusch *et al.*, 2018:21). Through triangulation, the researcher examines the data from different angles and then presents the results in a way that helps others understand the shared experience of the phenomenon under study (Fusch *et al.*, 2018:21,23). Rich data were captured through thick descriptions and in-depth probing of participants' experiences, enabling a nuanced understanding of the operational,

financial, and technological factors affecting rural water supply. Potential conflicts of interest were identified and managed in accordance with ethical guidelines to maintain objectivity and fairness.

Overall, the methodology provided a structured yet flexible framework that allowed the researcher to gather detailed, reliable, and actionable insights from stakeholders, supporting the formulation of strategies to improve water infrastructure in the John Taolo Gaetsewe District Municipality.

1.7.3 Theoretical Analysis

The theoretical analysis frames the improvement of water infrastructure in John Taolo Gaetsewe District Municipality through an integrative lens that combines economic, governance, institutional, and systems-based approaches (Section 2.15). Economic and performance-oriented theories emphasise the role of macroeconomic conditions and investment patterns in shaping infrastructure outcomes, but often overlook local governance dynamics (Marshall *et al.*, 2024:616). Governance and policy paradigms emphasise how strategic decision-making and participatory models can enhance sustainability, while institutional capacity frameworks stress the importance of leadership, human capital, and resource allocation for effective service delivery (Malemane & Nel-Sanders, 2021:2).

Complementing these, systems thinking and network analysis provide tools to uncover interdependencies and identify the root causes of failures within complex water supply networks. Together, these perspectives demonstrate that water challenges in the John Taolo Gaetsewe District Municipality cannot be addressed through a single lens. Instead, the study adopts an integrative theoretical framework that draws on governance, institutional, and systems-based insights to align interventions with local realities, strengthen capacity, and guide sustainable improvements in rural water infrastructure.

1.7.4 Strategy to conduct literature review

Some of the databases used for this study are:

- SACat: National catalogue of books and journals in South Africa.
- Nexus: Databases compiled by the NRF of current and completed research in South Africa.
- SAePublications: South African Journals.
- EbscoHost: International journals on Academic Search Premier, Business Source.
- Premier, Communication and Mass Media Complete and EconLit.
- Emerald: International journals.
- ProQuest: International dissertations in full text.

- Internet: Google Scholar.
- SAMEDIA: Newspaper articles.
- Open book publishers.

The literature review aims to identify, evaluate, and synthesise relevant literature in a particular field. It explains how knowledge in the field has advanced by highlighting what has already been accomplished, what is well known, what is novel, and the current state of knowledge. In research-based publications, a literature review identifies research gaps (i.e., unexplored or understudied areas) and explains how a specific research endeavour addresses them.

A literature review also helps the researcher provide a theoretical background for the study (Paul & Criado, 2020:2).

1.8 LIMITATIONS OF THE STUDY

The primary limitation is its geographical scope, as the research is restricted to the John Taolo Gaetsewe District Municipality in the Northern Cape Province, which limits the generalisability of the results to other rural contexts with different climatic, geological, and socio-economic conditions. The study also employed a qualitative mono-method design based on a literature review and semi-structured interviews with municipal stakeholders. While this approach provided rich, contextual insights, it excluded quantitative assessments such as water quality analysis, infrastructure condition measurements, and budget performance data, which may have added empirical depth.

1.9 LAYOUT OF THE STUDY

This study consists of the following chapters:

Chapter 1: Nature and Scope of Study – Provides the introduction, background, problem statement, objectives, research questions, scope, methodology, ethical considerations, and contributions of the study.

Chapter 2: Literature Review – Reviews relevant literature on rural water supply, governance, funding, planning, implementation, and operations, identifying research gaps. Theoretical analysis forms part of this chapter.

Chapter 3: Research Methodology – Explains the qualitative, interpretivist approach, data collection through semi-structured interviews, sampling, and analysis methods.

Chapter 4: Results and Discussion – Presents the analysed interview results, highlighting themes and linking them to the literature and study objectives.

Chapter 5: Conclusions and Recommendations – Summarises findings, evaluates the research objectives, provides recommendations for improving rural water supply in the John Taolo Gaetsewe District Municipality, and outlines policy and practical implications.

1.10 CHAPTER SUMMARY

This chapter examines methods to enhance rural water supply systems in the John Taolo Gaetsewe District Municipality of the Northern Cape, South Africa. It highlights the global and local challenges of water scarcity, inadequate infrastructure, poor maintenance, and governance issues that impact the dependability of water service delivery.

The background highlights the connection to SDG 6 (clean water and sanitation). It describes the socio-economic and environmental situation in the Northern Cape, where low rainfall and reliance on groundwater heighten the urgency of water management.

The problem statement emphasises that the John Taolo Gaetsewe District Municipality faces unreliable and unsustainable water services due to infrastructure neglect, insufficient funding, poor leadership, skill shortages, and inadequate maintenance, resulting in significant water losses and risks to public health.

The primary objective is to assess the most effective methods to enhance rural water supply in the three local municipalities of the John Taolo Gaetsewe District Municipality. Secondary objectives include examining governance, planning, funding, implementation, and operational practices; evaluating financing processes; and providing recommendations.

The research questions examine the key institutional, financial, technical, and environmental factors influencing the reliability and sustainability of rural water service delivery within the John Taolo Gaetsewe District Municipality. They further explore how improvements across these key performance areas can enhance governance, efficiency, and long-term infrastructure performance in the district's Water Services Authorities.

The scope outlines the study within the context of public management, specifically focusing on water resources, with a primary emphasis on the John Taolo Gaetsewe District Municipality. The methodology employs a qualitative, interpretivist approach, utilising literature reviews and semi-structured interviews with key stakeholders to ensure credibility, validity, and ethical compliance.

The contributions are theoretical (adding knowledge on the John Taolo Gaetsewe District Municipality's water supply system), practical (assessing infrastructure lifespan and design options), and policy (suggesting amendments to improve operations and community participation).

Finally, the limitations highlight that the study is geographically confined to the John Taolo Gaetsewe District Municipality, which may impact its generalisability.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Access to safe, reliable, and sustainable water services remains one of the most persistent development challenges globally and particularly in rural and water-scarce regions of South Africa (World Bank Group, 2025; United Nations, 2025). Although water covers more than 70% of the Earth's surface, only a small fraction is available as accessible freshwater suitable for human use (Water Science School, 2019; American Museum of Natural History, 2016). Water is fundamental to human survival, public health, economic activity, and environmental sustainability, yet its effective delivery through infrastructure systems is constrained by a complex interplay of technical, institutional, financial, environmental, and governance-related barriers (Ferreira *et al.*, 2021:13–14; Grigg, 2021:213).

In South Africa, these constraints are particularly evident in rural municipalities, where historical inequalities, ageing infrastructure, limited institutional capacity, and increasing climate variability converge to undermine water service provision (Ruiters & Matji, 2015:660; Department of Water and Sanitation, 2018:2). Despite constitutional recognition of the right to access sufficient water (Republic of South Africa, 1996), many communities continue to experience unreliable supply, poor water quality, and delayed infrastructure delivery.

This chapter critically reviews the literature on water infrastructure delivery with a specific focus on identifying and synthesising the key barriers that hinder effective implementation and long-term sustainability. The chapter adopts a structured and progressive approach, beginning with the legislative framework governing water resources in South Africa, followed by a discussion of water supply systems and infrastructure. It then examines the importance of water infrastructure, the major barriers to effective delivery, financing mechanisms, and strategies for improving implementation and efficiency. The chapter concludes by situating water supply challenges within the broader context of Integrated Water Resource Management (IWRM) and by contextualising these issues within South Africa and the John Taolo Gaetsewe District Municipality. This structure ensures close alignment with the research objective of identifying obstacles to effective water infrastructure delivery in under-resourced contexts.

2.2 LEGISLATIVE FRAMEWORK: THE NATIONAL WATER ACT OF 1998

The National Water Act (NWA) of 1998 provides the cornerstone of South Africa's water governance framework and establishes the legal basis for sustainable, equitable, and efficient water resource management (Republic of South Africa, 1998). The Act designates the national

government as the public trustee of the country's water resources, responsible for ensuring their protection, allocation, and use in the public interest while safeguarding ecological integrity (Republic of South Africa, 1998:14).

Central to the NWA are the principles of sustainability and equity. Sustainability requires that water resources be managed in a manner that meets present needs without compromising future availability, while equity seeks to redress historical imbalances in access to water across sectors and communities (Republic of South Africa, 1998; Palmer & Munnik, 2018:2). These principles are particularly relevant to rural and historically marginalised areas, where inadequate infrastructure and service delivery persist.

The Act introduces mechanisms that directly influence water infrastructure planning and delivery, including water-use licensing, water-use charges, and the establishment of Catchment Management Agencies (CMAs) (Republic of South Africa, 1998). These instruments provide the legislative foundation for Integrated Water Resource Management but require strong institutional capacity and effective governance to translate policy intent into operational outcomes (Meissner, 2016:2; Botha, 2020:97).

2.3 WATER SUPPLY SYSTEMS AND INFRASTRUCTURE

2.3.1 Water Supply Systems

Water supply systems consist of interconnected components responsible for sourcing, treating, storing, and distributing potable water to consumers (Lewandowski *et al.*, 2020:1). Water is primarily obtained from surface water sources such as rivers, dams, and reservoirs, as well as from groundwater stored in aquifers (Kipng'ok & Kanda, 2014:1). Surface water typically requires extensive treatment to remove physical, chemical, and biological contaminants before being deemed potable, in accordance with national water quality standards (Department of Water and Sanitation, 2022d:69).

Water treatment processes commonly include coagulation, sedimentation, filtration, corrosion control, and disinfection, supported by auxiliary facilities such as laboratories for continuous quality monitoring (Department of Water and Sanitation, 2022d). Once treated, water is stored in reservoirs or tanks and distributed through reticulation networks comprising pipelines, pumps, and booster stations. The effectiveness of water supply systems therefore depends not only on water availability but also on infrastructure condition, system design, and operational management.

2.3.2 Water Infrastructure

Water infrastructure encompasses the physical, technological, and institutional systems that enable the abstraction, treatment, storage, and distribution of water, as well as wastewater collection and treatment (Adeniran *et al.*, 2021:1; Grigg, 2024:2–3). It includes dams, reservoirs, pipelines, treatment plants, irrigation systems, and, increasingly, digital monitoring and control technologies (Proag, 2016:46–47; Locke, 2024:757–758).

Modern water infrastructure systems are designed as complex socio-technical networks that integrate sensors, data analytics, and automated control mechanisms to improve efficiency and water quality (Farah & Shahrour, 2024:15; Ansari, 2021:70–72). However, their effectiveness is contingent on enabling governance frameworks, skilled human resources, and sustained financial investment. In the absence of these conditions, infrastructure deterioration, service interruptions, and water losses become prevalent (Ruiters & Matji, 2015:660; George-Williams *et al.*, 2024:1–2).

2.4 IMPORTANCE OF WATER INFRASTRUCTURE

Reliable water infrastructure is essential for public health, as it reduces exposure to waterborne diseases and supports adequate sanitation (Ferreira *et al.*, 2021:14). It also underpins socio-economic development by enabling industrial production, agricultural activities, and household livelihoods (World Bank Group, 2025). At a global level, water infrastructure plays a crucial role in achieving the Sustainable Development Goals, particularly those related to clean water and sanitation, health, food security, and environmental sustainability (Taka *et al.*, 2021:260).

Beyond service delivery, water infrastructure contributes to resilience by enabling communities and economies to withstand and recover from shocks such as droughts, floods, and infrastructure failures (Almoghathawi & Barker, 2019:1134). Effective governance and policy alignment are therefore necessary to ensure that infrastructure investments translate into sustainable and equitable outcomes (Grigg, 2021:213).

2.5 BARRIERS TO EFFECTIVE WATER INFRASTRUCTURE DELIVERY

Despite its importance, water infrastructure delivery is frequently undermined by multiple, interrelated barriers. In rural and water-scarce regions, geographical constraints, dispersed settlements, and limited access to water sources increase the cost and complexity of infrastructure development (Krueger *et al.*, 2019:7). Ageing and poorly maintained infrastructure contribute to high levels of non-revenue water, service interruptions, and declining water quality (Krueger *et al.*, 2019:5; Malima *et al.*, 2022:149).

Institutional and governance challenges further exacerbate these problems. Weak management practices, limited technical capacity, and fragmented responsibilities among water service authorities often result in ineffective planning and delayed implementation (Botha, 2020:97; Dlamini, 2018:16). Financial constraints, including inadequate revenue collection, insufficient funding for maintenance, and reliance on short-term grants, limit municipalities' ability to sustain infrastructure assets (Mohanty & Rout, 2020:3; Machado *et al.*, 2022:4).

Environmental pressures, particularly climate variability and recurrent droughts, place additional strain on already stressed systems. Water sources are increasingly vulnerable to contamination, while extreme weather events disrupt infrastructure and reduce system reliability (Marpaung *et al.*, 2024:3555–3558). These interrelated barriers highlight the need for integrated strategies that address technical, institutional, financial, and environmental dimensions simultaneously (Tantoh *et al.*, 2019:12–13).

2.6 FINANCING WATER INFRASTRUCTURE PROJECTS

The development and maintenance of water infrastructure require substantial and sustained financial investment. Funding sources typically include government grants, municipal budgets, development finance, and municipal bonds (Greer, 2020:2; Cheteni *et al.*, 2025:2). In many developing contexts, public funding remains insufficient to meet infrastructure backlogs, resulting in deferred maintenance and delayed project completion (Department of Water and Sanitation, 2018:48).

Innovative financing mechanisms, such as public–private partnerships, green bonds, and blended finance models, have gained prominence as means of mobilising additional capital and technical expertise (Greer, 2020:8; Financial Sector Deepening Africa, 2025). However, their effectiveness depends on sound governance, transparent financial management, and adequate institutional capacity at the municipal level.

2.7 STRATEGIES FOR IMPLEMENTING EFFECTIVE WATER SUPPLY PROJECTS

Effective implementation of water supply projects requires an integrated and interdisciplinary approach that combines community participation, technological innovation, strategic planning, and policy support (CSIR, 2025:2). Community engagement enhances local ownership, ensuring that infrastructure design and operation reflect local needs, thereby improving sustainability (Olanrewaju *et al.*, 2023:34–35).

Technological integration, including the use of Geographic Information Systems, Building Information Modelling, and Internet of Things applications, improves data management, decision-

making, and operational efficiency (Wu *et al.*, 2024:2355; Jan *et al.*, 2021:2). Institutional coordination across governance levels is equally important, as it aligns policy objectives, funding mechanisms, and implementation responsibilities (Machado *et al.*, 2022:3). Public–private partnerships further contribute financial resources, technical expertise, and innovation to complex water projects (Auliya *et al.*, 2023:215).

Water conservation measures, such as rainwater harvesting, wastewater reuse, and demand management, reduce pressure on limited freshwater resources and enhance long-term sustainability (Wang *et al.*, 2020:2; Garrone *et al.*, 2020:1). Strategic planning within robust regulatory frameworks supports compliance, resilience, and project longevity (Lau *et al.*, 2023:21).

2.8 IMPROVING EFFICIENCY IN WATER SUPPLY SYSTEMS

Improving efficiency in water supply systems is critical for addressing water scarcity and reducing operational costs. Key interventions include reducing non-revenue water through leak detection, pressure management, and structured asset maintenance programmes (Teso *et al.*, 2019:4385; Egito *et al.*, 2023:1096). Advanced monitoring technologies and real-time data systems enable predictive maintenance and adaptive system control (Chen *et al.*, 2023:3; Todorov & Tonkov, 2024:3–4).

Energy efficiency is another important consideration, as pumping and treatment processes account for a significant share of operating costs (Farah *et al.*, 2024:2–3). Optimised pump scheduling, variable frequency drives, and the integration of renewable energy sources contribute to both economic and environmental sustainability (Patrick, 2022:102; Gan *et al.*, 2022:111594).

2.9 INTEGRATED WATER RESOURCE MANAGEMENT AND WATER SUPPLY

Water supply challenges cannot be addressed in isolation from broader water resource management considerations. Integrated Water Resource Management provides a holistic framework that recognises the interconnections between water supply, wastewater management, environmental protection, and socio-economic development (Martin-Candilejo *et al.*, 2019:16). In South Africa, IWRM is implemented through a catchment-based approach supported by the National Water Act (Republic of South Africa, 1998; Water Research Commission, 2018:1).

IWRM emphasises stakeholder participation, adaptive management, and ecological sustainability, aiming to balance competing water demands while protecting aquatic ecosystems (Dube *et al.*, 2021:53; Pollard & Du Toit, 2008:671). Despite its progressive legislative foundation,

effective implementation remains constrained by institutional capacity limitations and coordination challenges at local government level (Stuart-Hill *et al.*, 2020).

2.10 WATERSUPPLY IN SOUTH AFRICA

South Africa is a water-scarce country characterised by low and highly variable rainfall, with average annual precipitation significantly below the global average (Igamba, 2022). Although access to improved water services has expanded since 1994, the reliability and quality of supply have deteriorated in many areas due to ageing infrastructure, insufficient maintenance, and governance challenges (du Plessis, 2022; Department of Water and Sanitation, 2018:2).

National assessments indicate substantial backlogs in water and sanitation infrastructure investment, with available funding falling far short of estimated needs (National Water and Sanitation Master Plan, 2018:48). These systemic challenges underscore the urgency of addressing barriers to effective water infrastructure delivery.

2.11 CONTEXTUALISING WATER SUPPLY CHALLENGES IN THE JOHN TAOLO GAETSEWE DISTRICT MUNICIPALITY

The John Taolo Gaetsewe District Municipality exemplifies the challenges faced by rural, water-scarce regions in South Africa. The district relies heavily on groundwater sources and is highly vulnerable to recurrent droughts and climate variability (John Taolo Gaetsewe District Municipality, 2022:30). Infrastructure backlogs, limited financial resources, and institutional capacity constraints have resulted in persistent service delivery challenges (Department of Human Settlements, Water and Sanitation, 2020).

Despite interventions such as regional water supply schemes and emergency drought relief measures, water infrastructure in the district remains inadequate and poorly maintained, with significant delays in project implementation (John Taolo Gaetsewe District Municipality, 2022:111). Understanding these challenges within the broader theoretical and empirical literature provides a foundation for identifying targeted strategies to improve water infrastructure delivery in the district.

2.12 THEORETICAL ANALYSIS

This study situates the improvement of water infrastructure within a theoretical framework that integrates economic, governance, institutional, and systems-based perspectives. A strong theoretical foundation is essential to understand both the structural and operational challenges facing water management in South Africa, particularly in under-resourced districts like the John

Taolo Gaetsewe District Municipality. This section synthesises relevant theoretical approaches, critically evaluates their applicability, and identifies insights that inform the selection of a contextually appropriate framework for this study.

2.12.1 Economic and Performance-Oriented Theories

Economic and performance-focused frameworks offer insight into how macroeconomic conditions, population dynamics, and investment patterns influence water infrastructure outcomes. Dangui and Jia (2022:5) developed an integrative panel regression framework to examine the performance of water infrastructure in 31 Sub-Saharan African countries. Their findings highlight that higher per capita income and greater openness to trade positively impact infrastructure efficiency, while factors such as population density and economic growth influence outcomes in low- and lower-middle-income contexts. These insights are relevant to the John Taolo Gaetsewe District Municipality, suggesting that municipal water infrastructure performance cannot be analysed in isolation from broader economic conditions and investment patterns.

While useful, economic-focused models may underplay local governance, institutional capacity, and community-specific factors that critically influence water service delivery, particularly in resource-constrained municipalities. This limitation underscores the need for a multi-dimensional theoretical approach.

2.12.2 Governance and Policy Paradigms

Governance and policy theories provide a lens to examine how strategic decision-making, policy design, and institutional structures influence water resource management. Meissner (2016:2) identifies five paradigms, rationalism, post-positivism, interpretivism/constructivism, critical theory, and participatory theory, that shape the National Water Resource Strategy (NWRS). His analysis, using the PULSE³ framework (Meissner, 2016:1), reveals that rationalism continues to dominate NWRS2, potentially limiting adaptive and participatory approaches that respond to local complexities.

For the John Taolo Gaetsewe District Municipality, these findings highlight the importance of policy frameworks that move beyond top-down rationalist planning toward more inclusive, participatory governance models. Such an approach can better align water infrastructure initiatives with community needs, thereby improving sustainability and effectiveness.

2.12.3 Institutional Capacity and Local Governance

Institutional capacity is a critical determinant of effective water service delivery. Botha (2020:97) emphasises the role of human capital, leadership, strategic direction, and budgetary support in municipal water management, warning that weak institutional capacity exacerbates water security challenges. Similarly, Dlamini (2018:16) applies human development and neo-institutionalism frameworks to evaluate the uMkhanyakude District Municipality, demonstrating how governance, politics, and institutional dynamics shape water access outcomes.

These studies underline that infrastructure improvements alone are insufficient without adequate local governance and institutional capability. For the John Taolo Gaetsewe District Municipality, strengthening municipal leadership, technical expertise, and resource allocation is therefore central to ensuring sustainable water infrastructure outcomes.

2.12.4 Systems Thinking and Network Analysis

A systems-based perspective provides tools for analysing complex interdependencies within water infrastructure networks. Sambo *et al.* (2018:349) employ graph theory and community structure analysis to map failures in rural water systems, identifying root causes such as unskilled technical staff, poor infrastructure siting, and ineffective handovers. This approach demonstrates the value of systems thinking in diagnosing structural and operational inefficiencies that are often overlooked in conventional governance or economic models.

Applying such analytical tools to the John Taolo Gaetsewe District Municipality can reveal hidden bottlenecks, clarify interconnections among infrastructure components, and guide prioritisation of interventions to maximise impact.

2.12.5 Summary and Theoretical Positioning

This review highlights four complementary theoretical lenses:

- **Economic and performance-oriented theories**, which link macroeconomic conditions to infrastructure outcomes.
- **Governance and policy paradigms**, which emphasise the influence of decision-making structures and participatory approaches.
- **Institutional capacity frameworks**, which underscore the critical role of local governance and human resources.

- **Systems thinking and network analysis**, which offer tools for mapping interdependencies and identifying root causes of service delivery failures.

Each perspective offers valuable insights, but no single framework fully captures the complex challenges of water infrastructure in the John Taolo Gaetsewe District Municipality. Therefore, this study will adopt a contextualised, integrative theoretical framework that combines elements from governance, institutional capacity, and systems-based approaches. This choice will ensure alignment with local realities, support targeted interventions, and guide practical recommendations for enhancing water infrastructure and service delivery in the district.

2.13 CHAPTER SUMMARY

This chapter has presented a coherent and critically synthesised review of the literature on water infrastructure delivery, with a specific focus on barriers that hinder effective implementation. By progressing from the legislative framework to water supply systems, infrastructure importance, barriers, financing, and implementation strategies, the chapter establishes a logical foundation for the empirical investigation that follows. The next chapter outlines the research methodology employed to examine water infrastructure challenges in the John Taolo Gaetsewe District Municipality.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

While Chapter 1 provides an overview of this study and Chapter 2 presents the literature review, this chapter focuses on the methodology, design, and specific methods used to conduct this research. The chapter begins with an explanation of the rationale behind the selected methods, emphasising ethical considerations and potential limitations encountered during the study. This study aims to identify gaps in the John Taolo Gaetsewe District Municipality's rural water supply system and propose solutions from planning through operation. It evaluates a method expected to optimise the performance of the three WSAs by examining governance, planning, funding, implementation, financing, and operations. The findings will inform recommendations to improve the WSAs' overall water supply functionality.

3.2 EMPIRICAL STUDY

3.2.1 Research Paradigm

Criticism of positivism in the social sciences gave rise to the interpretivist paradigm (Rehman & Alharthi, 2016:55), which was adopted for this study. Interpretive research does not aim to establish universal truths but seeks to understand how participants interpret social phenomena, typically through qualitative and inductive methods such as interviews, observations, and case studies (Rehman & Alharthi, 2016:55). In this approach, theory emerges from the data rather than predetermining it, with findings organised into themes and patterns to build a deeper understanding (Rehman & Alharthi, 2016:56). The quality of interpretive research is judged by credibility, transferability, dependability, and confirmability, ensuring that results are authentic, contextually meaningful, and conducted with transparency and rigour (Rehman & Alharthi, 2016:56). As Nickerson (2023) notes, interpretivism emphasises understanding individuals' beliefs, motivations, and reasoning within their social context as key to interpreting data meaningfully. Guided by this paradigm, the study explored approaches to improve the rural water supply system across the three WSAs in the John Taolo Gaetsewe District Municipality—Gamagara, Ga-Segonyana, and Joe Morolong—providing detailed insights into existing challenges and deficiencies and identifying potential strategies to enhance service delivery and accelerate infrastructure development.

3.2.2 Research Design

The study employed a qualitative, exploratory research design, chosen for its suitability in investigating complex and under-researched phenomena (Roy *et al.*, 2015:252), including rural water infrastructure in the John Taolo Gaetsewe District Municipality. Exploratory research is appropriate when the aim is to gain insights into processes, experiences, and contextual challenges rather than to test hypotheses (Rangarajan & Shields, 2020:1703). This design enabled the study to systematically explore gaps in planning, management, and operational practices across the three WSAs and to identify opportunities for improvement.

The qualitative, exploratory approach enabled the study to gather detailed, context-specific insights from participants, focusing on how municipal staff perceive, experience, and handle challenges in the rural water supply system. This approach is especially beneficial in settings with limited previous research, incomplete data, or resource limitations, as it helps uncover issues and patterns that might not be apparent through structured or quantitative methods (Creswell & Poth, 2018:45; Aspers & Corte, 2019:139).

Using this design, the study could explore the operational, financial, and technological aspects of water infrastructure comprehensively, without being limited to predetermined variables or outcomes. The aim was to understand the context, identify key gaps, and generate insights to inform practical strategies for enhancing water services in the district.

In summary, the qualitative, exploratory research design provided a flexible framework for investigating a complex, real-world problem in an underexplored context, enabling the study to generate rich, actionable insights while remaining open to discoveries within the John Taolo Gaetsewe District Municipality's water supply system.

3.2.3 Research approach

This study adopted an inductive research approach, appropriate for its exploratory nature. The aim was not to test a predetermined hypothesis but to derive insights directly from the data to uncover gaps in the John Taolo Gaetsewe District Municipality's rural water supply system and to propose strategies to accelerate infrastructure upgrades.

The inductive approach allowed the researcher to progress from specific observations—gathered through interviews with municipal teams—to broader generalisations and strategic recommendations. This aligned with the study's aim of identifying context-specific challenges and assessing methods with the greatest impact on improving the rural water supply system, within the limitations of limited municipal budgets.

By employing interviews as the primary data collection method, the research captured the lived experiences, perspectives, and operational challenges of teams within the three WSAs of the John Taolo Gaetsewe District Municipality. These findings were then analysed thematically to develop a strategy that reflected both practical realities and the need for systemic improvement. This approach, therefore, provided a solid foundation for the data collection and analysis presented in Chapter Four.

3.2.4 Methodological Choice

This study employed a mono-method qualitative research approach. The study combined a literature review with semi-structured interviews conducted with one representative from each of the Gamagara, Ga-Segonyana, and Joe Morolong municipalities. This approach was chosen to gain in-depth insights into the challenges and gaps in the John Taolo Gaetsewe District Municipality's rural water supply system and to explore potential strategies for improving service delivery and accelerating infrastructure upgrades.

Semi-structured interviews enabled the researcher to clarify misunderstandings immediately, probe for deeper responses, and foster a conversational environment conducive to open and candid sharing (Ruslin *et al.*, 2022:24). They also allowed observation of non-verbal cues such as tone, pauses, and body language, offering additional context. This approach facilitated focused discussions on key themes, including planning constraints, operational inefficiencies, budgetary limitations, and opportunities for system improvement.

The methodological choice laid the foundation for data collection and analysis, ensuring that the study's objectives were systematically and effectively addressed.

3.2.5 Research Strategy

A case study research strategy was adopted to enable an in-depth examination of the rural water supply system within the John Taolo Gaetsewe District Municipality. The strategy facilitated a holistic exploration of the planning, operational, and financial challenges faced by the three WSAs and enabled the identification of practical solutions to accelerate infrastructure upgrades.

Focusing on the John Taolo Gaetsewe District Municipality as a single-district case study was justified for two main reasons. First, the district is one of the largest and most rural in the Northern Cape, where water supply challenges are acute and have significant social and economic impacts. Second, focusing on a single district enabled a more detailed, contextually grounded analysis than would have been feasible in a broader multi-district or national study. This strategy highlighted both everyday challenges and municipality-specific factors, such as resource

limitations, planning frameworks, and operational practices, providing insights that could inform practical recommendations.

Data were gathered through semi-structured group interviews with purposively selected municipal representatives and triangulated with relevant policy and planning documents to strengthen the validity of the findings.

3.2.6 Time Horizon

The study employed a cross-sectional time horizon, as the investigation was conducted over a single, short-term period. This approach enabled the researcher to capture a “snapshot” of the current state of the rural water supply system, including planning, operational, and budgetary challenges, as well as opportunities for improvement.

Neuman (2014:44) distinguishes cross-sectional research, which collects data at a single point in time and provides a “picture” of social phenomena, from longitudinal research, which collects data over multiple points to provide a “moving picture” of events or processes. The cross-sectional approach was appropriate for this study because it allowed the efficient collection of qualitative data from interviews and document reviews within practical time and resource constraints. While it does not track changes over time, the triangulation of multiple data sources ensured that the findings accurately reflected the prevailing context across the three municipalities.

3.2.7 Study Population and Sampling

3.2.7.1 Target group

The study population comprised executives directly involved in planning, funding, and managing rural water supply infrastructure within the three WSAs of the John Taolo Gaetsewe District Municipality: Gamagara, Ga-Segonyana, and Joe Morolong municipalities. These individuals were identified as possessing the necessary strategic insight into budgetary processes and the factors that either support or hinder water supply performance. Their expertise enabled them to provide informed perspectives on systemic gaps, operational challenges, and potential opportunities to improve rural water service delivery.

3.2.7.2 Sample inclusion and exclusion criteria

To ensure that the data collected were both relevant and insightful, participants were selected according to the following criteria:

- **Inclusion criteria:** Executives with technical expertise or managerial responsibilities related to water infrastructure planning, operations, and budgeting; ability to articulate perspectives clearly; and availability to participate in interviews.
- **Exclusion criteria:** Individuals lacking relevant managerial and technical knowledge, those considered vulnerable or unable to provide informed consent, and personnel with conflicts of interest that could bias responses (e.g., working for an external competitor or having prior involvement in the study's planning).

A purposive non-probability sampling method was applied, deliberately selecting participants most capable of providing contextually rich information relevant to the study objectives (Alchemer, 2021). One executive participant from each of the three municipalities was purposefully invited to take part in the study. This selection ensured the inclusion of both strategic and technical perspectives, capturing insights into governance, operational management, and decision-making processes relevant to water service delivery. At the same time, the approach was designed to remain feasible within the researcher's logistical, time, and resource constraints, allowing for in-depth qualitative engagement while maintaining practical manageability of the research process.

The participants are residents of the district, which facilitated access for interviews. Logistical arrangements were manageable because the researcher's employer is based in Kuruman, while the researcher resided in Klerksdorp, North West Province. All recruitment and engagement procedures complied with the Protection of Personal Information Act (POPIA) (South Africa, 2013), ensuring participants' confidentiality and privacy.

3.2.7.3 Sampling Method

The study employed purposive sampling to target individuals with specific knowledge and experience relevant to rural water infrastructure management. This method enabled the researcher to focus on participants most likely to provide rich, detailed insights into operational challenges, service delivery gaps, and potential improvement strategies. Screening of potential participants was conducted through email or phone contact to confirm eligibility, availability, and willingness to participate.

3.2.8 Collection of data

Data collection involved acquiring the fundamental information that the researcher used to address the study objectives (Bryman & Bell, 2014:376). The first step in the process was to formulate the objectives of the interview schedule, which aimed to gather information from

participants that would help identify gaps and develop strategies to improve the rural water supply system in the John Taolo Gaetsewe District Municipality.

Participants were purposively selected based on the following criteria:

- Only executives with the desired managerial and technical background in planning, funding, and water supply infrastructure operations were invited to participate.
- Participants had to be articulate and able to describe their experiences clearly.
- Relevant publications or conference presentations were considered but not required.
- The researcher ensured sufficient time, resources, and budget to conduct the recruitment.
- Vulnerable participants or those unable to give informed consent were excluded.
- Demographic characteristics were not used as selection criteria.
- No incentives were offered.

The researcher identified and approached one executive from each of the three local municipalities within the John Taolo Gaetsewe District Municipality to participate in the study. Selection was based on their professional roles, availability, and willingness to provide informed insights into water service delivery operations. Before recruitment, the researcher ensured that all prospective participants met the ethical criteria of suitability and independence. This included confirming that none of the participants had any conflict of interest, such as direct involvement in the specific research topic, prior participation in related studies, or current employment with an organisation that could be perceived as a competitor or stakeholder with vested interests.

In accordance with these criteria, one qualified and consenting participant was purposefully selected from each of the three WSAs (Joe Morolong, Ga-Segonyana, and Gamagara Local Municipalities). This ensured balanced representation and the inclusion of participants with direct operational and managerial experience relevant to the study's objectives.

After confirming participant eligibility, the researcher held face-to-face meetings to obtain informed consent in accordance with the Protection of Personal Information Act (POPIA) and the procedures outlined in Annexure A. A generic Letter of Consent is provided in Annexure A, as the study involved three different Water Services Authorities (WSAs). During these meetings, participants were informed about the purpose of the study, the nature of their expected contributions, and the estimated duration of the interviews. Interviews were then scheduled at times most convenient for the participants.

Interviews were conducted either face-to-face at mutually agreed venues or via Zoom. The semi-structured interview schedule (Annexure B) was designed to capture participants' real-life experiences, perspectives, and opinions, aligned with the research objectives. Interviews were recorded using both detailed note-taking and the cell phone's audio recording feature to ensure accuracy.

The study adhered to established interviewing principles (Sahoo, 2022):

- Participants were approached professionally and courteously to encourage participation.
- The researcher refrained from expressing personal opinions or judgments.
- A clear understanding of the research objectives and scope was maintained.
- Rapport was established to make participants comfortable and encourage open disclosure.
- Interview sessions were carefully planned regarding venue, date, and time.
- Questions were clear, relevant, and asked one at a time. Repetition was allowed if needed.
- The researcher observed participants' verbal and non-verbal cues and listened attentively, allowing sufficient time for responses.
- The researcher avoided interruptions, sensitive or awkward questions, topic-hopping, arguments, or any influence on participants' responses.
- Gratitude was expressed at the conclusion of each interview.

Participants were actively managed throughout the research process, including ongoing communication, reminders, addressing concerns, and soliciting feedback after the interviews to evaluate their experience.

In conclusion, semi-structured interviews proved to be a significant and effective data-gathering approach for this qualitative study, providing in-depth, contextually rich insights into the operational and infrastructural challenges faced by the John Taolo Gaetsewe District Municipality WSAs.

3.2.9 Designing the Interview Schedule

The interview schedule for this study was designed to gather in-depth insights and perspectives from stakeholders involved in improving water infrastructure within the John Taolo Gaetsewe

District Municipality. The primary aim was to explore participants' experiences, opinions, and recommendations regarding challenges, opportunities, and strategies for enhancing the district's rural water supply system.

The interview schedule consisted of nine open-ended questions, structured to cover key thematic areas aligned with the study objectives (Section 1.5). These areas included:

- Current challenges hindering a sufficient and reliable water supply in the district.
- Critical areas of infrastructure requiring immediate attention and improvement.
- Factors contributing to water scarcity or shortages, along with potential solutions.
- Past initiatives or projects that were successful and the factors contributing to their success.
- Water quality assessment, including steps to ensure safe and consistent water quality in all communities.
- Technological innovations or advancements that could improve water infrastructure and management.
- Financial challenges and constraints, and possible strategies for mitigation.
- Collaboration mechanisms between the government, the private sector, and civil society to enhance water services.
- Best practices or models from other regions or countries that could be adapted for the John Taolo Gaetsewe District Municipality.

The questions were formulated to be clear, concise, and open-ended, allowing participants to elaborate on their experiences and provide rich, context-specific information. Each question was designed to probe relevant aspects of planning, operational management, resource allocation, and governance within the district's WSAs.

In designing the interview schedule, the researcher considered several methodological principles:

- Questions were sequenced logically, moving from general observations about challenges to specific discussions about solutions and innovations.
- Questions were framed neutrally to avoid leading or influencing participants' responses.

- Only one question was asked at a time, with follow-up prompts used to clarify or expand on answers where necessary.
- The schedule was pre-tested for clarity and relevance, ensuring alignment with the study objectives and feasibility within the interview timeframe.

The semi-structured format allowed the researcher to balance structure with flexibility, enabling consistent coverage of key topics across participants while also allowing for exploration of unanticipated issues or insights raised during the discussions. This design ensured that the interviews produced rich, actionable data to inform strategies for improving water infrastructure in the John Taolo Gaetsewe District Municipality.

3.2.10 Conducting the interviews

The interviews were conducted following a semi-structured interview schedule (Annexure B). For each Water Services Authority (WSA), the executive participant was contacted in advance to schedule the interview at a time and location convenient for them, either face-to-face at a mutually agreed venue within the district or via Zoom for remote participation. Each participant was reminded of the study's purpose, the expected duration of the interview, and their rights regarding participation, including confidentiality and the option to withdraw at any time.

Before the interviews commenced, informed consent was obtained in accordance with the Protection of Personal Information Act (POPIA) and ethical guidelines (Annexure A). Participants were provided with an overview of the study, the interview process, and assurances that their responses would be used solely for research purposes.

During the semi-structured interviews, participants were encouraged to elaborate on key issues, including funding constraints, water supply shortages, and other factors affecting rural water service delivery. Follow-up questions and probing techniques were employed to clarify responses and elicit additional context where necessary. All interviews were audio-recorded on a mobile device, and detailed notes were taken concurrently to ensure the accuracy and completeness of the data collected.

Several principles guided the conduct of the interviews:

- The researcher maintained a professional, friendly, and non-judgmental demeanour to foster trust and openness.
- Questions were posed clearly and one at a time, with repetition or rephrasing where needed.

- The researcher paid close attention to verbal and non-verbal cues, such as tone, pauses, gestures, and facial expressions, to enrich understanding.
- External interruptions were minimised, and sensitive or potentially embarrassing questions were avoided.
- At the conclusion of each interview, the researcher expressed gratitude for the participants' time and cooperation.

This approach ensured that the interviews were conducted ethically and efficiently, with each session structured to give the executive participant equal opportunity to provide insights across all three interviews. The repeated engagements produced rich, reliable, and contextually grounded data, which were triangulated with independent documentary sources to inform strategies for improving rural water infrastructure in the John Taolo Gaetsewe District Municipality.

3.2.11 Statistical Analysis

The data collected through semi-structured interviews were analysed at the NWU's Statistical Department using Thematic Analysis, a widely used qualitative method suitable for identifying, analysing, and reporting patterns or themes within a dataset (Bryman & Bell, 2014:385). Thematic Analysis is versatile and not constrained by any single theoretical framework, making it appropriate for exploratory studies such as this one, which seeks to uncover gaps in the rural water supply system of the John Taolo Gaetsewe District Municipality and propose strategies for infrastructure improvement.

The data were transcribed into written scripts and analysed electronically using ATLAS.ti, a computer-assisted qualitative data analysis software (CAQDAS) (NYU Libraries, 2025). Thematic analysis, as defined by Braun and Clark (2006:16-23), was employed for data analysis. This methodology helps to identify, analyse, and report patterns within a dataset, facilitating the descriptive organisation of data for interpretation.

The thematic analysis process commenced with the researcher familiarising themselves with the collected data, followed by the generation of initial codes. Recurring patterns and concepts were then identified, reviewed, and refined to form coherent themes. Each theme was operationalised and supported with relevant participant quotations to ensure transparency and traceability of interpretations. The analysis was guided by the overarching research questions facilitated using ATLAS.ti, a computer-aided qualitative data analysis software, which played a key role in organising the data, coding responses, and identifying significant themes and illustrative quotations.

The analysis followed a systematic, six-phase process (Braun & Clarke, 2006:16-23):

- **Familiarisation with the data:** Interview recordings were transcribed verbatim, and the transcripts were read repeatedly to ensure an in-depth understanding of the content and context of participants' responses.
- **Generating initial codes:** Relevant data segments were labelled with descriptive codes, capturing key concepts, experiences, and perspectives expressed by participants. Coding was conducted manually and verified for consistency.
- **Searching for themes:** Codes were examined and grouped into broader categories to identify emerging patterns and recurring issues across the three municipalities. Themes reflected the district's core challenges, operational gaps, and potential solutions relevant to rural water supply.
- **Reviewing themes:** Identified themes were reviewed in relation to the coded extracts and the entire dataset to ensure coherence, internal consistency, and clear differentiation between themes.
- **Defining and naming themes:** Each theme was refined and clearly defined to convey the underlying meaning of the data. Themes were named to accurately reflect their content, facilitating understanding of the district's water supply challenges and potential strategies.
- **Producing the report:** Themes were analysed in depth and related to the research objectives, literature review, and policy context. Representative quotes from participants were included to illustrate key findings, while thematic patterns were discussed to provide actionable insights for improving water infrastructure in the John Taolo Gaetsewe District Municipality.

Thematic Analysis was chosen because it allows for rich, nuanced interpretation of qualitative data, capturing both explicit and implicit meanings in participants' responses (Braun & Clark, 2006:5; Naeem *et al.*, 2023:7). It also facilitated the comparison of perspectives across municipalities, highlighting common challenges, municipality-specific issues, and opportunities for intervention. By applying this method, the study generated evidence-based recommendations grounded in the experiences and insights of municipal staff responsible for rural water service delivery.

3.2.12 Trustworthiness and Data Validation

To ensure the study's trustworthiness, several strategies were employed, focusing on credibility, confirmability, transferability, and dependability.

Credibility was established by presenting the findings to participants for verification, ensuring that their perspectives were accurately captured and interpreted (Bryman & Bell, 2014:272). Ethical standards were rigorously followed throughout the study, and participants were allowed to confirm that the researcher had correctly understood their social and operational contexts within the John Taolo Gaetsewe District Municipality rural water supply system.

Confirmability ensured that the researcher's personal values or theoretical biases did not influence the findings. While complete impartiality is unattainable, transparency in data collection, coding, and thematic analysis allowed the researcher to demonstrate that interpretations were grounded in the data rather than personal assumptions (Bryman & Bell, 2014:276).

Transferability was enhanced by providing detailed, context-rich descriptions of the rural water supply system and the operational environments of the three WSAs. This detailed contextualisation enables other researchers or practitioners to assess whether the findings can be applied to similar contexts (Korstjens & Moser, 2018:122).

Dependability involved evaluating the study's findings, interpretations, and recommendations against the data collected, ensuring consistency and alignment. Dependability was achieved in the following ways:

- Codes and thematic areas were developed based on the literature review and the study's theoretical framework. This provided a consistent guide for data collection and analysis, enhancing the dependability of the research process.
- Purposive sampling ensured that participants held direct responsibility for planning, funding, and managing water infrastructure. Involving these strategically selected individuals yielded reliable, consistent insights aligned with the study objectives.
- Data were gathered through semi-structured interviews and corroborated with relevant documents and reports. This triangulation of sources (section 3.2.13) strengthened the stability and consistency of findings, supporting the dependability of the results by capturing multiple perspectives.
- Interviews were conducted in sufficient depth to allow participants to provide comprehensive insights, with additional sessions arranged when necessary to capture any remaining information. This systematic approach ensured thorough, repeatable data collection, reinforcing the study's reliability.

Overall, the combination of credibility checks, confirmability procedures, detailed contextualisation, careful participant selection, triangulation, and attention to data saturation ensured that the study's findings were valid, reliable, and representative of the operational realities and challenges of rural water supply within the John Taolo Gaetsewe District Municipality.

3.2.13 Data saturation and data richness

In qualitative research, data saturation is the point at which no new themes or insights emerge from the data. In this study, three interviews were conducted - one with key individuals in each of the three selected municipalities in the Northern Cape. Since the study focuses on the perspectives of key decision-makers, no attempt was made to achieve traditional thematic saturation. The three elite interviewees represent the most authoritative informants within their respective municipalities, and their inputs therefore form the core of the research.

Although a limited number of interviews cannot guarantee strict saturation, the value of this study lies in the richness and depth of the data collected.

Richness of the data was achieved through:

- The use of a semi-structured interview guide with open-ended questions, allowing participants to provide extensive and nuanced responses;
- In-depth probing through follow-up questions and clarifications to elicit detailed insights;
- Direct quotations that faithfully represent the participants' voices and perspectives.

The thickness of the data was ensured by:

- Contextualising each municipality's unique water supply challenges, including infrastructure, financial capacity, and geographical factors;
- Triangulating interview findings with secondary sources such as policy documents, municipal reports, and available statistics.

This combination of rich, thick data, despite the small sample size, enabled a comprehensive description of water supply challenges across the three municipalities and supported a critical analysis of their similarities and differences.

3.2.14 Conflicts of Interest

A conflict of interest occurs when a secondary interest has the potential to unduly influence professional judgment or the objectives of a study (Østengaard *et al.*, 2020:1). In this context, the primary interest was the objective of the research: to evaluate the most effective methods for

improving rural water supply systems in the three WSAs of the John Taolo Gaetsewe District Municipality (Section 1.5). Secondary interests include financial, personal, or professional considerations that could compromise impartiality.

The study was conducted in the interests of the WSAs, as the DWS is currently upgrading the water infrastructure in the John Taolo Gaetsewe District Municipality (Section 1.2). This process remains incomplete, and the district is keen to improve its rural water supply system (Annexure C, Permission Letters). Conflicts of interest could arise if findings reveal shortcomings in planning or governance, potentially affecting the reputation of the WSAs. To mitigate this, the researcher ensured that all outcomes were discussed with the relevant authorities before publication in the mini-dissertation, in line with institutional and government guidelines for the disclosure and management of conflicts (OECD, 2025).

Potential conflicts of interest were also considered regarding the researcher. As an engineering consultant, the researcher had previously worked with Joe Morolong and Ga-Segonyana Local Municipalities, which could introduce a bias toward these WSAs. To address this, a Declaration of Conflicts of Interest was included in the Letter of Consent (Annexure A), ensuring transparency and commitment to conducting objective and fair research. Additionally, where applicable, an independent statistician was engaged to analyse the data, providing an extra safeguard against bias and ensuring impartiality in the results.

The study also addressed gender and race biases as potential sources of conflict (Østengaard *et al.*, 2020:7; Kafaee *et al.*, 2022:390). Participants' responses were treated equitably, regardless of gender or race, and the researcher focused solely on what the evidence revealed. By applying these measures, the research maintained the credibility, integrity, and ethical standards required for a trustworthy study.

3.3 EMPIRICAL CONTRIBUTIONS OF THE STUDY

This study generates practical, academic, and policy-related insights through its qualitative, exploratory research design, which involved collecting and analysing data from municipal staff directly involved in water management in the John Taolo Gaetsewe District Municipality (JTGDM). The empirical contributions are outlined below.

Practical contributions

- The study identifies systemic gaps in planning, funding, and operations that hinder the delivery of reliable rural water services across the three WSAs in JTGDM, providing actionable insights for municipal decision-makers.

- Context-specific recommendations are offered to improve infrastructure efficiency, supporting ongoing initiatives by the Department of Water and Sanitation (DWS) in the district.
- By capturing the lived experiences of municipal staff, the study highlights operational challenges and resource constraints that may be overlooked in top-down planning approaches.
- The proposed strategy functions as a practical roadmap for prioritizing infrastructure upgrades within financial limitations, enabling more effective allocation of scarce resources.

Academic contributions

- The study extends the application of qualitative, exploratory research in the South African rural water supply context, addressing a gap where empirical research is currently limited.
- Through thematic analysis of participant experiences, the research demonstrates how qualitative methods can reveal meaningful patterns in infrastructure management and operational practice.
- A model is proposed for integrating stakeholder perspectives into planning and evaluation, which can be adapted or replicated in other municipalities facing similar service delivery challenges.

Policy-level contributions

- The findings provide evidence for provincial and national policymakers on the operational realities of rural water supply delivery in the Northern Cape.
- By aligning with the objectives of the National Water Act (South Africa, 1998) and the Sustainable Development Goals (particularly Goal 6: Clean Water and Sanitation), the study strengthens the empirical foundation for policy interventions aimed at equitable and sustainable water provision.

In summary, the study not only addresses immediate operational and planning needs within the JTGDMS but also contributes to broader methodological and policy discussions on improving rural water service delivery in financially constrained South African municipalities.

3.4 ETHICAL CONSIDERATIONS

The study commenced only after receiving approval from the Scientific Committee (SCom) and the Research Ethics Committee (EMS-REC) of the NWU Business School, ensuring compliance with institutional ethical standards and the protection of participants' rights. Participants were recruited transparently through their organisations and relevant associations (such as SALGA, CIDB, and CESA) in line with the Protection of Personal Information Act (POPIA). Each participant received a formal consent letter explaining the study's objectives, methodology, risks, and benefits. Consent was further supported by verbal clarification from a neutral third party to prevent coercion and to guarantee complete understanding.

Ethical principles guided all stages of the research. Informed consent was prioritised, participants' confidentiality was safeguarded, and vulnerable individuals were excluded unless their involvement could provide direct or community benefit. The principle of altruism shaped the process, ensuring that participants' dignity and well-being were prioritised over academic or personal gain (Engelbrecht *et al.*, 2018:2-3). Transparency was maintained by sharing findings in accessible formats, reinforcing accountability and demonstrating societal value.

Semi-structured interviews and interview schedules were used to gather data, which were analysed with CAQDAS (NYU Libraries, 2025) in consultation with NWU's statistical department to ensure rigour and reliability. Anticipated ethical risks, such as lack of transparency in data analysis, were addressed by fully disclosing sources, methods, and analytical procedures (Jol & Stommel, 2016:37; Rose & Johnson, 2020:15). Throughout the study, participants were fully informed of their rights, including the option to withdraw at any stage, and their interests remained central to the research process.

3.5 SUMMARY

The study adopted a qualitative, mono-method approach, combining a literature review with semi-structured interviews to gather rich, context-specific data from relevant stakeholders across the three WSAs.

A comparative research strategy was applied to systematically examine perspectives across municipalities, while a cross-sectional time horizon enabled data collection over a defined short-term period. The study population was accessed through purposive non-probability sampling, targeting participants with technical backgrounds in water infrastructure planning, funding, and operations. Ethical protocols, including informed consent and adherence to POPIA guidelines, were strictly followed.

Data were collected using a semi-structured interview schedule designed to elicit detailed insights on challenges, operational gaps, technological opportunities, financial constraints, and collaborative strategies. The interviews were conducted face-to-face or via Zoom, recorded, and supplemented with detailed field notes to ensure accuracy and depth of information.

Thematic Analysis was employed to systematically analyse the interview data. Codes were developed from the transcripts, grouped into themes, and refined to capture the core patterns, perspectives, and insights. This process facilitated the identification of actionable recommendations for improving the district's water infrastructure.

The study ensured trustworthiness and data validity through measures of credibility, confirmability, transferability, and dependability. Data saturation was achieved, and triangulation with relevant documents enhanced the robustness of findings. The researcher also addressed potential conflicts of interest, including prior professional relationships and personal biases, through transparency, ethical safeguards, and, where necessary, independent review of the data analysis.

Finally, the study prioritised data richness, using thick descriptions and open-ended questions to capture participants' nuanced experiences, opinions, and recommendations. These methodological choices collectively ensured that the research was ethically sound, methodologically rigorous, and capable of producing rich, reliable, and actionable insights into improving rural water infrastructure in the John Taolo Gaetsewe District Municipality.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 INTRODUCTION

Chapter 3 outlined the research design, which adopted a qualitative approach to explore the factors influencing the development of water infrastructure and service delivery in the John Taolo Gaetsewe District Municipality. The chapter identified the research design, target population, sampling technique, data collection methods, and the method employed to analyse the participants' responses.

In this chapter, the results are organised into themes and subthemes that emerged from the data, supported by participant quotations and relevant literature. Each theme addresses a key aspect of improving water infrastructure, including governance and planning, operations and funding, implementation, and suggestions for improvement. The chapter provides a detailed interpretation of the data to identify internal governance, institutional, financial, and operational barriers, as well as potential solutions to promote sustainable and effective water service delivery within the district.

4.2 QUALITATIVE RESULTS

This section provides a thematic analysis and discussion of qualitative data from participants in the John Taolo Gaetsewe District Municipality. It explores key issues affecting water supply reliability, identifies critical infrastructure areas needing improvement, and examines the leading causes of water scarcity. The analysis also discusses potential solutions, highlights successful water-related initiatives and their success factors, and evaluates the current state of water quality and its management. Further, it considers technological innovations, financial challenges, and the role of collaboration among the government, the private sector, and civil society in addressing water issues. The findings are structured around central themes and subthemes related to governance, operations, funding, implementation, and proposed improvements.

4.2.1 Theme Presentation

The data analysis identified four main themes related to improving water infrastructure: Governance and Planning, Operations and Funding, Implementation, and Suggestions/Recommendations. Each theme encompasses specific subthemes that emphasise the key factors influencing service delivery, operational performance, and the long-term sustainability of water infrastructure in the district. Table 4.1 collectively presents the emergent themes and their relative importance based on the number of quotations extracted during coding.

Table 4.2: Summary of Themes, Subthemes, and Their Generic Descriptions from Interview Analysis

Theme	Subtheme	Generic Description
Theme 1: Governance and Planning	1.1 Institutional Roles and Multi-Agency Responsibilities	Examines the complex interplay between municipal, district, and external agency roles in water service delivery, with a primary focus on operational mandates, asset ownership, and coordination mechanisms that influence overall efficiency and accountability.
	1.2 Misalignment Between Policy Frameworks and Planning Practices in Water Demand Standards	Discusses challenges arising from discrepancies between national water standards and local community needs. Emphasises the importance of adopting flexible, context-specific planning approaches and district-wide water distribution models to promote equity and ensure reliable service delivery.
	1.3 Integrated Development and Budget Planning	Discuss the coordination among water projects, Integrated Development Plans (IDPs), and strategic budgets. Delves into the combination of business planning, stakeholder involvement and external collaboration to facilitate the infrastructure planning of the district.
	1.4 Effective Project Planning and Coordination	Emphasises the role of organised project management, professional control, and coordination at the district level to ensure the successful operation and reliability of water infrastructure projects.
	1.5 Stakeholder Collaboration	Examines the nature of partnerships with mining companies, civil society, and other stakeholders, emphasising the importance of coordinated collaboration to advance water infrastructure initiatives and move beyond traditional social projects.

Theme 2: Operations and Funding	2.1 Operational and Monitoring Limitations in Borehole Management	Discusses the technological and operational constraints of borehole management, including the lack of monitoring systems, reliance on diesel-powered engines, and the associated risks these pose to water supply reliability.
	2.2 Water Infrastructure and Operational Challenges	Discuss the deteriorating infrastructure, capacity constraints and structural water shortage. Identifies environmental and technical aspects that limit service delivery.
	2.3 Groundwater Quality and Treatment Management	Concentrates on water-quality assurance practices, such as monitoring, treatment, and aquifer recharge schemes, to maintain a safe and reliable groundwater supply.
	2.4 Funding Acquisition and Bureaucratic Delays	Examines issues surrounding the accessibility and management of financial resources, including delays caused by bureaucratic processes, grant conditions, and eligibility requirements that affect project implementation.
Theme 3: Implementation	3.1 Effective Project Planning and Coordination	Stresses the necessity of coordinated implementation, professional project management and control to achieve infrastructure functioning at the desired capacity and in response to community needs.
	3.2 Budget Limitations and Revenue Shortfalls	Highlights the financial constraints affecting both operational and capital expenditures, emphasising the municipality's reliance on grants and partnerships to fund major projects.

	3.3 Vandalism and Theft	Reviews the effects of theft and vandalism on water facilities with a special focus on the necessity of security, community compliance, and protection strategies.
	3.4 Settlement Growth and Community Water Demand Pressure	Discusses the issues of sudden and unplanned growth of settlements, illegal networks, and unfair water use, which puts pressure on available infrastructure.
Theme 4: Suggestions / Recommendations	4.1 Alternative and Bulk Water Supply	Highlights the strategic implementation of bulk water supply plans and the gradual development of infrastructure to improve water availability and distribution in the district.
	4.2 Use of Technology	Shows technological solutions, including real-time monitoring systems, drones, and portable treatment plants, to increase the efficiency of operations, decrease risks, and protect infrastructure.
	4.3 Centralised Monitoring	Discusses the importance of SCADA and centralised control systems to monitor water infrastructure, optimise performance, and meet abstraction and operational standards.
	4.4 Stakeholder Engagement and Collaboration	Concentrates on formalised partnerships between municipalities, communities, the private sector and civil society to safeguard assets, enhance project implementation, and strengthen long-term sustainability.
	4.5 Human Resource Capacity and Skills Development	Focuses on recruitment, training, and retention of qualified staff to enhance operational management, infrastructural

Figure 4.1 shows the groundedness of themes in the water infrastructure study of the John Taolo Gaetsewe District Municipality. The most recurring themes are Stakeholder Engagement and Collaboration (14) and Budget Limitations and Revenue Shortfalls (13), suggesting they play a decisive role in the delivery of water services. Other prominent themes are Groundwater Quality and Treatment Management (11), Integrated Development and Budget Planning (9), Vandalism

and Theft (9), and Effective Project Planning and Coordination (8). Conversely, the least grounded are Institutional Roles and Multi-Agency Responsibilities (3) and Alternative and Bulk Water Supply (4), which indicate low frequency or a lack of focus in participants' answers. In general, the graph shows that the key issues in developing better water infrastructure in the district are social collaboration, financial constraints, and operational planning.

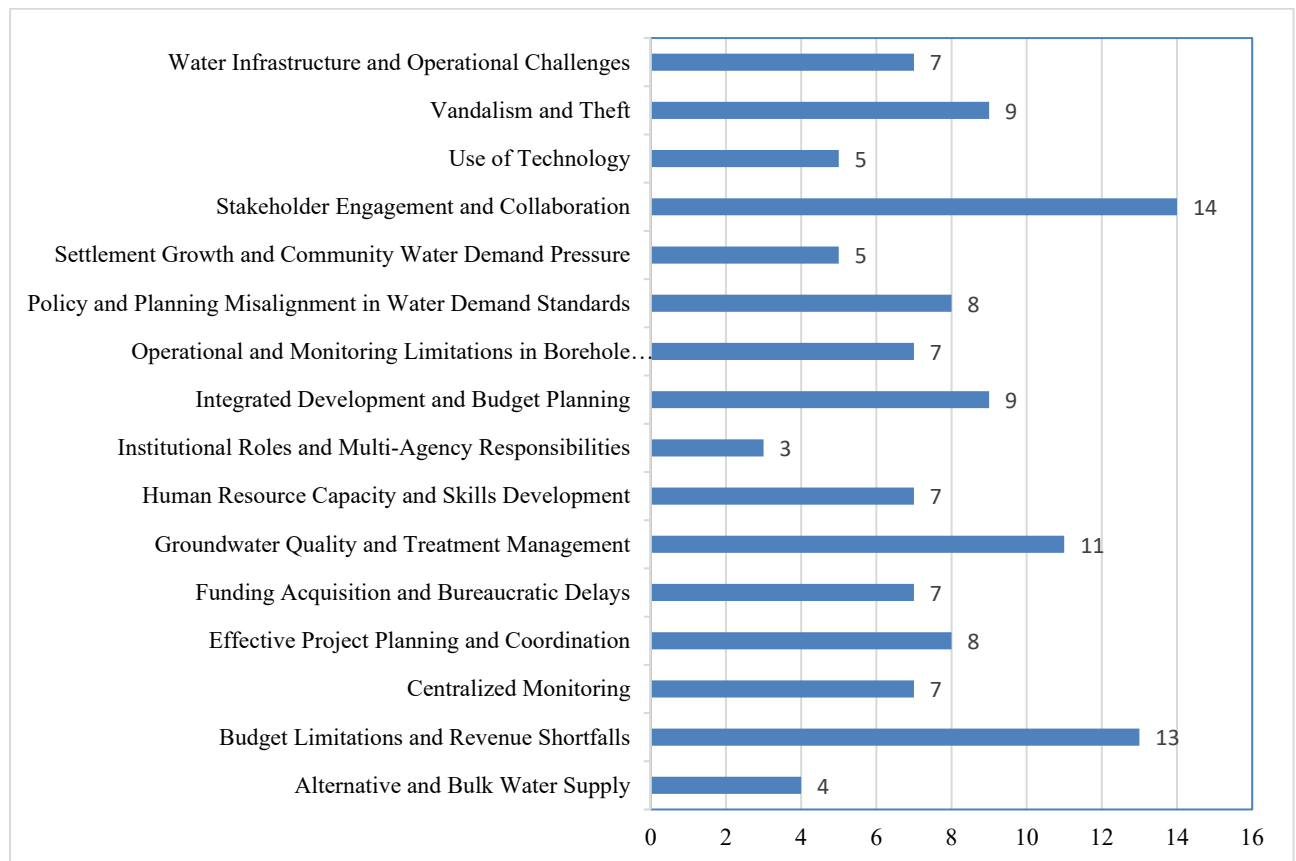


Figure 4.2: Groundedness of Themes in the John Taolo Gaetsewe District Municipality Water Infrastructure Study.

4.2.2 Theme 1: Governance and Planning

The theme explores the organisational, policy, and coordination frameworks involved in developing water infrastructure and service delivery within the John Taolo Gaetsewe District Municipality. It focuses on how institutional roles, multi-agency collaboration, policy frameworks, strategic planning, project coordination, and stakeholder cooperation influence the effectiveness and sustainability of water services. The theme also examines how municipal planning aligns with national water standards, IDPs, budgeting procedures, and the governance mechanisms and planning strategies that underpin decision-making and operational management within the district's WSAs.

4.2.2.1 Subtheme 1.1: Institutional roles and multi-agency responsibilities

Participants highlighted the complex institutional environment and the shared accountability among various water authorities in the John Taolo Gaetsewe District Municipality, noting that overlapping mandates often lead to operational and financial problems. This supports Botha (2020:97) and Dlamini (2018:31), who found that limited institutional capacity and poor governance at the local level hinder water service delivery and infrastructure maintenance. One participant explained that in Ga-Segonyana Municipality, the operational takeover of Vaal Central Water by provincial governments, followed by intervention from the national minister under Section 78, exemplifies these problems.

"We have actually been trying for many years to take over operations in this area from Vaal Central Water. We have written to the MEC, to the provincial authorities, and also to the board. There has been a great deal of engagement, and the matter of Section 78 has even been escalated to the minister." (Participant 1)

This experience highlights issues discussed in the literature, such as inadequate role definitions among water boards, municipalities, and provincial organisations, which can lead to delays, operational inefficiency, and higher costs (Department of Water and Sanitation, 2018:20; Krueger *et al.*, 2019:11). Under shared responsibility, municipalities typically retain ownership of the assets but rely on external agencies to conduct their operations and maintenance. This was exemplified by one participant, who stated that although Vaal Central Water manages operations, the municipality incurs replacement costs for stolen or damaged equipment.

"As I mentioned, there is a Phase Two of the project to construct a bulk pipeline from Delportshoop, which will end in Olifantshoek. These initiatives are already underway. There are also the social labour plans for the mines." (Participant 3)

These operational issues highlight broader problems in South Africa's rural water infrastructure, where funding shortages, ageing infrastructure, and poor coordination between agencies limit the effectiveness of water systems (Mathe, 2023; Department of Human Settlement, Water and Sanitation, 2020). Tantoh *et al.* (2020:12) assert that to ensure accountability, improve operations, and maintain infrastructure performance, roles within institutions must be clearly defined, capacity must be built, and collaboration between agencies strengthened. Similarly, efforts under the Social Labour Plan, as noted by participants, show how external stakeholders, including mining companies, can support municipalities with financial resources and expertise, aligning with findings by Olanrewaju *et al.* (2023:34) regarding community and stakeholder involvement in water projects.

All participants emphasised that the key to effective project implementation in the John Taolo Gaetsewe District Municipality should be clear roles for participants, efficient coordination among municipalities, water boards, and other external actors, and active organisation of regular work and extensive infrastructure projects. Without these steps, overlapping responsibilities could slow decision-making, overburden the municipal budget, and undermine the long-term sustainability of water infrastructure in the district (John Taolo Gaetsewe District Municipality, 2022:30-31; Botha, 2020:97; Dlamini, 2018:24).

4.2.2.2 Subtheme 1.2: Policy and planning misalignment in water demand standards

The participants highlighted significant challenges arising from a mismatch between national water policy requirements and the actual water demand of rural communities in the John Taolo Gaetsewe District Municipality. These findings align with Krueger *et al.* (2019:8) and Mohanty and Rout (2022:9), who note that, in most cases, top-down water planning approaches fail to consider the area's socio-economic and environmental conditions. One participant emphasised that municipalities have a statutory obligation to plan and design their infrastructure in accordance with the DWS rural water standard of 25 litres per person per day, with communal standpipes located within 200 metres of residential properties.

"The municipalities will submit the business plan for funding based on a water demand of 25 litres per capita, in accordance with the Department of Water Services guidelines. The level of service will consist of communal standpipes located within a 200-meter walking distance. Reservoirs and pipelines will also be designed to accommodate 25 l/c/day." (Participant 2).

But in reality, nearly all communities need significantly more to meet daily requirements, and some regions can only operate efficiently with a minimum of 70 litres per capita per day. This discrepancy also aligns with studies by Department of Human Settlement, Water and Sanitation (2020) and Igamba (2022), which show that rural water shortages are worsened by strict national standards that underestimate actual consumption rates. Another participant emphasised that adherence to the 25 l/c/day norm does not promote fair water distribution and limits municipalities' ability to address regional inequalities.

"The current approach is not in line with the district development model, which has been preached for years with no implementation. The district municipality should be providing bulk water to all three local municipalities. This would work out better because there would be better planning at the regional level, instead of the current silo planning." (Participant 1).

This view aligns with Botha (2020:97) and Dlamini (2018:31), who emphasise that delivering water services requires good governance, institutional capacity, and coordinated regional planning.

Those involved stated that strict adherence to the national standard often forces municipalities to install communal standpipes to qualify for full-scale DWS funding, even in communities that require higher volumes. This reflects reactive planning, as noted by Mathe (2023) and News24 (2020). Upgrades to yard connections, funded by mining companies through the Social Labour Plan (SLP), can be seen as piecemeal efforts that lead to inefficiencies and prolonged water scarcity, which aligns with Olanrewaju *et al.* (2023:42) on stakeholder-driven interventions.

All these factors imply that aligning policy paradigms with community needs and adopting flexible, location-specific planning standards are vital for ensuring fair water distribution, efficient use of infrastructure, and the overall sustainability of rural water systems in the John Taolo Gaetsewe District.

4.2.2.3 Subtheme 1.3: Integrated development and budget planning

The research findings showed that water infrastructure planning in the John Taolo Gaetsewe District Municipality is closely connected to the IDP and municipal development budgets. This method aligns with the systematic governance strategy outlined by Dlamini (2018:29-31), which involves developing service delivery initiatives aligned with the municipality and district's strategic priorities. Participants observed that the five-year IDP and Service Delivery and Budget Implementation Plan are utilised to guide project selection, funding allocation, and implementation, ensuring consistency with broader development goals. One participant explained:

"We also prepare the budget according to the Service Delivery Budget Implementation Plan and align our projects with our five-year plan, the Integrated Development Plan." (Participant 1)

This concordance is similar to what Grigg (2021:213) and Ferreira *et al.* (2021:9) identify as a crucial process for ensuring the consistency and systematisation of plans for infrastructure investment and operation. In the John Taolo Gaetsewe District Municipality, participants indicated that municipal financial systems guide project budgeting and development, with service delivery priorities focused on long-term goals rather than ad hoc decisions. Practical interventions have also been introduced to address localised supply interruptions, with the most effective ones occurring in schools and rural communities where water reliability is a concern. One participant described such an intervention as:

"The initiatives involve providing the elevated steel tank for 48 hour storage in Batlharotlhaping High School... to fill in the gap during intermittent municipal supply." (Participant 2).

The targeted initiatives demonstrate how local governments combine budgeting with development planning to address their communities' short-term needs. This aligns with the findings of Machado *et al.* (2022:14), who note that, within the broader planning process, municipalities tend to prioritise short-term, solution-focused infrastructure projects. Participants also highlighted that several micro-level projects, such as borehole rehabilitation and reticulation upgrades, have been carried out. However, these projects have been undertaken within the framework of the IDP and lack integration into a comprehensive district-wide master plan. This pattern aligns with the findings of Henning and Van der Hoven (2019:52), who observed that increases in water supply in Northern Cape districts are often driven by project-based planning rather than inclusive, district-wide planning. Overall, the evidence suggests that the institutionalisation of integrated development and budgeting processes in the water infrastructure management of the John Taolo Gaetsewe District Municipality is facilitating funding and operational decisions at the local municipality level.

4.2.2.4 Subtheme 1.4: Effective project planning and coordination

The participants emphasised that effective project planning and coordination are vital for the successful realisation of water infrastructure projects in the John Taolo Gaetsewe District Municipality. Consistent with Egito *et al.* (2023:1101-1103) and Grigg (2019:215), they noted that the municipality's success in implementation depends on organised management, technical expertise, and close cooperation among stakeholders. Projects are developed and executed under careful supervision and continuous interaction between the project teams and local authorities. One participant described the following structured process:

"I selected these projects because I observed effective planning, strong coordination, and a high level of professionalism in their implementation. In my view, the level of engagement and project management was satisfactory." (Participant 1)

This aligns with the approach identified by Wu *et al.* (2022:2353), which enhances infrastructure functionality through clearly defined roles and effective project management systems. The participants noted a significant improvement after the projects were completed, especially in the operation of reservoirs and community water systems. As one participant remarked:

"After the completion of the project, I observed the reservoir and elevated tank overflowing more frequently, ensuring that the community had a consistent water supply." (Participant 2)

These reports indicate that project implementation has become more coordinated in the John Taolo Gaetsewe District Municipality, which has improved the reliability of services and operational stability, aligning with du Plessis' (2019) observations that effective coordination

enhances the efficiency of local water delivery. Participants explained that local WSAs actively plan and carry out projects with technical teams, ensuring that resources, schedules, and deliverables are well managed. The process is further supported by collaborative schemes involving WSA-district arrangements and partnerships with other entities, such as mining firms, to increase implementation capacity and provide additional technical expertise, a scheme commonly seen in other resource-based districts (Kutcher *et al.*, 2023:19; Department of Water and Sanitation, 2016:18, 28). Overall, it can be concluded that structured coordination, clear project management, and inter-institutional collaboration are already embedded within the water service delivery system in the John Taolo Gaetsewe District Municipality.

4.2.2.5 Subtheme 1.5: Stakeholder collaboration

The study found that stakeholders in the John Taolo Gaetsewe District Municipality collaborate, particularly between WSAs and mining companies. Participants observed that partnerships also exist, but do not significantly improve water infrastructure. Most current interactions have focused on social development projects rather than investing in water supply systems. This aligns with the definition of fragmented stakeholder collaboration in developing areas by Machado *et al.* (2023:14), in which partnerships tend not to prioritise infrastructure development but instead focus on visible projects within the community. As one participant noted:

“I have observed this in several social projects, such as community halls and sports facilities. I believe both parties need to come together and place more focus on water infrastructure. The area where I have not observed any collaboration is between the WSAs and civil society organisations.” (Participant 2)

This observation aligns with the broader findings of Tanto *et al.* (2020:9), who highlighted that, in rural water management settings, community-level collaboration tends to be weaker, with local authorities and private organisations acting independently rather than being integrated. Mining houses hold a significant socio-economic role in the John Taolo Gaetsewe District Municipality, and their involvement in water-related projects has largely been part of their corporate social investment programmes. Although these interactions are beneficial, they are more likely to serve the interests of the mining companies—both operationally and strategically—rather than prioritising water planning in the district. As one of the participants explained:

“A major project is being initiated in partnership with the mining houses to address the challenge of providing sufficient and reliable water” (Participant 3)

This statement shows that the involvement of the private sector in the development of the John Taolo Gaetsewe District Municipality water supply is evident but selective, with the targeted model

of collaboration also evident with the Department of Water and Sanitation (2016:23) where the PPP manifest itself not in the long-term institutional structures but in the individual, large-scale developments. The relationship between WSAs and mining houses is thus determined by mutual gain and resource availability, which aligns with Botha (2020:97), who found that the economic environment and the dynamics of leadership within a district often influence institutional collaboration in the sphere of municipal governance.

Comprehensively, the results reveal that the partnership in the water infrastructure environment of the John Taolo Gaetsewe District Municipality is practical but skewed, between partnerships with mining houses and government agencies and minimal with civil society organisations.

4.2.3 Theme 2: Operations and Funding

The theme explores the operational procedures, resource management systems, and funding mechanisms that influence water service delivery in the John Taolo Gaetsewe District Municipality. It focuses on the technical, logistical, and administrative aspects of borehole management, the functionality of water infrastructure, groundwater quality, and treatment practices. Additionally, the theme examines funding processes, bureaucratic regulations, and securing financial resources for developing water infrastructure. These aspects highlight how operational capabilities and financial constraints affect the effectiveness, reliability, and sustainability of water services within the district.

4.2.3.1 Subtheme 2.1: Operational and monitoring limitations in borehole management

The results showed that borehole activities in the John Taolo Gaetsewe District Municipality face challenges due to inadequate technological systems and inefficient operations. Participants also noted that the lack of real-time monitoring reduces data accuracy and leads to excessive pump usage, resulting in frequent mechanical failures and supply disruptions. This supports the findings of Egito *et al.* (2023:1103) and Zimoch *et al.* (2021:17), who reported that operational inefficiencies and the absence of monitoring technologies shorten the lifespan and reduce the effectiveness of rural water systems. One participant described:

“Firstly, most boreholes lack any form of regular monitoring equipment. Having such equipment would help extend the lifespan of the boreholes, as they could be operated based on up-to-date data rather than the information available at the time of development. Without monitoring technology, boreholes are often operated at 10 l/s until the pump fails, leaving the entire community without water.” (Participant 2)

This assertion suggests that the management of boreholes in the district depends on outdated operational data rather than ongoing feedback systems. Similar to the issues identified by Krueger *et al.* (2019:10) and Mohanty and Rout (2022:7), the asset management and the insufficient monitoring infrastructure in the John Taolo Gaetsewe District Municipality have contributed to the establishment of an unsustainable water delivery system in resource-deprived cities. It was also observed that diesel-powered pumps are frequently used despite the limited number of power points, further increasing the risks and potential disruptions to their performance. As one participant noted:

“One of our strongest boreholes in Seoding can yield between 10 and 15 litres per second. However, these boreholes currently operate on diesel engines because Eskom imposed a moratorium on new electricity connections and extensions in the Kuruman area in 2008. Operating with diesel engines also brings challenges, including the theft of diesel and equipment.” (Participant 1)

This experience highlights the vulnerability to theft, cost fluctuations, and downtime associated with dependence on diesel systems, consistent with the observations of Müller *et al.* (2020:645) that low energy security and outdated pumping systems contribute to inefficiencies in rural operations. Overall, these findings indicate that borehole operations in the John Taolo Gaetsewe District Municipality are impacted by technological shortages, logistical challenges, and infrastructural limitations—factors also identified by SADC-GMI (2020:49) and the Department of Water and Sanitation (2024:119) as significant barriers to sustainable borehole performance in South Africa's rural areas.

4.2.3.2 Subtheme 2.2: Water infrastructure and operational challenges

The results showed that the water infrastructure in the John Taolo Gaetsewe District Municipality is severely limited by the age of the existing infrastructure and the ongoing water shortage. Participants explained that much of the infrastructure was built decades ago and has since failed to meet current population and consumption demands. This aligns with the Department of Water and Sanitation's (2018:2, 14; 2019:191) findings, which state that outdated infrastructure and slow maintenance reduce the capacity and reliability of systems in South African municipalities. One participant remarked:

“One of the challenges we are currently facing is the ageing infrastructure, which was built many decades ago. Over the years, due to migration and the expansion of villages, the reservoir has rarely reached full capacity. The water service provider, Vaal Central Water, has been able to achieve only 20 to 30% of the reservoir's capacity, which is far from ideal.” (Participant 1)

It means that non-productive and degraded reservoirs hinder adequate water storage and distribution, which are the same operational shortcomings identified by George-Williams *et al.* (2024:8) and Ferreira *et al.* (2021:12); both stated that outdated infrastructure tends to limit the reliability of supply performance and water quality. The participants also noted that over-reliance on groundwater sources and limited access to surface water worsen structural water shortages within the district. This issue aligns with the findings in Section 2.14, which reported low rainfall and unpredictable runoff, making groundwater the primary source of water for most settlements in the John Taolo Gaetsewe District Municipality. One participant explained:

“The number one challenge is the overreliance on groundwater sources. There are no major surface water sources, such as rivers or dams, located nearby. Although surface water could serve as an alternative source, it is quite costly to develop the necessary infrastructure to extract and supply water from the river effectively.” (Participant 3)

This characterisation aligns with the overall environmental and financial limitations reported by Henning and Van der Hoven (2019:49) and by the Department of Human Settlements, Water and Sanitation (2020:12), who further noted that reliance on boreholes, combined with high infrastructure costs, hampers the diversification of water sources in the district. All of this indicates that the John Taolo Gaetsewe District Municipality's water infrastructure faces compounded operational stress due to ageing systems, groundwater reliance, and economic constraints, which is consistent with findings from Krueger *et al.* (2019:6) and Machado *et al.* (2022:1,11), who identified deteriorating infrastructure and insufficient investment as the primary factors limiting the realisation of rural water security in water-scarce areas.

4.2.3.3 Subtheme 2.3: Groundwater Quality and Treatment Management

In the John Taolo Gaetsewe District Municipality, groundwater is the primary source of water, as most boreholes produce water of acceptable quality. The results show that water samples from different boreholes consistently meet drinking water standards, indicating that groundwater is naturally of high quality throughout most of the district. This aligns with the Department of Water and Sanitation's (2024) findings, which reported that groundwater in South Africa's arid and semi-arid regions requires minimal treatment before use, as it naturally filters through geological layers. One of the participants confirmed this by saying:

“The quality of groundwater is tested and commonly found to be Class 0 to Class 1... ready for consumption with no prior treatment.” (Participant 2)

This observation shows that routine testing and classification are components of the district's operational process to ensure compliance with national water quality standards. Nevertheless,

the participants also noted that some of the boreholes belong to Class 2 or Class 3, and that further treatment or even abandonment is needed to improve water quality. It is consistent with Lewandowski *et al.* (2020:3), who pointed out that even within the same aquifer system, recharge conditions and geological composition can differ significantly. Such differences require selective interventions in treatment, especially where high salinity or metal levels have been recorded.

Besides monitoring and testing, the municipalities in the John Taolo Gaetsewe District Municipality employ managed aquifer recharge methods to stabilise groundwater levels. This operational plan aligns with that of SADC-GMI (2020:49), which cited recharge of aquifers as a sustainable measure to help maintain water supply in drought-prone areas. Another participant explained:

“The municipality uses treated wastewater and riverbank infiltration to recharge aquifers... helping to stabilise groundwater levels.” (Participant 2)

The practice is an adaptive approach to water management in a water-limited environment, combining natural and engineered systems to harmonise withdrawal and replenishment. Global Water Partnership-Caribbean (GWP-C) (2022:27) also emphasised similar practices, finding that managed recharge with treated wastewater can enhance groundwater resilience under evolving climatic conditions. In general, the results indicate that the overall water quality in the John Taolo Gaetsewe District Municipality is relatively safe and is supported by organised surveillance, selective treatment, and new recharge measures that support the district's primary water source.

4.2.3.4 Subtheme 2.4: Funding Acquisition and Bureaucratic Delays

The difficulty in securing funds for water infrastructure projects in the John Taolo Gaetsewe District Municipality is marked by sluggish administrative processes and a complex approval hierarchy. Participants noted that towns face prolonged delays in obtaining approval to finance a project, which subsequently hampers implementation. This issue corroborates findings by Greer (2020:8) and Mohanty and Rout (2022:2), who identified bureaucratic inefficiencies and multi-tier approval procedures as common causes of delays in infrastructure development within rural municipalities. One participant commented:

“The first challenge is the process of acquiring the funding for developing and maintaining water infrastructure. The municipalities wait too long before the funding can be approved.” (Participant 2)

This means that, even with technical designs and justifications prepared, procedural bottlenecks can still prevent timely execution. Machado *et al.* (2022:2) argue that such institutional and

administrative delays lead to underperformance in service delivery by government structures, and in many cases, projects are either delayed or abandoned. Lengthy approval processes in the John Taolo Gaetsewe District Municipality mean that by the time funding becomes available, environmental or population changes may have occurred, rendering the initial project parameters no longer relevant.

It is also complicated by multiple layers of reporting and the need to obtain approvals at both provincial and national levels. The South African Local Government Association (SALGA) (2022:47) reported that centralised funding mechanisms may limit municipalities' autonomy and delay project implementation. One of the participants commented on this burden of multi-level coordination, saying:

“It takes the submission of many reports, presentations to the provincial government, sometimes even national government... It cannot take more than 3 years to approve funding.” (Participant 2)

Municipalities are required to complete extensive documentation and provide detailed financial justification before accessing grants such as the Regional Bulk Infrastructure Grant (RBIG) or Social and Labour Plan (SLP) funds (Mulaudzi, 2023). While these requirements promote accountability, they also increase transaction costs and delay project implementation. In the case of the John Taolo Gaetsewe District Municipality, participants noted that such procedural complexity often postpones project initiation and inflates budgets—an observation consistent with the Department of Water and Sanitation's (2018:2) findings that administrative inefficiencies remain a key obstacle to infrastructure rehabilitation. Overall, the evidence suggests that water infrastructure development in the district is constrained not only by limited financial resources but also by the bureaucratic rigidity of multi-level governance systems, which prolong processes and hinder the timely delivery of essential services.

4.2.4 Theme 3: Implementation

This theme examines real-world issues in implementing water infrastructure projects within the John Taolo Gaetsewe District Municipality. It focuses on the roles of project planning, coordination, resource allocation, and financial management in determining the effectiveness and sustainability of water service delivery. The theme also addresses operational challenges that arise from vandalism, theft, rapid settlement development, and the community's evolving water demands, all of which highlight the interconnectedness of technical, social, and financial factors in executing water infrastructure projects.

4.2.4.1 Subtheme 3.1: Effective project planning and coordination

Participants recognised effective planning and coordination as essential for successfully implementing water infrastructure projects in the John Taolo Gaetsewe District Municipality. The facts showed that projects which are well coordinated, planned, and executed by professionals tend to have better functionality and sustainability outcomes. This aligns with Machado *et al.* (2023:6), who emphasised that strategic coordination and intersectoral collaboration positively influence project performance and reduce risks in complex water systems. Similarly, Mohanty & Rout (2020:3) found that organised project planning allows water distribution systems to operate efficiently, minimising technical and administrative inefficiencies. A participant noted:

“I selected these projects because I observed strong planning, effective coordination, and a high level of professionalism in their implementation. In my view, the level of engagement and project management was satisfactory.” (Participant 1).

This assertion underscores the importance of institutional professionalism and planning rigour in providing WSAs to deliver infrastructure that meets service levels. It aligns with Ferreira *et al.* (2021:2), who emphasised that strong policies, governance, and collaborative workforce efforts form the backbone of sustainable water infrastructure delivery. There is also effective coordination between municipal departments and stakeholders, which facilitates better resource utilisation, holds stakeholders and policymakers accountable, and ensures that projects are completed on time, as observed by Olanrewaju *et al.* (2023:2,34), in similar community-based water projects.

The results of these well-coordinated projects were evident through tangible physical improvements in community services. The functionality of water reservoirs and the successful completion of planned interventions directly enhanced performance in multiple locations. One participant explained:

“After that project was completed, I noticed that the reservoir and elevated tank began overflowing more frequently, and the community had a consistent water supply.” (Participant 2).

This demonstrates that operational efficiency and improved service delivery result from planned and controlled operations. The same findings were reported by Grigg (2024:3), who observed that adequate water infrastructure reliability depends on clear implementation frameworks. The John Taolo Gaetsewe District Municipality situation illustrates how well-organised water schemes, such as the intersectoral model outlined by Machado *et al.* (2023:215-216), can increase water accessibility through the integration of planning and monitoring. In the John Taolo Gaetsewe District Municipality, teamwork between WSAs is coordinated at the district level, enabling water infrastructure projects to achieve their goals and sustain service continuity in rural settlements.

4.2.4.2 Subtheme 3.2: Budget limitations and revenue shortfalls

Budget constraints and low revenue collection were critical issues affecting water service delivery in the John Taolo Gaetsewe District Municipality. Participants reported that, although WSAs develop detailed business plans aligned with service standards, funding cuts during approval processes hinder full implementation. This budget shortfall directly impacts maintenance, repairs, and the development of new infrastructure. Mohanty and Rout (2022:9) identified similar patterns, demonstrating that low fiscal capacity and delayed fund releases are substantial limitations to infrastructure performance in rural municipalities. According to the Department of Water and Sanitation (2018:20), underfunding and poor revenue management also contribute to service interruptions across South Africa's districts. A participant stated:

“When WSAs submit business plans that include higher levels of service, the allocated funding is often reduced, as they are expected to recover the additional costs through revenue collection. However, in reality, only a small portion of residents—particularly in Ga-Segonyana and Joe Morolong—actually pay for services. Gamagara performs relatively better in terms of revenue collection. This limited income is one of the reasons why even simple infrastructure leakages take a long time to repair.” (Participant 2)

This highlights the structural weaknesses in the district's financial system, which relies heavily on government transfers because of a limited local revenue base. These fiscal challenges align with the findings of Palmer *et al.* (2017:101), who noted that municipalities with low revenue recovery rates rely on grants such as the Municipal Infrastructure Grant (MIG) and Water Services Infrastructure Grant (WSIG), both of which are susceptible to fluctuations and bureaucratic delays. This leads to delays in approval processes and insufficient funding, resulting in slow maintenance and declining infrastructure functionality, as seen in many South African rural municipalities (Machado *et al.*, 2022:5).

Another theme discussed by participants concerned large, capital-intensive projects that require external funding and partnerships with private sector actors, especially the mining industry. These projects are not completed within a few years because they demand significant investment and feature complex financing arrangements. One participant explained:

“There is an ongoing initiative between the mines and the municipalities in the area to abstract raw water from the Orange River in Delpoortshoop, located approximately 200 km away. This project requires a significant financial investment and is designed to yield benefits only over the next seven to eight years. It is being implemented through a phased approach.” (Participant 3)

This indicates that the district depends on multi-stakeholder collaborations to address long-term water scarcity, aligning with Auliya *et al.* (2023:217), who found that PPPs are effective for funding large-scale water infrastructure in resource-scarce settings. However, as noted by the Department of Water and Sanitation (2024:2), the limited fiscal capacity of most local governments in the Northern Cape restricts their ability to maintain such projects independently. Overall, the John Taolo Gaetsewe District Municipality case demonstrates that a lack of finances and insufficient revenue sources, combined with reliance on external funding, hinder project implementation and weaken the sustainability of water supply systems across the district.

4.2.4.3 Subtheme 3.3: Vandalism and theft

Operation also causes significant issues in the John Taolo Gaetsewe District Municipality, where vandalism and theft have weakened investments and compromised service reliability. Participants reported common cases of stripped and damaged boreholes, diesel engines, generators, and recently installed equipment, all of which hinder service delivery due to limited municipal resources. This situation aligns with national data published by the Department of Water and Sanitation (2024:19,26), which identified asset theft and vandalism as major challenges in maintaining rural water systems. Similarly, Krueger *et al.* (2019:3) and Malima *et al.* (2023:151) found that frequent destruction of infrastructure in under-resourced regions raises operational costs and hampers recovery efforts. One of the participants described it as:

“Theft and vandalism are additional challenges that significantly set the municipalities back.”
(Participant 2).

This narrative underscores the impact of criminal activities in disrupting the continuity and performance of infrastructure. The economic consequences go beyond immediate losses, as local authorities repeatedly allocate funds and resources to replace stolen property rather than invest in new projects or proactive maintenance. In other rural municipalities, Mohanty and Rout (2022:8) identified similar patterns where such disruptions cause resource inefficiency and delays in project timelines. Another participant emphasised how this trend is evident in newly established sites, where vandalism quickly hampers progress.

“Vandalism and theft have been particularly problematic in Bankhara Budulong. Boreholes that were constructed just two to three years ago have been stripped, making them difficult to operate.”
(Participant 1)

Recent reports of vandalism at newly completed boreholes highlight the vulnerability of water infrastructure security in the John Taolo Gaetsewe District Municipality. This aligns with Machado *et al.* (2022:13), who noted that rural assets are often damaged or stolen due to weak institutional

oversight and social vulnerabilities. Such incidents not only reduce the lifespan of infrastructure but also diminish community confidence in municipal services.

Overall, vandalism and theft remain key operational threats that continue to undermine the district's capacity to maintain efficient water supply systems.

4.2.4.4 Subtheme 3.4: Settlement growth and community water demand pressure

The high rate and rapid, unplanned settlement growth in the John Taolo Gaetsewe District Municipality have exerted significant pressure on existing water infrastructure. Participants observed that villages tend to develop irregularly, and sudden population shifts often result in unpredictable planning of water services and demand, leaving municipalities uncertain of what to expect. This situation aligns with findings by Malima *et al.* (2022:149), who noted that unplanned settlement expansion in rural areas hampers planning and shortens the effective lifespan of supply systems. Similar patterns were also identified by Krueger *et al.* (2019:5-6), who linked irregular population growth to imbalances between supply and demand for limited resources in municipalities with limited capacity. A participant explained.

“These areas, which are primarily villages, are difficult to manage due to sporadic development. They can expand two, three, or even more times in size almost overnight, making it impossible to predict any clear pattern of growth.” (Participant 2).

The impact of such unplanned and unpredictable expansion has resulted in boreholes, reservoirs, and treatment facilities operating beyond their designed capacity. Newly developed areas frequently establish informal or illegal connections to existing systems, leading to over-extraction and reduced groundwater recharge periods. This aligns with Tshona *et al.* (2024:23), who argue that unauthorised connections and uncontrolled urbanisation are major contributors to system overload and water loss in rural South Africa. One participant provided an example of this challenge.

“However, immediately after project completion, about 90% of existing households begin applying for—and often illegally making—yard and house connections, while new areas experience rapid growth that demands water services. This places significant strain on the entire water system. Boreholes end up operating beyond the recommended periods, leaving little time for recovery, and eventually they run dry.” (Participant 2)

The participant's account indicates that human behaviour notably increases operational stress on water infrastructure. Disproportionate consumption patterns, especially among non-paying users, escalate demand pressures and undermine service reliability. Research by Mohanty and Rout

(2022:8) and Egito *et al.* (2023:1103) shows that poor demand management and inadequate billing systems hinder municipalities from effectively controlling consumption, further straining already limited resources. Overall, the findings demonstrate that rapid settlement growth, illegal connections, and uneven consumption behaviours are overstressing the John Taolo Gaetsewe District Municipality's infrastructure, causing recurring shortages and operational inefficiencies across the district.

4.2.5 Theme 4: Suggestions / Recommendations

The participants provide numerous insights and suggestions to help improve water infrastructure and service delivery in the John Taolo Gaetsewe District Municipality. They focused on alternative water supply options, technological choices, centralised monitoring, stakeholder collaboration, and human resource development, highlighting practical approaches to addressing both operational and structural challenges.

4.2.5.1 Subtheme 4.1: Alternative and bulk water supply

As noted by participants, implementing bulk water supply schemes and phased infrastructure projects has proven to be a strategic approach to ensuring a sustainable and reliable water supply in the John Taolo Gaetsewe District Municipality. This strategy aligns with the findings of Machado *et al.* (2023:8-10), who observed that coordinated, multi-level planning enhances the sustainability and efficiency of large-scale water systems. Similarly, Ferreira *et al.* (2021:2) emphasised that sustainable water infrastructure relies on centralised or strong governance structures that can optimise scarce resources and ensure equitable distribution between service authorities. This issue of coordination was also highlighted by one of the participants.

"Perhaps what we need is a bulk water scheme, and then the local municipalities can handle the water reticulation." (Participant 1).

This emphasises the practical importance of the institutional differences between the district and local municipalities, where the former supplies most of the resources and the latter manages reticulation. Such coordination prevents duplication and ensures consistent service delivery. It reflects South Africa's approach, where IWRM is regarded as a shared responsibility across various levels of governance, supporting efficient water distribution (du Plessis, 2019:163; Pollard & Toit, 2019:672). Participants also stressed the significance of infrastructure development through partnerships, especially in joint projects with the mining sector.

"There's a major project that is being initiated in partnership with the mining houses... phased approach... from Delportshoop to Olifantshoek." (Participant 3).

This demonstrates that using PPPs is a vital tool for mobilising the technical and financial resources required for capital-intensive water projects. Similar conclusions were reached by Auliya *et al.* (2023:215,220-221), who found that PPPs facilitate infrastructure development by pooling skills, capital, and technology. In the John Taolo Gaetsewe District Municipality, such partnerships are essential to meet the increasing water demands driven by settlement growth and industrial expansion. Another best practice highlighted by participants as transferable and applicable to their own areas was the Polokwane Municipality's artificial aquifer recharge system, which shows how adaptive management strategies can stabilise regions dependent on groundwater. The relevant innovative methods align with the technological and environmental solutions recommended by Wang *et al.* (2020:2,5,12), who emphasised the importance of reusing and recharging water through sustainable practices. Overall, the findings suggest that combining centralised bulk water supply, phased infrastructure development, and adaptive aquifer management offers a practical approach to addressing the district's ongoing water security challenges.

4.2.5.2 Subtheme 4.2: Use of technology

Participants noted that using technology to monitor, manage, and secure water infrastructure in the John Taolo Gaetsewe District Municipality is becoming increasingly vital. The district's large size and decentralised communities require efficient manual oversight, which heightens the need for real-time technologies. This aligns with Egito *et al.* (2023:1103), who emphasised that digital transformation enhances operational efficiency and resource management in water supply networks. Similarly, Farah and Shahrour (2024:20-22) stated that real-time monitoring and control systems enable municipalities to detect leakages, forecast failures, and optimise energy consumption. This was one of the operational needs highlighted by a participant.

“And to implement more software that allows the Water Service Authority to remotely monitor the water zones.” (Participant 3)

This indicates that the municipality recognises that technology is a key driver of proactive management. WSAs can visualise the performance of their systems using software-based tools, monitor borehole outputs, and predict breakdowns before they disrupt services. Zimoch *et al.* (2021:17) also support the use of digital tools and found that automated pump and valve control systems are linked to a notable reduction in water loss and improved distribution efficiency. Another participant highlighted the benefits of drone surveillance for infrastructure inspection and vandalism prevention.

“In the last financial year, we managed to acquire a drone to assist with tasks such as monitoring water levels and conducting visual inspections. However, it is currently not in use due to ongoing issues of vandalism and theft in the area.” (Participant 1).

This indicates that operational barriers to fully utilising technology exist through theft and insufficient technical capacity, despite the commencement of technology acquisition. Such issues align with the observations of Malima *et al.* (2023:149), who noted that rural municipalities often face challenges in maintaining and safeguarding technical assets. Participants also highlighted other technologies, such as CCTV cameras, borehole sensors, and portable reverse osmosis units, as potentially useful for monitoring water levels, preventing contamination, and improving water quality. These align with the research of Jan *et al.* (2021:32) and Roy and Bhardwaj (2024:250), who showed that IoT-based applications and Smart Treatment Systems could transform rural water management by increasing efficiency and reliability. Overall, integrating technology into the John Taolo Gaetsewe District Municipality is increasingly becoming a feasible approach to enhance operational integrity, provide better service redundancy, and protect infrastructure from vandalism and systemic failures.

4.2.5.3 Subtheme 4.3: Centralised monitoring

The interviewees revealed that centralised monitoring is becoming a vital solution for enhancing operations management of the water infrastructure in the John Taolo Gaetsewe District Municipality. The municipality's vast size and remote settlements make manual inspections challenging, thus creating a demand for digital oversight systems. This aligns with the findings of Egito *et al.* (2023:1101-1103), who observed that centralised digital systems effectively improve coordination, data handling, and response efficiency in water operations. Likewise, Chen *et al.* (2021:4-5) found that SCADA systems enhance control by integrating sensors, real-time analytics, and automation to detect leaks and efficiently monitor water flow. An example illustrating this need was provided by one of the participants.

“We need a single control system, such as SCADA, with a centralised control room where all operators can monitor the reservoirs, water levels, usage, leakages, and valves—allowing the entire system to be managed from one location.” (Participant 1).

This quote highlights that participants recognise that single control systems are more transparent and responsive in water management. This centralisation enables municipalities to monitor borehole yields, detect malfunctions, and maintain optimal abstraction levels from a single control centre. Roy and Bhardwaj (2024:250) supported this approach, stating that SCADA and remote sensing systems improve service reliability by enabling predictive maintenance and reducing system downtime. However, participants also noted that the effectiveness of such technological

systems depends on qualified human resources to interpret real-time data and ensure proper equipment operation. As one of them expressed:

“The challenge lies in having the necessary human capital to effectively monitor the system. Even with the best technology for remote monitoring of groundwater levels, questions remain: Are the boreholes still yielding the same output? Are the pumps operating properly?” (Participant 3)

This supports the idea that developing technology without adequate technical skills does not improve operational effectiveness. Similar patterns were observed by Malima *et al.* (2023:149) in rural municipalities due to low levels of technical expertise, which limit the advantages of automation. Under the John Taolo Gaetsewe District Municipality, participants mentioned efforts to enhance monitoring systems with CCTV cameras and alarm clocks to prevent theft and vandalism, which have previously affected infrastructure reliability. Research by Machado *et al.* (2022:10-11) and Zimoch *et al.* (2021:17) confirms that combining human supervision with automated monitoring encourages proactive water management, increases company efficiency, and reduces operational costs by minimising the need for field inspections. Overall, participants regarded centralised monitoring as an essential step towards sustainable, secure water operations in the district.

4.2.5.4 Subtheme 4.4: Stakeholder engagement and collaboration

The participants noted that effective stakeholder participation and collaboration are vital for enhancing governance and sustainability of water infrastructure in the John Taolo Gaetsewe District Municipality. Engaging inclusively with government agencies, the private sector, and communities aligns with the principles of Integrated Water Resource Management, which promotes recent involvement of multiple stakeholders in planning and implementation (du Plessis, 2019; Pollard & du Toit, 2019:671). Consistent with the findings of Colvin *et al.* (2019), the participants expressed that meaningful engagement encourages shared responsibility, improved communication, and community ownership of water initiatives. One participant highlighted this inclusive approach.

“It's important that we have stakeholder engagement with the private sector, government, civil society and the community because I must say we are spending a lot of money in ensuring that we build water infrastructure... We need to come up with a strategy because the municipality needs to render the service, and the community needs those services.” (Participant 1)

This quote illustrates that participants recognise the role of community participation in enhancing accountability and protecting municipal property from vandalism and neglect. However, they also noted that existing collaborations are uneven, with social and economic projects receiving greater

visibility than water infrastructure. This observation aligns with Machado *et al.* (2023), who argue that poor sectoral coordination undermines the short-term sustainability of infrastructure in developing countries. Another participant highlighted this imbalance, stating:

“The collaborations between the WSAs in the regions and mines are more visible and have been yielding positive results... but not necessarily in water infrastructure projects. This issue can easily be dealt with if you have a partnership with civil society organisations, by giving them the responsibility of looking after the infrastructure.” (Participant 2).

This indicates that, despite partnerships with mining companies, water infrastructure projects in the John Taolo Gaetsewe District Municipality lack formal engagement with civil society and local communities. Similar findings were reported by Ferreira *et al.* (2021:3), who noted that collaborative structures incorporating input from public, private, and community actors are more effective in achieving project outcomes and sustainability. Participants in the John Taolo Gaetsewe District Municipality suggested that district-level coordination meetings and joint planning sessions are necessary for role alignment, priority setting, and improved resource allocation. These observations align with Tantoh *et al.* (2020:2), who found that stakeholder-based governance enhances ownership and reduces conflicts in rural water projects. Overall, the research highlights that long-term collaboration among stakeholders is crucial for promoting equitable practices, protecting infrastructure investments, and improving sustainable service delivery in the district.

4.2.5.5 Subtheme 4.5: Human resource capacity and skills development

Participants identified human resource capacity and skills development as crucial for improving the management of water infrastructure in the John Taolo Gaetsewe District Municipality. A lack of adequately trained and qualified staff negatively affects operational competence, contributing to maintenance backlogs and delays in project execution. This challenge reflects broader institutional capacity constraints, as noted by Botha (2020:64), who reported that municipal WSAs in South Africa often struggle with leadership gaps, technical deficiencies, and inadequate workforce planning. Similarly, Dlamini (2018) found that governance and human development frameworks directly impact the accessibility and quality of municipal water services. One participant emphasised the need to recruit and train qualified personnel to enhance system performance.

“And the municipalities need to employ the right people and train the current team.” (Participant 2)

This assertion highlights a broader issue of technical capability in the operation and maintenance of infrastructure such as boreholes, treatment plants, and pipelines. It aligns with the arguments of Egito *et al.* (2023:1101), who suggested that sustainable water operations require skilled human resources capable of implementing the latest technologies, including SCADA systems, to deliver services effectively. The surveyed participants also reported that cities face persistent challenges in recruiting and retaining skilled professionals due to budget constraints and rural settings. These findings are consistent with those of Malima *et al.* (2023), who noted that rural municipalities often lack talent due to limited incentives, insufficient budgets, and inadequate career development frameworks. As one participant stated:

“Similarly, we need more trained staff, such as plumbers and artisans, but it is difficult to attract the skills that are most needed.” (Participant 3)

It suggests a systemic problem at the district level. because the number of artisans and technicians is insufficient to service pumps, fix leaks, and operate the monitoring system. Both Grigg (2021:214) and Machado *et al.* (2023:11) emphasise the importance of having skilled personnel to achieve operational resilience and maintain infrastructure performance, especially when resources are limited. As part of the John Taolo Gaetsewe District Municipality, participants also recognised the importance of professional service providers. They compared local practice with other municipalities that perform better to improve the competence of local staff. These types of collaborative learning align with the paradigms of participatory learning and capacity-building suggested by Meissner (2016:7), promoting lifelong learning and strengthening institutions to resist systemic flaws. Overall, the results suggest that to improve operational efficiency, protect infrastructure, and deliver sustainable water services in the district, it is essential to invest in human capital development through recruitment, technical training, and professional partnerships.

4.3 CHAPTER CONCLUSIONS

The effective governance and planning of water infrastructure in the John Taolo Gaetsewe District Municipality require clear institutional roles, better coordination among multiple agencies, and alignment between municipal and national water standards. Overlapping mandates and policy misalignment, particularly regarding water demand standards, undermine operational efficiency and long-term sustainability. IDPs and strategic budgeting improve project prioritisation but lack comprehensive district-wide planning, limiting systemic improvements. Effective project coordination and stakeholder collaboration, including partnerships with mining companies, exist but need strengthening, especially with civil society, to enhance governance and infrastructure outcomes.

Operationally, water service delivery faces significant challenges, including ageing infrastructure, heavy reliance on groundwater with limited surface water resources, and inefficient borehole management due to outdated monitoring and logistical constraints. Groundwater quality is generally good, supported by organised testing and managed recharge practices. However, funding delays and bureaucratic hurdles slow the development and maintenance of critical infrastructure. Additionally, vandalism, theft, rapid unplanned settlement growth, and flawed revenue collection create ongoing stresses on water systems, further limiting reliability and expansion.

Recommendations to improve water services focus on adopting bulk water supply schemes and phased infrastructure projects supported by PPs. The integration of advanced technology for real-time monitoring and centralised control systems is highlighted as vital for improving operational efficiency and protecting infrastructure. Strengthening stakeholder engagement, particularly with civil society, and investing in human resource capacity through training and recruitment are essential for sustainable water infrastructure management.

Overall, sustainable water service delivery in the John Taolo Gaetsewe District Municipality hinges on institutional clarity, technological adoption, collaborative governance, and sufficient financial and human resources. Balancing these factors can help the district address its water security challenges effectively and ensure reliable access for its rural communities.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

Chapter 4 emphasises that effective governance, coordinated operations, and stakeholder collaboration are vital for improving water infrastructure in the John Taolo Gaetsewe District Municipality. Challenges such as institutional weaknesses, rapid settlement growth, and limited resources disrupt service delivery. It also highlights that integrated strategies, including bulk water supply, centralised monitoring, technological integration, and human resource development, are crucial for enhancing efficiency, equity, and long-term sustainability.

This chapter presents the conclusions and recommendations of the study, summarising the key findings from both the literature review and the empirical investigation. It provides an overview by linking theoretical insights with practical experiences in the John Taolo Gaetsewe District Municipality, particularly regarding governance, planning, financing, operations, and human resource capacity in rural water infrastructure. The chapter also addresses the study's primary and secondary objectives, discusses the implications for policy, practice, and future research, and offers recommendations for enhancing the sustainability, efficiency, and equity of water service delivery in the district.

5.2 FINDINGS

This section presents the key results of the literature review and the empirical study. The initial literature findings establish the theoretical and contextual bases for rural water infrastructure management, while the primary study findings illustrate the practical realities of water service provision, planning, and sustainability in the rural South African context of the John Taolo Gaetsewe District Municipality.

5.2.1 Findings from the Literature Study

The literature highlights that sustainable water infrastructure in rural municipalities depends on effective governance, strategic planning, sufficient funding, and skilled human resources. Challenges such as limited institutional capacity, poor coordination, and leadership gaps are recognised as significant obstacles to the effectiveness of WSAs. The role of participatory and performance-based governance is consistently emphasised to enhance accountability and improve service delivery.

Policy alignment and effective planning have been identified as critical for sustainable water infrastructure. Frameworks such as the National Water Act (1998) and the IWRM approach

promote inclusive, catchment-based planning that considers community needs and environmental sustainability. Yet, implementation gaps remain due to limited technical and financial capacity at the local level. The reliance on government grants and insufficient funding further constrain infrastructure development, highlighting the need to explore alternative financing mechanisms, including PPPs and green finance.

Finally, the literature highlights that integrating technology, human resource development, and stakeholder engagement is essential for operational efficiency and sustainability. Centralised monitoring systems, such as SCADA, improve reliability but require skilled personnel for maintenance. Collaborative involvement of government, private sector actors, and communities fosters project ownership and helps reduce vandalism. Overall, the literature confirms that enhancing rural water infrastructure requires a holistic approach encompassing governance, planning, financing, skills development, technology, and multi-stakeholder collaboration.

5.2.2 Findings from the Empirical Study

The findings from the empirical study show that governance, institutional coordination, and planning mechanisms are essential for water infrastructure performance in the John Taolo Gaetsewe District Municipality. Participants highlighted ongoing challenges, including overlapping institutional roles, slow operational transfers between WSAs, and unclear lines of accountability. These issues cause inefficiencies, duplication of responsibilities, and delays in planning and implementation. Misalignment between national policy requirements and local realities further complicates service delivery, hampering municipalities' ability to meet set standards.

Operational and financial constraints emerged as major barriers to sustainable water provision. Participants reported limited monitoring systems, frequent equipment theft, unreliable energy supplies, and ongoing reliance on diesel engines to operate boreholes. Ageing infrastructure, inadequate maintenance, and dependence on groundwater add further pressure to already fragile systems. Funding processes were described as bureaucratic and slow, with multi-level approvals delaying key projects. Local revenue is insufficient to support long-term maintenance, making municipalities heavily reliant on external partners whose contributions are often inconsistent.

Implementation challenges such as vandalism, theft, rapid population growth, and the expansion of informal settlements were also recognised as major pressures on existing infrastructure. These factors increase operational costs, diminish system reliability, and complicate planning for future demand. Participants suggested several potential solutions, including:

- Expanding bulk water supply schemes.

- Implementing centralised monitoring and control systems (such as SCADA).
- Strengthening intergovernmental and stakeholder collaboration.
- Building technical and managerial human resource capacity.

These proposed interventions reflect a need for more integrated, technology-enabled, and participatory approaches to water service delivery.

Overall, the findings indicate that improving water infrastructure in the district requires coordinated and holistic interventions. Strengthening governance structures, improving institutional alignment, securing sustainable financing, modernising infrastructure, and developing skilled personnel are essential steps. The study concludes that long-term sustainability will depend on establishing cooperative governance arrangements that integrate planning, resources, and human capacity to provide reliable and equitable water services across the district.

5.3 CONCLUSIONS

The study concludes that improving rural water infrastructure in the John Taolo Gaetsewe District Municipality depends fundamentally on strengthening governance, institutional coordination, and planning mechanisms. The findings reveal that overlapping roles, slow operational transfers, and inadequate accountability have created inefficiencies that undermine effective service delivery. These institutional weaknesses, coupled with policy misalignment between national directives and local realities, have contributed to persistent challenges in water provision. While planning tools such as Integrated Development Plans (IDPs) and Service Delivery Budget Implementation Plans exist, coordination between institutions remains fragmented, limiting their overall effectiveness.

Operational and financial constraints further intensify the situation. The lack of monitoring systems, reliance on diesel-powered boreholes, and equipment theft significantly hinder performance and sustainability. Ageing infrastructure limited municipal revenue, and bureaucratic delays in funding approvals collectively constrain municipalities' capacity to maintain and expand water infrastructure. Although partnerships with private and mining sector stakeholders have helped to fill some gaps, these collaborations remain irregular and insufficient to meet growing community needs.

Social and environmental pressures, such as rapid settlement growth, vandalism, and drought-related impacts, exacerbate these limitations, placing additional strain on already fragile systems. Nevertheless, participants identified several practical solutions, including adopting bulk water

schemes, implementing centralised monitoring systems (SCADA), improving stakeholder collaboration, and strengthening human resource capacity. These strategies collectively represent a shift towards more sustainable, integrated, and technologically enabled rural water management.

In conclusion, the research underscores that achieving sustainable water service delivery in the John Taolo Gaetsewe District Municipality requires a holistic, systems-based approach. Success will depend on the alignment of governance structures, adequate and diversified funding, and the integration of modern technologies within a framework of collaborative stakeholder engagement. By fostering institutional cooperation, investing in capacity development, and promoting innovative financing models, rural municipalities can move closer to ensuring reliable, equitable, and resilient water supply systems. The study therefore contributes to both policy and practice by providing a context-specific understanding of the systemic challenges facing rural water infrastructure and by offering actionable pathways toward improvement.

From a theoretical perspective, the study reinforces the interconnected nature of governance, institutional capacity, and systems thinking in explaining water service performance in rural contexts. It confirms that governance cannot be treated as an isolated variable but rather as part of an interdependent system in which institutional coordination, resource allocation, and technological adaptation interact dynamically. The integrative framework adopted in this research, therefore, provides a valuable lens for analysing and addressing rural water supply challenges, demonstrating that improvements in one component, such as planning or funding, are only sustainable when supported by corresponding advances in institutional capability and systemic coherence. This theoretical alignment strengthens the study's contribution to understanding how multidimensional governance models can guide more sustainable, contextually appropriate rural water management strategies.

5.4 RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed to improve the functionality, sustainability, and equity of rural water service delivery in the John Taolo Gaetsewe District Municipality. These recommendations translate the study's conclusions into practical, implementable actions across governance, planning, funding, operations, technology, and human capacity development.

Strengthen governance and institutional coordination

Governance and coordination should be strengthened by formally clarifying roles and responsibilities between the district municipality and the local Water Service Authorities through

revised service-level agreements and delegated authority frameworks. Regular intergovernmental coordination forums should be institutionalised, supported by shared performance reporting aligned with Blue Drop and Green Drop indicators. Clear accountability mechanisms, including measurable performance targets for water service delivery, should be embedded within municipal management systems to reduce duplication and improve oversight.

Promote integrated, demand-driven planning

Water planning processes should be improved by aligning Integrated Development Plans (IDPs) and Service Delivery and Budget Implementation Plans (SDBIPs) with updated water demand assessments, settlement growth patterns, and population projections. This can be achieved through the periodic review of planning assumptions using verified consumption data and groundwater yield assessments. District-wide infrastructure planning should be coordinated to ensure that projects are prioritised based on actual demand, system capacity, and long-term sustainability rather than solely on uniform national design standards.

Improve funding mechanisms and financial management

Financial sustainability should be enhanced by streamlining funding approval processes through clearer timelines, decentralised decision-making where appropriate, and improved financial reporting to provincial and national authorities. Municipalities should strengthen revenue management by improving billing accuracy, debt collection systems, and financial controls. Public–private partnerships should be formalised through structured agreements with private and mining-sector stakeholders to mobilise financial resources, technical expertise, and long-term investment in bulk water infrastructure and system upgrades.

Integrate technology and establish centralised monitoring systems

Operational efficiency should be improved through the phased implementation of centralised monitoring technologies, including SCADA systems, borehole sensors, and remote telemetry for reservoirs and pumping stations. A district-level control room should be established to enable real-time monitoring, early fault detection, and coordinated response to system failures. These technological interventions should be supported by structured training programmes, clear maintenance protocols, and dedicated operational budgets to ensure long-term functionality.

Build human resource capacity and technical skills

Human resource capacity should be strengthened through the targeted recruitment of critical technical personnel, including engineers, artisans, and water technicians. Municipalities should

implement structured skills-development programmes, including on-the-job training, mentorship arrangements, and continuous professional development. Partnerships with higher education institutions and professional service providers should be used to support skills transfer, internship placements, and graduate development programmes. Incentive mechanisms should also be considered to attract and retain skilled professionals in rural municipalities.

Promote inclusive stakeholder collaboration and community engagement

Stakeholder collaboration should be institutionalised through the establishment of structured forums involving government departments, private-sector partners, civil society organisations, and community representatives. These forums should facilitate coordinated planning, resource sharing, and information exchange. Community participation in monitoring and safeguarding local infrastructure should be strengthened through awareness programmes and community-based oversight initiatives, which can reduce vandalism, improve reporting of system failures, and enhance local ownership of water infrastructure.

Promote alternative and bulk water supply schemes

Long-term water security should be supported by diversifying water supply sources and reducing over-reliance on groundwater. This can be achieved by advancing bulk water supply schemes, such as the Delpportshoop–Olifantshoek project, through coordinated planning with provincial authorities and private-sector partners, particularly mining houses. Complementary measures, including artificial aquifer recharge, rainwater harvesting, and water reuse initiatives, should be explored to enhance resilience and buffer the impacts of drought and climate variability.

Collectively, these recommendations provide practical guidance on how governance, planning, funding, technology, and human capacity can be strengthened to support sustainable, reliable, and equitable water service delivery in the John Taolo Gaetsewe District Municipality.

5.4 CONTRIBUTIONS OF THE STUDY

Practical contributions

- **Identification of systemic challenges:** The study highlights key operational, financial, and governance-related challenges affecting rural water supply in the John Taolo Gaetsewe District Municipality (JTGDM), including overlapping institutional roles, unclear accountability, ageing infrastructure, insufficient maintenance, unreliable energy supply, and frequent equipment theft.

- **Actionable interventions:** Participants' suggestions, such as expanding bulk water supply schemes, implementing centralised monitoring systems (e.g., SCADA), strengthening stakeholder collaboration, and building technical and managerial capacity, provide context-specific strategies that municipalities can adopt to improve water service delivery.
- **Roadmap for integrated solutions:** The study underscores the importance of holistic, coordinated approaches that integrate governance, planning, financing, and human resource development, offering municipal managers a practical framework for enhancing operational efficiency and infrastructure sustainability.

Academic contributions

- **Extension of qualitative inquiry:** By adopting an exploratory, qualitative design in a rural South African context, the study fills a gap in empirical research on rural water infrastructure management, demonstrating how practitioners' lived experiences can inform broader theoretical understanding.
- **Insights into governance and institutional coordination:** The research contributes to the literature by linking governance structures, institutional alignment, and planning mechanisms to water service performance, providing evidence on how misalignment between policy and local realities affects service delivery.
- **Thematic analysis application:** The study illustrates how thematic analysis can be applied to uncover meaningful patterns from qualitative data, offering a methodological example for future research in infrastructure management and rural service delivery.

Policy-level contributions

- **Evidence for policy refinement:** The study provides concrete insights into the operational realities of rural water supply, which can inform provincial and national policymakers on the effectiveness of current frameworks, such as the National Water Act (1998) and Integrated Water Resources Management (IWRM) approaches.
- **Support for sustainable water provision policies:** Findings emphasise the need for multi-stakeholder collaboration, sustainable financing mechanisms, and human resource development, strengthening the evidence base for interventions aimed at achieving equitable and reliable water services in rural municipalities.

Overall, the study contributes to the understanding of rural water infrastructure management by linking governance, institutional capacity, operational realities, and policy frameworks. It provides actionable recommendations for municipalities, advances academic knowledge on qualitative approaches to infrastructure research, and informs policy strategies to enhance sustainable water service delivery in rural South Africa.

5.5 SHORTCOMINGS OF THE STUDY

While the study offers valuable insights into rural water infrastructure challenges in the John Taolo Gaetsewe District Municipality, several shortcomings should be acknowledged to contextualise the findings and inform future research.

Firstly, the study's participant profile was limited to one key informant from each of the three WSAs. Although these officials possessed relevant institutional knowledge, excluding community members, end-users, local leaders, contractors, and provincial or national officials narrowed the range of perspectives captured. A broader sample could have offered a more comprehensive understanding of how governance, operations, and service delivery challenges are experienced across different stakeholder groups.

Secondly, the study did not include site visits or technical inspections of water infrastructure assets such as boreholes, pumps, reservoirs, and pipelines. As a result, the analysis relied primarily on participant accounts and policy documents, without an independent assessment of the infrastructure's physical condition or operational status. Direct observation could have enhanced the reliability of the findings by corroborating reported operational challenges.

Thirdly, the qualitative and interpretivist nature of the research means that the researcher's subjectivity might have influenced data interpretation. Although measures were taken to ensure rigour, thematic analysis within this paradigm inevitably reflects the researcher's perspective and contextual understanding.

Furthermore, the study reflects conditions at a specific moment in time. Water service performance, governance arrangements, funding cycles, and policy frameworks in South Africa are fluid and may change after the research is complete. This temporal limitation impacts the long-term generalisability of some conclusions.

Despite these shortcomings, the study provides meaningful and contextually grounded insights into the governance, operational, and infrastructural challenges affecting water service delivery in the district. It offers a solid foundation for further inquiry. Future studies could benefit from a larger and more diverse sample of participants, mixed-methods designs incorporating quantitative

and technical data, and the inclusion of real-time monitoring or field observations to enhance empirical robustness.

5.6 MEETING RESEARCH OBJECTIVES

Reaching the secondary objectives is discussed first because primary objectives are usually broad and overarching, defining the overall aim of the study. Secondary objectives, on the other hand, break this broader aim into smaller, measurable parts that guide the research process. By systematically addressing these secondary objectives, the researcher collects the evidence, data, and insights needed to answer or ultimately achieve the primary objective. In this way, secondary objectives serve as essential steps towards reaching the final goal represented by the primary objective.

Secondary objectives:

- 1 To investigate the governance, planning, funding, implementation, and operational factors affecting the functionality of the WSAs' water supply systems.

Achievement and Justification: This objective was met by examining institutional frameworks, policies, and project management practices within the WSAs. The analysis revealed that overlapping institutional roles, policy misalignment, and funding constraints were key drivers of poor performance in water infrastructure. Furthermore, bureaucratic inefficiencies, outdated infrastructure, and ineffective monitoring systems were identified as significant barriers to operational efficiency. Although some positive coordination efforts were observed, the study concluded that persistent weaknesses in planning and financial management continue to undermine reliable service delivery.

- 2 To evaluate the findings and develop recommendations for improving the water supply system.

Achievement and Justification: This objective was fulfilled through a synthesis of empirical findings and thematic analysis, resulting in a set of actionable recommendations. These included strengthening governance and institutional coordination, promoting stakeholder collaboration, adopting technologies that enable centralised monitoring, developing bulk water schemes, and enhancing human resource capacity within the WSAs. The recommendations directly address the identified systemic and operational challenges and align with the study's broader aim of improving water service reliability and sustainability.

- 3 To assess the financing process as a potential cause of project delays and propose targeted recommendations to address it.

Achievement and Justification: This objective was achieved through an assessment of the financing mechanisms underpinning water projects in the district. The study found that funding

delays, bureaucratic obstacles, and reliance on grants and external partnerships significantly hindered timely project execution and maintenance. The findings led to targeted recommendations, including implementing phased infrastructure projects, promoting bulk water schemes supported by public–private partnerships, and enhancing stakeholder engagement to streamline financing processes. Consequently, this objective was met by identifying and addressing the financial and institutional constraints contributing to project delays, and by offering practical solutions to improve financial management and project delivery.

Primary objective: Within the constraints of limited municipal budgets, the primary objective of this study is to evaluate the most effective methods for improving rural water supply systems in the three Water Services Authorities (WSAs) of the John Taolo Gaetsewe District Municipality.

Achievement of the objective: This objective was achieved through a qualitative analysis of governance structures, planning mechanisms, operational processes, and funding arrangements. The study demonstrated that enhanced institutional coordination, greater use of technology for centralised monitoring, and the implementation of bulk water schemes can significantly improve the efficiency and sustainability of rural water service delivery. The findings, therefore, confirmed that integrated planning and centralised oversight are critical to optimising scarce financial and technical resources.

5.7 SUMMARY OF THE CHAPTER

This chapter presented research findings, including conclusions and recommendations for improving water infrastructure in the John Taolo Gaetsewe District Municipality. The results showed that the main factors limiting effective water service delivery in the district were governance issues, policy distortions, poor planning, insufficient financing, and weak operational capacity. Bureaucratic delays, ageing infrastructure, theft, and rapid settlement growth further worsen these problems.

Despite these obstacles, the study found several opportunities for improvement. Introducing bulk water schemes, adopting technology and centralised monitoring systems, and strengthening stakeholder partnerships were identified as key measures to boost efficiency and sustainability. Furthermore, enhancing human resource capacity, improving the governance framework, and increasing coordination among the three WSAs were recognised as vital for long-term service reliability and fair access.

In general, the research achieved both its primary and secondary goals. It provided a clear perspective on the factors influencing water infrastructure performance in the John Taolo

Gaetsewe District Municipality and offered feasible ways to improve them. The findings provide policymakers, practitioners, and researchers with valuable information to address water problems in rural areas and enhance sustainable water management within the same district municipalities.

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ANNEXURE A: GENERIC LETTER OF CONSENT

Study Title: Exploring the Improvement of Water Infrastructure within the John Taolo Gaetsewe District Municipality

Ethics Number: NWU-01836-23-A4

Dear Participant,

You are invited to participate in the qualitative data collection for the MBA research project of Olebogeng Asieng. This research forms part of the requirements for the MBA degree at the NWU Business School.

Purpose of the Study

The study aims to explore opportunities to improve the rural water supply systems of the three Water Service Authorities (WSAs) within the John Taolo Gaetsewe District Municipality. Specifically, it investigates governance, planning, funding, implementation, and operational factors affecting water service delivery, and evaluates findings to develop recommendations for improvement.

What Your Participation Involves

Participation involves taking part in an interview in which you will be asked questions related to the study objectives. Interviews are expected to last no more than 30 minutes. Your responses will provide important data to complete the research project.

Data Handling, Confidentiality, and POPIA Compliance

Participation is voluntary, and the information you provide will be used solely for academic purposes. No personal identifying information will be collected. Your affiliation with a WSA will be recorded solely for profiling purposes, not for comparison across institutions.

Your responses will be treated with strict confidentiality:

- No answers or comments will be attributed to you or your WSA.
- Data will be stored securely in a password-protected database.
- All data will be destroyed after the dissertation is completed and examined.

- You have the right to access, correct, or request deletion of any personal information you provide.
- Sensitive personal data (e.g., race, political affiliation, health) will not be collected.

Risks and Benefits

There are no anticipated physical or psychological risks associated with participation. While you will not receive direct benefits, your input may help inform improved water service delivery in rural municipalities.

Voluntary Participation and Right to Withdraw

Participation is entirely voluntary. You may withdraw from the study or decline to answer any question at any time without consequence.

During the interviews:

- Data will only be used for research purposes.
- Data will not be made known to any public entity that might benefit from the data.
- Information will not be disclosed to other WSAs or public entities.
- Data will only be stored in the database of the researcher (student).
- WSAs will be identified using codes only. The names of the WSAs involved in the research will not be revealed in the researcher's database.
- After examination and approval of the dissertation, all data will be destroyed.

Participant Confirmation

By participating in this study, you hereby confirm the following:

1. You understand that, even if you agree to participate at this stage, you may withdraw from the study or decline to answer any question at any time, without suffering any adverse consequences of any kind.
2. You understand that the purpose and nature of the study have been explained to you in writing, and that you have had the opportunity to request clarification or ask questions regarding the content of the survey.

3. You understand that you will not derive any direct personal or financial benefit from participating in this research.
4. You understand that all information provided by you will be handled in a strictly confidential manner.
5. You understand that your identity will remain anonymous in any report, publication, or presentation that arises from this research.
6. You understand that if you disclose information indicating that you, or any other person, are at risk of harm, the researcher may be obligated to report such information to the relevant authorities. The researcher will, where possible, discuss this with you beforehand, but may be legally required to proceed without your consent.
7. You understand the purpose of the study and that participants will not receive individual feedback on the research results.
8. You understand that, under relevant freedom of information legislation, you are entitled to access the information you have provided at any time while it is retained in storage, as specified in this document.
9. You understand that the data collected will be used solely for academic research purposes and may be published in aggregated form.
10. You understand that you may contact the researcher at any time to request additional information or clarification regarding the study.
11. You understand that, in accordance with the Protection of Personal Information Act (POPI Act), personal data will be collected and processed exclusively for the purposes of this dissertation. Records will be retained only for as long as necessary and will be securely deleted thereafter. Participants maintain the right to access, correct, or delete their personal information. Furthermore, sensitive personal data, including information relating to health status, political affiliation, race or ethnic origin, or criminal behaviour, will not be collected or processed.
12. You understand that, in accordance with the Promotion of Access to Information Act (PAIA Act), formal permission to conduct research within the WSA was obtained from the designated signing authority. The research request detailed the title and objectives of the mini-dissertation and outlined the intention to collect information regarding water infrastructure within the WSA through interviews or questionnaires. The designated

signing authority subsequently approved to conduct the study and authorised the use of publicly available municipal data for research purposes.

Conflicts of Interest

The researcher hereby declares that there are no actual, potential, perceived, or financial/non-financial conflicts of interest arising from previous contractual work undertaken with any of the respective Water Services Authorities (WSAs). Furthermore, any form of positive or negative bias towards employees within these municipalities, with whom the researcher may have previously collaborated, will be consciously avoided where applicable.

Conflicts of Interest

Conflicts of interest will be managed as follows:

- The researcher will remain neutral, objective, and professional throughout all phases of the research process.
- Employees from the three WSAs within the John Taolo Gaetsewe District Municipality (JTGDM) with whom the researcher has previously collaborated will, wherever feasible, be excluded from the interview sample.
- Participants' views will be treated equally and without prejudice, irrespective of race, gender, or any other personal characteristic.
- Any information pertaining to weaknesses in planning or governance within the JTGDM's water infrastructure will be treated sensitively and ethically and will not be disclosed in a manner that could cause reputational harm to the municipality or individuals involved.
- The researcher affirms that no personal or professional interests will interfere with the fair, transparent, and objective execution of the interviews or the interpretation of findings.
- Should it be deemed necessary, an independent statistician will be appointed to analyse the data. This will ensure that the results are unbiased, impartial, and free from any intentional misrepresentation that might negatively affect participants or associated institutions.

For any questions or concerns regarding potential conflicts of interest, please contact the research supervisor:

Dr F.F. Prinsloo

Cell phone: 076 981 8483 Email: ffprinsloo9706@gmail.com

Approval and Organisational Consent

Formal permission to conduct this study at your institution has been requested and approved by management.

I consent:

Signed at _____ on this _____ day of _____ 2025

Signature

ANNEXURE B: SEMI-STRUCTURED INTERVIEW SCHEDULE

This Interview Schedule aims to gather in-depth insights and perspectives from stakeholders involved in improving water infrastructure in the John Taolo Gaetsewe District Municipality, South Africa.

1. In your opinion, what are the current challenges hindering the John Taolo Gaetsewe District Municipality (JTGDM) from providing a sufficient and reliable water supply?
2. From your perspective, what are the most critical areas of water infrastructure in the region that need immediate attention and improvements?
3. In your experience, what are the main factors contributing to water scarcity or shortages in the JTGDM? How can these challenges be effectively addressed?
4. In the past, what initiatives or projects related to water infrastructure have been successful, and what contributed to those successes?
5. How do you assess the current state of water quality in the region? To ensure safe and consistent water quality in all communities, what steps can be taken?
6. What technological advancements or innovations could significantly improve water infrastructure and management in the region? Please elaborate on them.
7. Developing and maintaining water infrastructure poses several financial challenges and constraints. What are these challenges and constraints? How can these challenges be overcome or mitigated?
8. How can the government, private sector, and civil society organizations collaborate in the JTGDM to improve water infrastructure?
9. Are there any best practices or successful models from other regions or countries that could be adapted and implemented in the JTGDM to enhance water infrastructure development and management?

ANNEXURE C: PERMISSION LETTERS



TO WHOM IT MAY CONCERN

Permission letter to conduct research in Gamagara Local Municipality

This letter serves to confirm that Mr. Olebogeng Alpheus Asieng under supervision of Dr Frans Prinsloo and Dr Johan Jordaan may conduct research on our Water Supply Infrastructure and/or may make use of our organisation publicly available data. Any other data of our organisation which is collected in a form of interviews and/or questionnaire will be consented by organisation's representative (participant). Furthermore, the data generated during the research may be used to compile the dissertation.

Our organisation hereby commits to providing the necessary research support in the form of data (interviews and/or questionnaire).

Yours sincerely

Mr. L. Seetile
MUNICIPAL MANAGER
GAMAGARA LOCAL MUNICIPALITY

Date: 04/08/2023



GA-SEGONYANA LOCAL MUNICIPALITY

Enquires: Infrastructure Director
Bonolo Kgosieng

Date :04 September 2023

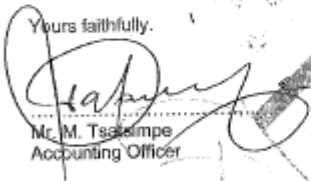
To whom it may concern

Permission letter to conduct research

This letter serves to confirm that Mr. Olegeng Alpheus Asiang under supervision of Dr Frans Prinsloo and Dr Johan Jordaan may conduct research on our Water Supply Infrastructure and/or may make use of our organisation publicly available data. Any other data of our organisation which is collected in a form of interviews and/or questionnaire will be consented by organisation's representative (participant). Furthermore, the data generated during the research may be used to compile the dissertation.

Our organisation hereby commits to providing the necessary research support in the form of data (interviews and/or questionnaire).

Yours faithfully,


Mr. M. Tsatsimpe
Accounting Officer

GA-SEGONYANA MUNICIPALITY

04 SEP 2023

REGISTRY

PROSPERITY

♀ Cnr Voortrekker & Schools
street, Kuruman 8460053

☎ 053 712 9300

✉ registry@ga-segonyana.gov.za

03 October 2025

To whom it may concern

PERMISSION LETTER TO CONDUCT RESEARCH

This letter confirms that permission is hereby granted to Olebogeng Alpheus Asieng, a student at North West University, to conduct research involving John Taolo Gaetsewe Developmental Trust (JTGDT), as part of their academic study titled "Exploring the improvement of the water infrastructure within the John Taolo Gaetsewe District Municipality"

Please note that our participation is voluntary, and the Trust reserves the right to withdraw at any stage should circumstances require. We understand that the findings will be used solely for academic purposes and that no proprietary or sensitive information will be disclosed without prior written consent.

The Trust commits to providing the necessary research support in the form of data (interviews and/or questionnaire).

Yours sincerely



Mrs Boipelo Oageng - Seoheng
Acting Chief Executive Officer
Contact no: 082 856 5003