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Assessment of Factors Impacting Water Supply Services in Lusaka District: A Case of Lusaka Water Supply and Sanitation Company

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ABSTRACT

The water supply situation in Lusaka district faces numerous challenges related to reliability, accessibility, and sustainability of water supply services. Despite a population of 3,079,964, only 134,807 household connections were established by LWSC in 2022. With a record 4.5% population increase from 2022 to 2023, the demand for water stands at over 420,000 cubic meters per day, while LWSC produces 250,000 cubic meters per day. Groundwater, accounting for 57% of LWSC's water, is threatened by land development and pollution. Meanwhile, 45% of the population relies on site sanitation, contributing to groundwater pollution, the very source LWSC is dependent upon. Lusaka faces low or no water supply, an average of 18 hours per day. Despite existing research on the peri-urban water supply, a gap remains in addressing the challenges of rapidly growing urban areas like Lusaka. This study aims to fill this gap by providing a comprehensive analysis focusing on the unique challenges faced by LWSC, such as land development, population growth, and climate change. The research will offer practical solutions for sustainable water supply management in Lusaka and similar contexts.

The research philosophy employed for this study is interpretivism, as it allows for a deep understanding of the subjective experiences and perceptions of experts involved in the water supply sector in Lusaka. This approach aligns with the qualitative nature of the research, which aims to explore and understand the complex interactions between various factors influencing water supply services in the district.

The findings of the study reveal that climate change, population growth, and land development are significant factors influencing water supply services in Lusaka. Erratic rainfall patterns and prolonged droughts have led to challenges in water availability and quality, while rapid population growth has increased the demand for water supply services, putting pressure on the existing infrastructure. Unplanned land development has also led to challenges in water supply services, particularly in areas with shallow water tables that are vulnerable to groundwater pollution. The study recommends investing in climate-resilient infrastructure, diversifying water sources, enhancing water conservation practices, and strengthening land use planning regulations to address these challenges and ensure the sustainability of water supply services in Lusaka.

Keywords: Service provider, Water and Sanitation, Urbanization, Commercial Utility, Partnership, Land Development, Population Growth, Climate, Accessibility, Water Provider, Lusaka, Zambia.

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“But Jesus beheld them, and said unto them, with men this is impossible; but with God all things are possible.” Matthew 19:26.

CHAPTER ONE
BACKGROUND TO THE STUDY

1.0 Introduction

In many parts of the world, population growth and urbanization are increasingly becoming major challenges to governments (WHO/UNICEF, 2012). According to the (UN, 2014), 52 percent of the world’s population now resides in urban areas, with 90 percent of the world’s population growth occurring in cities located in developing countries. The relentless pace of urbanization in developing countries is placing an unprecedented burden on water supply services (WaterAid, 2006; Liang, 2011).
Adding to the complexity of the situation, climate change is a looming threat (UN, 2023). Predictions indicate that climate change will induce dramatic shifts in precipitation patterns, leading to potential water scarcity and further straining the already delicate balance between supply and demand (SDG Report, 2022).
Furthermore, population growth and land development could lead to a dramatic increase in water consumption and wastewater discharge (Zhou, et al, 2008). The provision of portable water is very critical for achieving sustainable development in line with SDG 6, whose aim is to ensure availability and sustainable management of water by the year 2030 (UN, 2016).
Given the pressing challenges faced, an examination of the factors impacting water supply in Lusaka district is crucial. This chapter provides a comprehensive overview, including the study's background, problem statement, objectives, research questions, theoretical framework, conceptual framework, significance, scope, limitations and dissertation organization, with a specific focus on water supply in Lusaka district.

1.1 Background

Lusaka, the capital and largest city of Zambia, stands as one of the most rapidly developing urban centers in southern Africa. Nestled in the southern region of the central plateau, it sits at an elevation of around 1,279 meters (BGR, 2011). As of 2022, Lusaka Province boasted the largest population, totaling 3,079,964

(ZamStats, 2022). Despite its growth, Lusaka has faced significant challenges in providing adequate water supply services (IWA, 2018).

The foundation of Zambia's drinking water infrastructure was laid between its declaration of independence in 1964 and the mid-1970s, a period marked by robust economic growth and substantial earnings from copper mining exports (JICA, 2019). However, a study by the Millennium Challenge Corporation in 2020 indicated that during this era, water was supplied with little regard for the long-term sustainability of these vital services.

JICA (2014) identified Lumumba, Kabwata, and Kabulonga zones as areas in need of water pipeline expansion and rehabilitation. In 2022, parts of Lusaka continued to experience low hours of supply, with an average of 18 hours, affecting areas such as Roma Township, Roma Park, Woodlands, Bauleni, Kabanana, upper parts of Chunga, and upper parts of Ibex Hill (NWASCO, 2022). Additionally, some parts of Chalala, Salama Park, Meanwood, Lusaka West, and areas in the east still remain unserved or require network expansion (NWASCO, 2022).

Currently, LWSC achieves an average water production of 250,000 cubic meters as of 2022, with 43% sourced from surface water and 57% from groundwater reserves (LWSC, 2022). Despite this, only an estimated 2,786,596 out of Lusaka's total population are serviced by LWSC, with 38% of the population connected via household connections and 61.2% serviced by Public Standposts & Kiosks (NWASCO, 2022).

A study conducted by IWA in 2018 on Global Water Policy indicated that the escalating water demand correlates with an increase in land development, particularly in informal settlements. The arrangement of pit latrines in these settlements poses a risk of groundwater contamination due to their proximity to water sources such as shallow wells and dugouts (LWSC, 2021). Over the past two decades, the number of residents in highly dense informal settlements has nearly tripled to about 1.4 million as of 2020, constituting nearly 62% of Lusaka's current population (IGC, 2022).

Climate change adds further complexity, disrupting weather patterns and exacerbating water scarcity and contamination (BGR, 2011). The decadal trend in monthly rainfall over AERIII for the period 1981–2022 showed a decreasing trend, with an increase in the frequency, magnitude, and intensity of extreme events such as droughts, extreme temperatures, and dry spells (Zambia National Drought Plan, 2018). Additionally, a bacteriological analysis by BGR in 2014 of water samples from 20 points in Lusaka indicated an increase in microbial contamination counts during the wet season.

Building upon this context, the purpose of this study is to investigate how the water supply services within the Lusaka district are influenced by the interplay of population growth, climate change, and land development.

1.2 Problem statement

The water supply situation in Lusaka district, faces a myriad of challenges related to reliability, accessibility, and sustainability of water supply services (IWA, 2018). With a population of 3,079,964 (ZamStats, 2022), Lusaka alone is home to 687,923 houses; however, LWSC has established only 134,807 household connections as of 2022 (NWASCO, 2022). Furthermore, there has been a record 4.5% increase in population from 2022 to 2023, with Lusaka's population reaching 2,906,000 in 2021, representing a 4.76% increase from 2020 (Macrotrends, 2022). Additionally, 57% of LWSC's water is drawn from groundwater reserves (LWSC, 2022) and is threatened by land development and pollution. While 47% of LWSC’s Water is drawn from surface water (LWSC, 2022). The water demand for Lusaka stands at over

420,000 cubic metres per day (FRACTAL, 2019). Current, LWSC produces 250,000 cubic metres per day been 170,000 less the water demand (LWSC, 2021). The overwhelming number of pit latrines, septic systems, improper waste disposal, and wastewater threatens groundwater sources globally (WHO, 2003). About 45 percent of the population in Lusaka rely on site sanitation for the disposal of sewage and wastewater (JICA, 2009).

Parts of Lusaka housing industries, like Lusaka West, Lusaka East continue to face low hours of water supply or no water supply at all (NWASCO, 2022). Lusaka receives on average 18 hours of water supply (NWASCO, 2022). Furthermore, the lack of water supply services can increase the cost of production for industries, necessitating investments in alternative water sources, storage facilities, or water conservation technologies to cope with inadequate water supply services (OECD, 2009).

Past studies have not adequately addressed the unique challenges faced by rapidly growing urban areas, such as Lusaka, in managing their water supply. While some research exists on the financial viability of commercial utilities and water supply in peri-urban areas, there is a notable gap in the current body of knowledge. This study will provide a more comprehensive analysis that includes urban areas as well. Additionally, it will focus on the specific challenges faced by the Lusaka Water Supply and Sanitation Company (LWSC) such as land development, population and climate, offering practical solutions that can be implemented in the local context. This research will also contribute valuable insights to the field of water supply management in Least Developed Countries (LDCs), informing strategic planning and policy formulation for sustainable water supply management in Lusaka and similar sites.

1.3 Main Objectives

To assess factors impacting water supply services within Lusaka district.

1.3.1 Specific Objectives

a) To assess the influence of climate change on water supply service
b) To assess the impact of population growth on water supply service.
c) To assess the impact of land development on water supply services.

1.4 Research Questions

a) How does climate change influence water supply services in Lusaka district?
b) How does population growth impact water supply services in Lusaka district?
c) How does land development impact water supply services in Lusaka district?

1.5 Significance of the Study

The study proposed in this research holds substantial significance due to its focus on the complex challenges facing water supply services in the rapidly developing areas of Lusaka, Zambia. Lusaka's rapid urbanization and population growth have created an urgent need to examine the dynamics between water supply services, population growth, land development, and climate change. As urbanization continues to reshape the landscape, there is a pressing need to understand how these factors interact and impact water supply services. Access to clean and safe water is fundamental to public health and well-being. This study's focus on promoting the well-being of Lusaka's residents adds a humanistic dimension to its significance. Access to clean and reliable water is not just a matter of infrastructure; it is a fundamental human right that directly impacts health, sanitation, and overall quality of life. By highlighting the importance of equitable water access, this research underscores the broader implications of poor water supply on public

health and well-being. The study's findings will provide insights into how challenges related to climate change, population growth, and land development can compromise water supply services. By identifying these challenges, the study contributes to the formulation of strategies and strengthens the water supply services in Lusaka.

The study aligns with the United Nations' Sustainable Development Goal 6, which focuses on ensuring the availability and sustainable management of water and sanitation for all by 2030.

By investigating the factors affecting water supply services in Lusaka, the research contributes to the global effort to achieve sustainable water management by 2030. The research findings will provide crucial insights for policymakers, water management authorities, water utilities and government agencies involved in urban planning and development. With the looming threat of climate change, understanding its potential impact on water supply services is vital for building resilience. The study's examination of how climate change influences water supply services can inform adaptation strategies that ensure a continuous and reliable water supply in the face of changing weather patterns.

Also, this study will not only make a valuable contribution to existing literature by building upon the works of other esteemed scholars, but it will also enrich the knowledge landscape within the water sector. By doing so, it will furnish other utilities and stakeholders with insightful lessons and takeaways that can be readily applied to their own contexts.

In conclusion, this study's significance lies in its potential to shed light on the intricate relationships between land development, climate change, population growth, and water supply services. By addressing these challenges, the research contributes to the development of strategies that ensure equitable access to water supply services and promotes the overall well-being of Lusaka's residents.

1.6 Scope and limitation

This research endeavours to conduct a thorough and all-encompassing evaluation of the elements that influence water supply services within the Lusaka district. The analysis will encompass multiple facets, including water supply service provisioning, population expansion, climate change effects, and land development dynamics. Although the primary focus centers on all areas in Lusaka district, it is acknowledged that the applicability of findings to other contexts may have limitations. The study will particularly zero in on the operations of LWSC while still recognizing the broader spectrum of factors delineated in the conceptual framework. In terms of the participants, the study involved experts in the water supply sector in Lusaka. This includes representatives from the NWASCO and LWSC.

1.7 Organisation of Dissertation

This dissertation consists of six chapters, and the introduction is presented in this chapter. Chapter two is a literature review. It gives a detailed literature review that aims at appreciating the works of prior researchers on the subject, identifying gaps, and contributing to the body of knowledge. Chapter 3 presented the theoretical and conceptual framework underpinning the study. Chapter four is about research methodology. It narrated the research philosophy and techniques used to arrive at the research outcome. The research design used in this study was discussed in this chapter. It also discusses the techniques used to arrive at the population of participants. Sampling techniques and estimation of sample size will be elaborated on. Techniques used to collect and analyse the data will also be presented. Furthermore, validity and reliability tests, limitations, and ethical considerations were presented. Chapter five presented data analysis and the presentation of results. It delt with in-depth data analysis, interpretation, and results.

Chapter six carried on from Chapter five to present a discussion of findings. Finally, chapter seven provided conclusions and recommendations.

CHAPTER TWO
LITERATURE REVIEW
2.0 Introduction

This chapter presents a comprehensive review of the literature that underpins the study. It aligns with the research questions and objectives focusing on the factors influencing water supply services in the Lusaka district, with a specific emphasis on the Lusaka Water Supply and Sanitation Company. The chapter begins with an overview of water supply services, emphasizing their significance from both a global and Zambian perspective. It then delves into the specific context of Lusaka, providing empirical evidence and highlighting lessons learned from previous studies. Finally, the chapter concludes with a summary of key findings.

2.1 Water Supply Services

Water supply refers to the provision of safe and reliable access to clean drinking water for various purposes, primarily for human consumption, but also for industrial, agricultural, and other essential uses (UNDESA, 2015). It involves the collection, treatment, storage, distribution, and management of water resources to meet the needs of communities and industries (NIH, 2020). The availability of clean water is essential for sustaining life, promoting public health, supporting economic activities, and maintaining overall quality of life (World Bank, 2022).

Water supply systems typically begin with the identification and development of water sources (IWA, 2022). According to a study conducted by IWA in 2022, these sources can include groundwater from wells or aquifers, surface water from rivers or lakes. Regardless of the source, water often requires treatment to remove impurities, contaminants, and pathogens to make it safe for consumption (NWASCO, 2022). Water treatment processes can include filtration, chemical disinfection (e.g., chlorination), and sometimes fluoridation to improve its quality (WARMA, 2022).

After treatment, clean water is distributed to homes, businesses, and industries through a network of pipes, pumps, and storage reservoirs. The distribution system ensures that water is delivered reliably to consumers (NWASCO, 2022). Water quality is a critical aspect of water supply services (NWASCO, 2022). Monitoring and maintaining water quality are essential to ensure that the water remains safe for consumption and complies with health and safety standards (MoH, 2019). 297,000 children under five die every year from diarrhoeal diseases due to unsafe drinking water (WHO/UNICEF 2019).

Reliable water supply systems aim to provide a continuous flow of water to meet the demands of the population and various users (IWA, 2022). Interruptions in supply can have significant consequences for public health and daily life (MoH, 2019). The institutional responsibility for water supply can vary from one region to another (IWA, 2021). It often involves government agencies, utilities, or private companies responsible for policy and regulation, service provision, and standardization to ensure that water supply services are safe, accessible, and sustainable (IWA, 2021).

Sustainable water supply practices are crucial to manage water resources efficiently, minimize environmental impact, and ensure long-term availability (Gleick, P.H., 1993). This includes considerations for watershed protection, energy-efficient treatment, and wastewater recycling (UNEP, 2014). The cost of supplying water comprises both fixed costs (capital investments and personnel)

and variable costs (energy, chemicals) that depend on the amount of water consumed. Service providers often charge tariffs to recover part of these costs while maintaining affordability for consumers (NWASCO, 2022).

According to the UN, billions of people will lack access to these basic water supply services in 2030 unless progress quadruples. Demand for water is rising owing to rapid population growth, urbanization and increasing water needs (UN, 2020). Decades of misuse, poor management, over extraction of groundwater and contamination of freshwater supplies have exacerbated water stress (Gleick, P.H, 2000). In addition, countries are facing growing challenges linked to degraded water-related ecosystems, water scarcity caused by climate change, underinvestment in water and insufficient cooperation on transboundary waters (UN, 2023).

At its core, the fundamental needs of both communities and individuals revolve around the availability of uncontaminated water and the implementation of hygienic waste management practices (Mensah and Antwi, 2013). Despite vigorous endeavours by national and international bodies, the reality persists that approximately 1.1 billion individuals still lack access to improved water supply sources (WHO, 2019). This grim reality translates into the unfortunate outcome of 2.2 million lives, predominantly among children in developing nations, succumbing to diseases directly linked to the absence of water supply services (WHO/UNICEF, 2012).

In addition, many world regions face Intermittent Water Supply (IWS). IWS systems can be defined as piped water supply service that is available to consumers less than 24 hours per day (IWA, 2016). Comprehensive surveys conducted by reputable international organizations contribute to the compounding evidence. Reports from the World Bank indicate that IWS systems are notably common in many developing nations, resulting from factors like rapid urbanization, inadequate infrastructure, and resource scarcity (World Bank, 2017). These findings align with investigations carried out by the United Nations, showcasing how IWS systems emerge as a pervasive phenomenon in regions where water resources are strained due to escalating demand (UN-Water, 2018).

Approximately two billion people live in countries experiencing high water stress. (UN 2019). This alarming statistic underscores the critical importance of addressing water scarcity and ensuring sustainable water supply systems worldwide. As populations continue to grow and climate change poses unprecedented challenges, the need for effective water management strategies becomes ever more pressing (UN-Water, 2013).

The provision of adequate and reliable water supply services is a paramount concern on a global scale. Access to clean and safe water is not only a fundamental human right but also a cornerstone for public health, economic development, and environmental sustainability (UN, 2010). One of the most pressing issues shaping the global water supply landscape is the prevalence of water scarcity and stress (UN-Water, 2023). Despite advancements in technology and infrastructure, access to reliable water supply services remains uneven across different regions and populations (Gleick, 2000). Rural communities, marginalized groups, and informal settlements often face significant barriers to accessing clean water (WHO/UNICEF, 2019). These disparities exacerbate social inequalities and hinder progress toward achieving universal access to water supply and sanitation, as outlined in the United Nations Sustainable Development Goals (SDGs) (UN, 2019). The impact of climate change further complicates the global water supply landscape. Altered precipitation patterns, rising temperatures, and increased frequency of extreme weather events disrupt the predictability of water resources (IPCC, 2014). Glacial melt, changing river flow patterns, and altered groundwater recharge rates pose significant challenges to existing water supply systems (Bates et

al., 2008). The rapid growth of urban populations contributes to the complexity of global water supply systems. Urban centers often require extensive infrastructure to meet the demands of densely populated areas (UN-Habitat, 2016). Outdated or insufficient infrastructure can result in water losses, inefficiencies, and inadequate sanitation services (UNESCO, 2017).

Water pollution remains a persistent issue affecting water supply services globally. Agricultural runoff, industrial discharges, and inadequate wastewater treatment compromise the quality of available water sources (UNEP, 2016). Contaminated water not only poses health risks but also requires costly treatment processes (WHO, 2019).

2.2 Importance of Water Supply Services

Access to clean and reliable water supply services is fundamental for the well-being and development of communities across the globe (UN, 2023). From public health advancements to economic growth and environmental sustainability, the provision of adequate water supply services has been consistently recognized as a cornerstone for societal prosperity (World Bank, 2022).

Numerous studies have demonstrated the direct link between access to safe drinking water and improved public health outcomes (WHO, 2023). Contaminated water sources are often responsible for the transmission of waterborne diseases, such as cholera, typhoid, and dysentery (WHO, 2023). The availability of clean and potable water reduces the prevalence of these diseases, subsequently alleviating the burden on healthcare systems and enhancing overall life expectancy (NIH, 2023). Research by Bartram and Cairncross (2010) highlights that improvements in water supply infrastructure have led to substantial reductions in morbidity and mortality rates, particularly among vulnerable populations.

Water supply services play a pivotal role in fostering socio-economic development (Asian Development Bank, 2023). Access to reliable water sources is essential for agriculture, industrial production, and energy generation. Reliable water availability enhances agricultural productivity, ensuring food security and contributing to rural livelihoods (Molden et al., 2007). Moreover, industries heavily reliant on water, such as manufacturing and mining, depend on consistent and quality water supply for their operations (UNESCO, 2016). Thus, the provision of water supply services is closely linked to job creation, income generation, and overall economic growth (United Nations, 2019).

Water scarcity disproportionately affects women and girls in many societies (World Bank, 2023). Women often bear the responsibility of water collection and management, which can be time-consuming and physically demanding, limiting their opportunities for education and income-generating activities (UN, 2023). Improving water supply infrastructure, particularly in rural areas, can significantly alleviate the burden on women and girls, empowering them to pursue education and economic opportunities (UNICEF, 2012). This empowerment contributes to greater gender equity and social progress (UN, 2023).

Balancing the increasing demand for water supply with the need for environmental conservation is a critical challenge (UN-Water, 2022). Research by Gleick (2003) highlights the intricate connections between water supply and climate change. Sustainable water management practices, such as watershed protection and efficient water use, are crucial for safeguarding ecosystems and ensuring the long-term availability of water resources (WARMA, 2023).

Access to portable water is not only a basic human right but also a catalyst for achieving various Sustainable Development Goals (SDGs).

2.3 Water Supply Services Globally

Lack of safe and reliable water supply affects more than 800 million people worldwide; over 2.5 billion people lack adequate sanitation services (IWA, 2022). Globally, this has a major negative impact on human health, environmental sustainability and on economic development. Rapid population growth, urbanisation, climate change, pollution and inadequate financing, present unprecedented challenges to the provision of water and sanitation services (IWA, 2022). The report, entitled Policy Options for Decoupling Economic Growth from Water Use and Water Pollution by UNEP in 2016, finds that as the global population rises, increased urbanization, climate change and a shift in how food is consumed are likely to dramatically increase future demand for water.

Climate change, population growth and economic development are pushing the limits of the world's finite water resources (World Bank, 2023). Improving and managing universal services of water and sanitation in a holistic manner is critical to achieving the Sustainable Development Goals, and addressing the needs of millions of people around the world (IWA, 2023). In some cases water scarcity is already constraining economic growth. Lack of access to improved water supply and sanitation services impose huge costs on society, especially for the poor (World Bank, 2023).

Climate change affects the world's water in complex ways. From unpredictable rainfall patterns to shrinking ice sheets, rising sea levels, floods and droughts, most impacts of climate change come down to water water (UN Water, 2022). Climate change is exacerbating both water scarcity and water-related hazards (such as floods and droughts), as rising temperatures disrupt precipitation patterns and the entire water cycle (UNICEF, 2020). About two billion people worldwide don't have access to safe drinking water today (SDG Report, 2022), and roughly half of the world's population is experiencing severe water scarcity for at least part of the year (IPCC, 2022). These numbers are expected to increase, exacerbated by climate change and population growth (WMO, 2023).

The global urban population is estimated to grow from 3.9 billion people today to 6.3 billion in 2050 (UNESCO, 2012). Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050, adding another 2.5 billion people to urban areas with close to 90% of the increase taking place in Asia and Africa (UN DESA, 2018). The number of city inhabitants globally lacking safely managed drinking water has increased by more than 50% since 2000 (UN-Water, 2021).

Land degradation and drought have negative impact on the availability, quantity and quality of water resources that result in water scarcity (UNCCD, 2022). Urbanisation is often directly linked to the degradation of environmental quality, including quality of water (IWA, 2019). Urbanization significantly increases the demand for drinking water as it concentrates populations in cities (UN Water, 2018). This concentration also intensifies the impact of urban activities on water quality (Zhang et al., 2019). Industries in urban areas discharge pollutants into water bodies, and the runoff from industrial zones introduces harmful chemicals and heavy metals into water sources, posing risks to drinking water safety (Gupta et al., 2019).

2.4 Water Supply Services in Zambia

Oversight of the water and sanitation sector in Zambia is conducted by the Ministry of Water Development and Sanitation (MWDS, 2020). Commercial Utilities (CUs) play a critical role as the primary providers of water and sanitation services in Zambia (NWASCO, 2019). To improve cost recovery and service efficiency, most urban local authorities have established CUs, such as the Lusaka Water and Sewerage Company (LWSC), to manage service delivery (World Bank, 2020).

A regulatory entity, NWASCO, was established in 1997 to independently regulate the provision of water supply and sanitation services in Zambia (NWASCO, 2014). NWASCO reports that around 6.55 million people reside in the service areas of CUs. Sanitation remains an underserved aspect in urban areas, leading to issues such as groundwater contamination and insufficient drainage, which contribute to widespread cholera outbreaks (NWASCO, 2022). Much like several African nations, Zambia is grappling with the rapid urbanization of its cities, which has led to challenges in providing adequate water supply services (World Bank, 2020). The majority of the population relies on onsite sanitation (JICA, 2022). Decades of underinvestment has translated into poor water delivery service to accommodate the nation's population growth (USAID, 2019). Over 6 million Zambians lack access to safe water and 11 million are without basic sanitation (USAID, 2019).

Zambia's population has more than quadrupled from 4,056,955 in 1969 to 19,693,423 in 2022 (ZAMSTATS, 2023). 64 per cent of the population use basic drinking water services, 87 per cent in urban areas and 49 per cent in rural areas (UNICEF, 2022). The IPCC 5th Assessment indicates that, through its interaction with non-climate change drivers (e.g. urbanisation, population growth), climate change will increase the vulnerability of access to safe water and adequate sanitation.

Average annual temperature has increased by 1.3OC from 1960 to 2006 (IRISHAID, 2022). The warming has been more rapid in winter. The frequency of hot days and hot nights has increased significantly with the average number of hot days and nights per annum having increased by 43 each from 1960 to 2003 (IRISHAID. 2022). Average annual rainfall over Zambia has decreased by an average rate of 1.9mm per month per decade since 1960 primarily due to decreases from December to February (IRISHAID. 2022). There is no significantly discernable trend in the frequency of heavy rainfall events in recent years (McSweeney et al, 2010).

2.5 Water Supply Services in Lusaka District

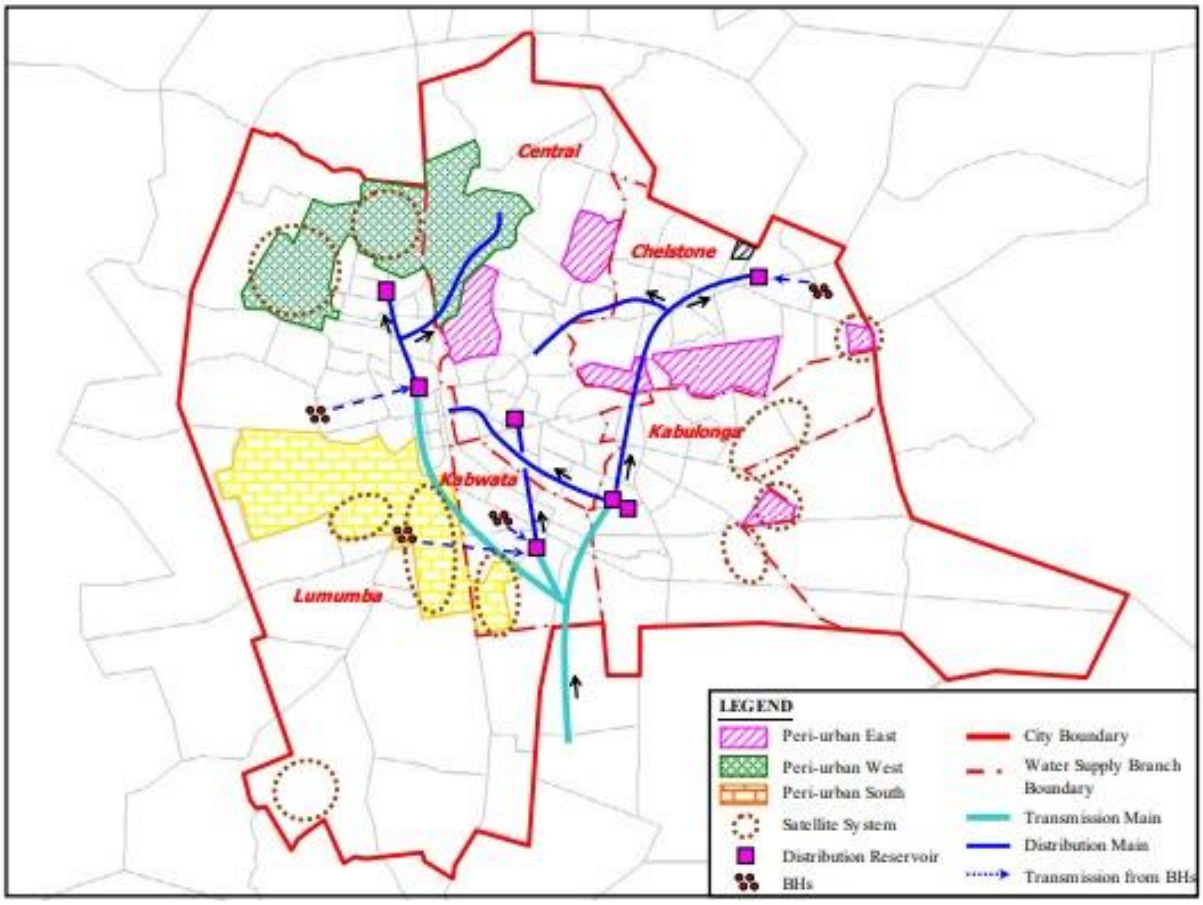
LWSC is responsible for delivering both potable water and sewerage services within the metropolitan areas of Lusaka, encompassing regions like Chongwe, Chilanga, Kafue, Luangwa, and Chirundu district (NWASCO, 2023). The water supply landscape in Lusaka City and its surrounding districts relies on LWSC and various water trusts (NWASCO, 2023). Two distinct water supply systems are operated by LWSC: the bulk water supply system and the satellite water supply system (LWSC, 2022).

The bulk water supply system is the primary framework, anchored by the Iolanda Water Works along with numerous boreholes dispersed across the city that feed into the distribution network (LWSC, 2022). The Iolanda Water Works utilizes the Kafue River's surface water, employing rapid filtration techniques in the water treatment process (LCC/ECZ, 2008). The satellite water supply system is tailored for peri-urban areas and operates independently from the major distribution network (LWSC, 2022). This system provides limited water supply to the surrounding regions through boreholes (JICA, 2009).

LWSC's daily water production averages around 200 million liters, drawn from two primary sources: 60% from the Kafue River's surface water located approximately 40 kilometers away, and the other 50% from approximately 50 boreholes situated within and around Lusaka City (LWSC, 2022). This necessitates the utilization of two main treatment processes: on-site chlorination facilities at borehole sites and conventional treatment facilities at the Iolanda Water Treatment Plant in Kafue (MCC, 2011). As reported by LWSC (2013), the main distribution system encompasses around 30,000 connections, with several sizable independent piped systems serving up to 100,000 consumers each. However, a significant portion of the city's residents, constituting approximately 40%, access water through non-regulated means,

including vending and resale from connected consumers (JICA, 2022). The distribution network and water supply system layout across Lusaka are depicted in Figure 3, illustrating the various types of water supply systems and their distribution across the city (JICA, 2009).

Figure 1 LWSC Water Distribution Branches



Source: JICA (2009)

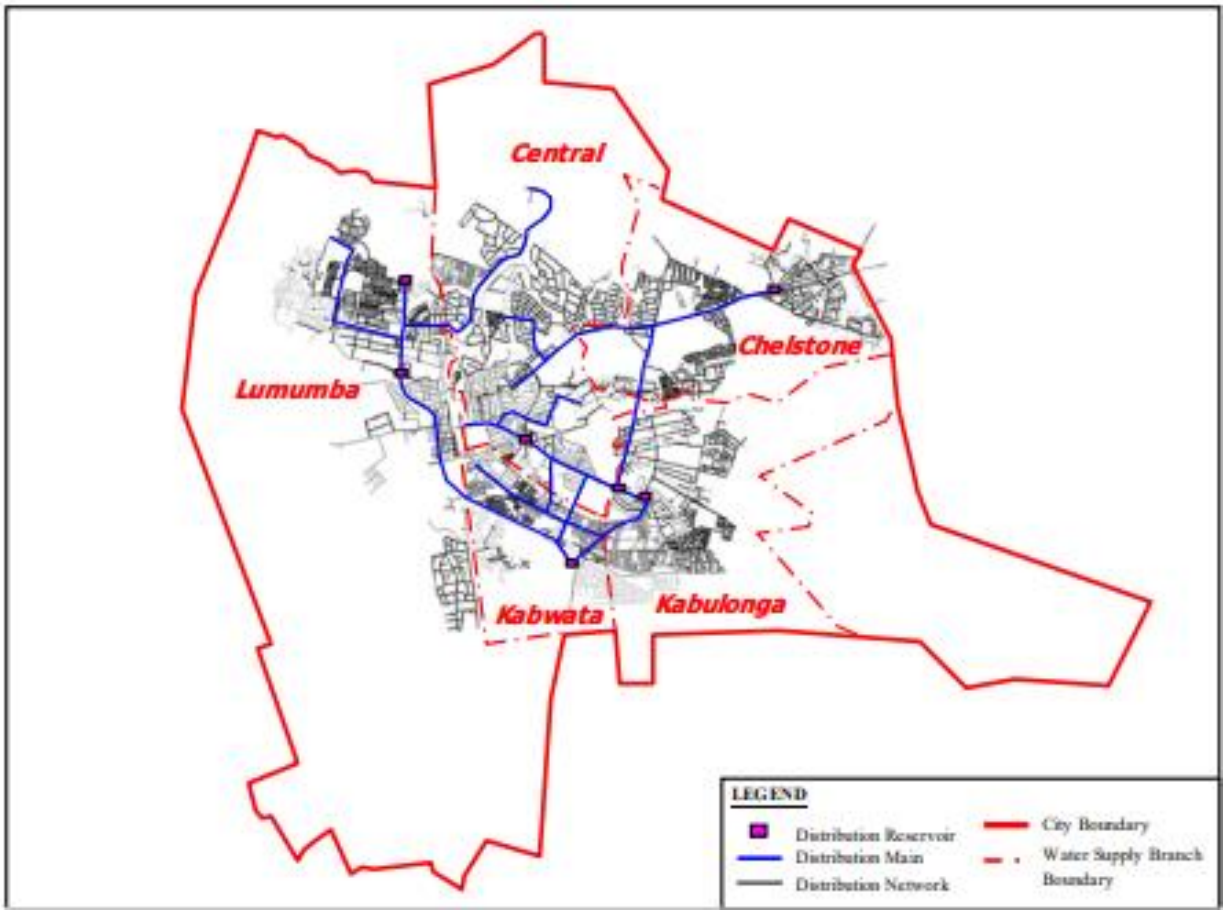
The inception of the water supply system dates back to 1970, marking its initiation as a first-phase project with a capacity of 45,450 m3/day (JICA, 2009). The subsequent year, 1979, witnessed the successful completion of the second-phase project, accompanied by a substantial capacity expansion to 109,050 m3/day (JICA, 2009). However, as the calendar turned to 1988, the capacity saw a reduction to approximately 90,000 m3/day, attributed to the aging infrastructure and outdated equipment (JICA, 2009). The pivotal year of 1989 saw a resurgence, as the Japanese Grant Aid Project stepped in to revitalize the system, elevating the capacity to 110,000 m3/day (JICA, 2009).

Presently, the "Water Sector Performance Improvement Project," funded by the World Bank, stands as a beacon for rehabilitation efforts (World Bank, 2019). This initiative targets the enhancement of the existing capacity from 94,800 m3/day to 110,000 m3/day, in addition to the installation of new boreholes (World Bank, 2019).

By August 2007, a significant stride had been achieved, with nearly 50% of the Lusaka district embraced by the expansive water distribution network (NWASCO, 2021). This intricate system encompassed an extensive pipeline stretch spanning 1,306 kilometers and fostering a connection count of 50,448 (NWASCO, 2021).

The variations observed in water production capacity primarily arise due to differences in groundwater levels between dry and rainy seasons, a phenomenon that can be attributed to the impacts of climate change and land development (JICA, 2009). Equally significant, the production of surface water resources encounters slight fluctuations, often triggered by disruptions in power supply, such as blackouts (JICA, 2009).

Figure 2 LWSC Water Distribution Network



Source: JICA (2009)

Current, LWSC produces 250,000 cubic metres per day been 170,000 less the water demand (LWSC, 2021). The overwhelming number of pit latrines, septic systems, improper waste disposal, and wastewater threatens groundwater sources globally (WHO, 2003). About 45 percent of the population in Lusaka rely on site sanitation for the disposal of sewage and wastewater (JICA, 2009).

Certain areas of Lusaka, including industrial zones like Lusaka West and Lusaka East, persistently encounter limited or no access to water supply services (NWASCO, 2022). On average, Lusaka receives 18 hours of water supply per day (NWASCO, 2022). Moreover, the absence of reliable water supply services can escalate production costs for industries, prompting the need for investments in alternative water sources, storage infrastructure, or water conservation technologies to mitigate the challenges posed by insufficient water supply services (OECD, 2009).

2.6 Empirical Evidence

Empirical evidence regarding water supply and its associated challenges and impacts can be drawn from various studies and reports. Here are some key findings supported by empirical evidence:

2.6.1 The Impact of Climate Change on Water Supply Services

Empirical evidence underscores the complex relationship between water supply and climate change. Studies by researchers like Gleick (2003) have shown that climate change can disrupt water supply systems through altered precipitation patterns, rising temperatures, and increased frequency of extreme weather events. These changes affect the availability and predictability of water resources, posing challenges for sustainable water management practices such as watershed protection and efficient water use (WARMA, 2020).

Climatic conditions are fundamental determinants of water availability. Regions with abundant freshwater resources, such as river basins and lakes, generally have a more secure water supply (IPCC, 2014). In contrast, arid and semi-arid regions face significant challenges due to limited rainfall and high evaporation rates (IPCC, 2014). Variability in precipitation patterns, including seasonal fluctuations and long-term shifts, can lead to water scarcity and prolonged drought conditions (IPCC, 2014). Studies by Bates et al. (2008) underscore the intricate relationship between changing precipitation patterns and the exacerbation of water scarcity and drought. Their findings illuminate how shifts in precipitation impact water availability, snowmelt rates, and the replenishment of groundwater reserves. This emphasizes the pivotal role of precipitation predictability in maintaining stable water supply systems.

However, the ramifications of climate change amplify these pre-existing challenges (UN Water, 2019). The transformation of climate patterns extends its influence to precipitation regimes, snowmelt dynamics, and the recharge of groundwater (IPCC, 2014). The research conducted by the IPCC highlights the far-reaching consequences of these changes on water resources. In their comprehensive assessment conducted in 2018, the IPCC delves into the multifaceted impacts of climate change on global water availability and emphasizes the necessity of adaptive strategies to counteract these effects.

2.6.2 The Impact of Population Growth and Land development on Water Supply Services

Rapid population growth and land development exert immense pressure on water supply systems (UN, 2014). The increased demand for water in urban areas for domestic, industrial, and commercial purposes requires the expansion and maintenance of infrastructure to meet growing needs (NWASCO, 2023). Urbanization has resulted in changes in land use, affecting natural water recharge processes and potentially leading to water pollution (UN Water, 2019). It is crucial to manage water supply in densely populated urban centers to ensure equitable access and prevent the over-extraction of water (United Nations, 2014). Maintaining water quality is crucial for ensuring safe drinking water and protecting ecosystems (NWASCO, 2023). Pollution from agricultural runoff, industrial discharges, and inadequate wastewater treatment can contaminate water sources, rendering them unsafe for consumption (WARMA, 2021). Poor water quality poses health risks and necessitates costly treatment processes (WHO, 2022). Addressing pollution through effective regulation, sustainable agricultural practices, and improved waste management is vital for safeguarding water supply systems (UN-Water, 2018).

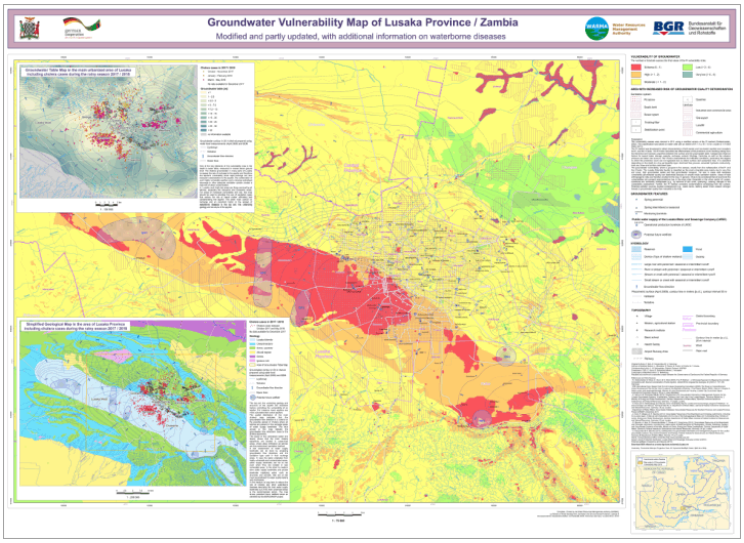
The efficiency and reliability of water supply services are heavily influenced by infrastructure and technological capabilities. Outdated or poorly maintained infrastructure can lead to water losses through leaks and inefficiencies (NWASCO, 2021). Advanced technologies, such as remote sensing, sensor networks, and data analytics, offer opportunities to monitor and manage water supply systems more

effectively (NWASCO, 2022). Investments in infrastructure upgrades and innovative technologies are essential for optimizing water distribution (Mala-Jetmarova et al., 2016).

The study undertaken by BGR, titled "Groundwater and Climate Change: Challenges and Possibilities," sheds light on the pervasive impact of land development. These processes not only entail extensive soil sealing but also encompass the installation of sewers and storm water drainage systems (BGR, 2023). These changes, while facilitating urban growth, also bring about rapid and pronounced peak discharges. These peak flows are frequently characterized by compromised chemical water quality, which can have detrimental effects on local water resources (Kaur et al., 2016). The research by BGR underscores the intricate relationship between urbanization, soil sealing, and water management systems, highlighting the urgency of addressing the multifaceted challenges to ensure sustainable water quality in urban environments.

Empirical studies consistently demonstrate the adverse effects of water pollution on water supply services. Agricultural runoff, industrial discharges, and inadequate wastewater treatment compromise the quality of available water sources (BGR, 2022). Contaminated water not only poses health risks but also requires costly treatment processes (WHO, 2019). Research conduct by NWASCO in 2022 highlights the importance of pollution control and effective wastewater management to safeguard water supply quality.

Figure 3 Groundwater Vulnerability Map of Lusaka Province



Source: BGR (2022)

Figure 5 graphically portrays the spatial distribution of production and monitoring boreholes across Lusaka, while concurrently shedding light on the potential influence of groundwater dynamics on the propagation of waterborne diseases, particularly in relation to prevailing land use patterns (BGR, 2022). This dimension gains prominence through an examination of the cholera outbreak that gripped Lusaka during the rainy season of 2017/2018. By juxtaposing the locations of cholera cases with pertinent hydrogeological data, such as the depth to groundwater, the map effectively unveils the intricate interplay between disease transmission and hydrological elements (BGR, 2022).

Numerous studies have consistently underscored the issue of compromised groundwater quality within Lusaka, predominantly attributable to microbial contamination (NWASCO, 2022). This predicament finds a compelling manifestation in the recurrence of cholera epidemics. The Lusaka Dolomite, a notably productive and pivotal aquifer, stands as a glaring example of vulnerability to contamination, as

substantiated by research conducted by both the former Department for Water Affairs and BGR. Regrettably, the protective measures for preserving groundwater resources in Lusaka and across Zambia at large remain remarkably deficient (WHYMAP, 2022).

An intriguing pattern surfaces, where areas characterized by shallow water tables, like Kanyama, which inherently face heightened susceptibility to groundwater pollution, align with the epicenters of the cholera outbreak (BGR, 2022). Moreover, the visualization aptly delineates regions of vulnerability that are concurrently predisposed to contamination, not solely due to the inflow of tainted groundwater from zones of greater vulnerability, but also due to the elevated risk of contamination resulting from densely populated settlements equipped with subpar sanitation facilities (WARMA, 2022). Moreover, contamination directly at the source, emanating from pit latrines and septic tanks, adds another layer of concern to the complex water supply dynamics (BGR, 2021). This comprehensive portrayal underscores the intricate interplay between hydrogeological factors and urban dynamics.

2.6.3 Disparities in Access to Water Supply Services

Research and surveys conducted by organizations like the World Bank and the United Nations highlight disparities in access to clean water supply services. Billions of people still lack access to basic water supply services, with rural communities and informal settlements facing significant barriers (World Bank, 2019). Reports indicate that Intermittent Water Supply (IWS) systems are notably common in many developing nations, resulting from factors like rapid urbanization, inadequate infrastructure, and resource scarcity (World Bank, 2017; UN-Water, 2018). Approximately two billion people live in countries experiencing high water stress, emphasizing the critical need for addressing water scarcity and ensuring sustainable water supply systems (UN, 2019). The demand for water in domestic settings in Lusaka has seen a significant increase over the years (NWASCO, 2021). In 2007, the daily average demand for domestic use was approximately 185,100 cubic meters. This demand has steadily risen to 125,600 cubic meters in 2015, and further surged to 173,700 cubic meters in 2020. Projections for 2030 estimate an even greater demand of 345,400 cubic meters on a daily basis (JICA, 2020). The table below illustrates an increase in water demand in Lusaka.

Table 1 Current and Future Water Demand (m3/day)

No	Area Category	2007	2015	2020	2030
1	Domestic	1 85,100	125,600	173,700	345,400
2	Public	20,300	24,700	28,400	40,400
3	Commercial	4,700	5,700	7,100	13,600
4	Industrial	108,000	130,200	172,200	206,400
	Total Daily Average Demand	218,100	286,200	381,400	605,800
	Total Maximum Daily Demand *	272,600	357,800	476,800	757,300

Source: JICA Study Team Note*: Daily peak factor=1.25

2.7 Lessons Learnt from the Review Literature

The literature review delved into the factors influencing water supply services, particularly in the context of the Lusaka district. It examined how climate change, population growth, and land development affect water supply services. Furthermore, the review highlighted the interplay between water supply and gender equity, economic growth, and public health, underscoring the significance of this research.

2.7.1 Research Gaps

Despite the extensive research on the factors influencing water supply services globally, several research gaps have been identified in the context of Lusaka, which this study aims to address:

2.7.1.1 Limited Research on the Combined Effects of Population Growth, Climate Change, and Land Development

While the existing literature has discussed the global, Zambian, and Lusaka contexts, there remains a scarcity of research specifically focusing on the unique challenges faced by Lusaka. This study aims to fill this gap by providing a detailed analysis of how the combined effects of population growth, climate change, and land development impact the resilience and sustainability of water supply services in Lusaka. Through this research, a more comprehensive understanding of the specific challenges and potential solutions for Lusaka's water supply services can be gained.

2.7.1.2 Limited Research on the Exploration of Long-Term

The existing literature primarily focuses on the immediate effects of Population Growth, Climate Change, and Land Development on water supply services in Lusaka. This study seeks to delve deeper and identify long-term strategies that the water sector in Lusaka can adopt to enhance the sustainability and resilience of water supply services in the district. While the literature highlights the various interventions implemented to support the water sector, there is limited research on the effectiveness of these measures. This study will examine the impact of these interventions and identify potential areas for improvement. The research findings will provide crucial insights for policymakers, water management authorities, water utilities and government agencies involved in urban planning and development.

2.8 Summary of Chapter Two

In conclusion, this comprehensive review of literature has unveiled a complex web of factors that intricately influence water supply services. Rapid population growth, climate change and land development have converged to create significant challenges in providing water supply services to communities. Going forward, these findings can aid in making decisions, add to existing literature and teach other CUs what works.

CHAPTER THREE
THEORETICAL AND CONCEPTUAL FRAMEWORK

3.0 Introduction

This chapter outlines the theoretical and conceptual foundations that guided the research investigation on the assessment of factors impacting water supply services in Lusaka District, focusing on the Lusaka Water Supply and Sanitation Company. Establishing a strong framework is central for maintaining continuity across the study methodology, analysis, and interpretations. Key theories like the Integrated Water Resources Management (IWRM) theory inform the research by offering a holistic approach to managing water resources, considering the interconnections between land use, population dynamics, and climate impacts on water supply services. Integrating these theoretical and conceptual elements provides a multi-dimensional lens to examine the intricate factors impacting water supply services in Lusaka, grounding the study within scholarly discourse while capturing nuanced shifts using tailored variables.

3.1 Theoretical Framework

This research is grounded in the theoretical foundations of crisis management, specifically drawing on the

Integrated Water Resources Management (IWRM) which has its roots in water management literature. As the water sector is confronted with complex challenges facing water supply services in the rapidly developing areas of Lusaka, Zambia. The application of established Integrated Water Resources Management frameworks to examine factor affecting water supply is imperative.

3.1.1 Origins of Integrated Water Resources Management Theory

The concept of Integrated Water Resources Management (IWRM) emerged in response to the challenges posed by fragmented and unsustainable water management practices. The origins of IWRM can be traced back to the Dublin Principles, which were formulated during the International Conference on Water and the Environment in 1992 (Grey and Sadoff, 2007). These principles emphasized the need for an integrated approach to water resources management, taking into account social, economic, and environmental dimensions.

The IWRM concept gained further traction with the publication of the Dublin Statement on Water and Sustainable Development, which called for the development and implementation of water management policies that are participatory, gender-sensitive, and environmentally sustainable (UN, 1992). The concept was later elaborated in the Agenda 21 document, which was adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 (UN, 1992). One of the key principles of IWRM is the recognition of water as an integral part of the ecosystem, with a focus on maintaining the ecological integrity of water resources (UN, 1992). Another important aspect of IWRM is the emphasis on stakeholder participation in decision-making processes, recognizing the diverse needs and interests of different stakeholders (UN, 1992).

Overall, the origins of IWRM can be traced back to the recognition of the need for a more holistic and sustainable approach to water resources management, which takes into account the complex interactions between water, land, and people.

3.1.2 Key Studies Supporting the Theory

Several key studies provide empirical evidence supporting the Integrated Water Resources Management (IWRM) theory. For example, a study by Biswas (2008) examined the implementation of IWRM principles in various countries and found that countries that adopted an integrated approach to water resources management were better able to address water-related challenges and achieve sustainable water use.

Another study by Falkenmark and Rockström (2006) highlighted the importance of considering the water, food, and energy nexus in water resources management. The study emphasized that integrated approaches are essential for ensuring water, food, and energy security, particularly in the face of growing population pressures and climate change.

Empirical evidence from these and other studies demonstrates that adopting an integrated approach to water resources management can lead to more sustainable and equitable water use practices. By considering the interconnected nature of water resources, land use, population dynamics, and climate impacts, IWRM provides a framework for addressing complex water challenges and achieving sustainable water management outcomes.

3.1.3 Application in this Study

In this study, the Integrated Water Resources Management (IWRM) theory serves as a foundational framework for examining the factors impacting water supply services in Lusaka District. By integrating the principles of IWRM, this research aims to assess how the interconnections between land use, population dynamics, and climate impacts affect the resilience and sustainability of water supply services

provided by the Lusaka Water Supply and Sanitation Company (LWSC).

The application of IWRM in this context is crucial due to the complex challenges faced by the water sector in Lusaka, as the region experiences rapid development and urbanization. Studies by scholars such as Shiklomanov (2000) and Gleick (2003) have demonstrated the effectiveness of IWRM in addressing water supply and sanitation challenges in various regions.

By utilizing established IWRM frameworks, this study seeks to provide a comprehensive analysis of the factors influencing water supply services in Lusaka. For example, research by Loucks and van Beek (2005) and Khan et al. (2015) has shown that adopting an integrated approach to water resources management can lead to more sustainable and equitable water use practices, especially in urban areas facing similar challenges as Lusaka. Additionally, studies by Hoekstra and Mekonnen (2012) have highlighted the importance of considering the interconnected nature of water resources, land use, population dynamics, and climate impacts in addressing complex water challenges.

Overall, this study aims to contribute to the development of sustainable water supply management strategies in Lusaka by examining how the principles of IWRM can be applied to enhance the resilience and sustainability of water supply services. Through this research, a better understanding of the complex interactions between land use, population dynamics, and climate impacts on water supply services in Lusaka can be gained, ultimately informing policy and decision-making processes in the water sector.

3.2 Conceptual Framework

This section presents a conceptual framework that deconstructs the research topic, " Assessment of Factors Impacting Water Supply Services in Lusaka District: A Case of Lusaka Water Supply and Sanitation Company," into its key variables and their hypothesized relationships. The framework provides a clear visualization of the independent variables population growth, land development, climate and the dependent variables (improved water supply services).

3.2.1 Development of the Conceptual Framework

The conceptual framework for this study is developed based on the Integrated Water Resources Management (IWRM) theory and its application to the assessment of factors impacting water supply services in Lusaka District. The framework deconstructs the research topic into key variables and their hypothesized relationships, providing a clear visualization of the interconnections between population growth, land development, climate, and improved water supply services.

Population growth is identified as a key independent variable in the conceptual framework, representing the increasing demand for water supply services in Lusaka due to a growing population. The framework hypothesizes that as the population grows, there will be a higher demand for improved water supply services to meet the needs of the expanding urban population.

Land development is another independent variable in the framework, reflecting the changes in land use patterns in Lusaka District. The framework suggests that land development, particularly urban expansion, can impact water supply services by increasing the demand for water and affecting natural water recharge processes.

Climate is also identified as an independent variable in the conceptual framework, representing the variability in climate patterns and its impact on water availability. The framework hypothesizes that changes in climate, such as increased droughts or extreme weather events, can affect water sources and the availability of water for supply services in Lusaka.

The dependent variable in the conceptual framework is improved water supply services, which is the outcome variable that the study aims to assess. The framework visualizes improved water supply services as the result of effective management and adaptation strategies in response to the challenges posed by population growth, land development, and climate variability.

Overall, the conceptual framework provides a structured approach to understanding the complex interactions between population growth, land development, climate, and water supply services in Lusaka District. It serves as a guide for analyzing the factors impacting water supply services and developing sustainable management strategies to address the challenges faced by the Lusaka Water Supply and Sanitation Company.

3.2.2 Mediating Factors

Mediating factors are variables that intervene between the independent and dependent variables, influencing the strength or direction of their relationship. In the context of this study, mediating factors included socio-economic factors, governance structures, and technological innovations. These factors may interact with population growth, land development, and climate variability to either amplify or mitigate their impact on water supply services in Lusaka District. Understanding these mediating factors is crucial for developing effective strategies to improve water supply services and enhance the resilience of the water sector in Lusaka.

3.2.3 Operationalize the variables

This section outlines how the variables of population growth, climate change, and land development are operationalized for the study.

3.2.3.1 Population Growth:

a) Measurement: The annual percentage change in the population of Lusaka District.
b) Data Source: Central Statistical Office of Zambia.
c) Variable Representation: Population Growth Rate (%) per year.

3.2.3.2 Climate Change:

a) Measurement: Changes in average annual temperature and annual rainfall.
b) Data Source: Zambia Meteorological Department.
c) Variable Representation: Change in Average Annual Temperature (°C) and Change in Annual Rainfall (mm) over a specified period.

3.2.3.3 Land Development:

a) Measurement: Changes in land cover, particularly urban land use.
b) Data Source: Satellite imagery and land use maps.
c) Variable Representation: Percentage of Land Converted to Urban Use (%) per year and Change in Urban Land Area (km^2) over a specified period.

These operationalisations will provide quantifiable measures for analysing the impacts of population growth, climate change, and land development on water supply services in Lusaka District.

3.2.4 Relationships between Elements

The conceptual framework illustrates the relationships between the key variables of population growth, land development, climate, and improved water supply services in Lusaka District. These relationships are based on the premise that population growth, land development, and climate variability have direct and indirect impacts on water supply services, which in turn affect the overall sustainability and resilience of the water sector.

Population growth is expected to have a direct impact on the demand for water supply services in Lusaka,

as a growing population requires more water for domestic, industrial, and commercial purposes. This increased demand can put pressure on existing water supply infrastructure, leading to challenges in meeting the water needs of the population.

Land development, particularly urban expansion, is also expected to directly impact water supply services in Lusaka. As urban areas expand, the demand for water increases, and changes in land use patterns can affect natural water recharge processes, leading to changes in water availability and quality.

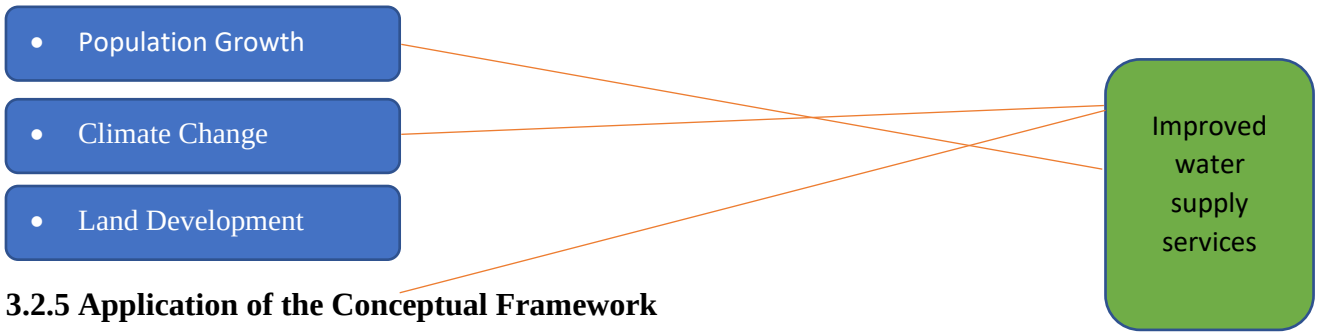
Climate variability is another key factor that directly impacts water supply services in Lusaka. Changes in climate patterns, such as increased droughts or extreme weather events, can affect water sources and the availability of water for supply services. This can lead to challenges in ensuring a reliable and sustainable water supply for the population.

Improved water supply services, as the dependent variable, are directly influenced by population growth, land development, and climate variability. The conceptual framework hypothesizes that effective management and adaptation strategies in response to these factors can lead to improved water supply services in Lusaka District.

Additionally, the conceptual framework recognizes the role of mediating factors, such as socio-economic factors, governance structures, and technological innovations, in influencing the relationships between the key variables. These mediating factors can either amplify or mitigate the impacts of population growth, land development, and climate variability on water supply services, highlighting the need for comprehensive and integrated approaches to water supply in Lusaka District.

Below is the conceptual framework that was adopted for this study.

Figure 4 Conceptual Framework



3.2.5 Application of the Conceptual Framework

The conceptual framework served as a guiding tool for data collection, analysis, and interpretation throughout the research process. It ensured that the study remained focused on the key variables and their interrelationships, enabling a comprehensive understanding of the impact of factors impacting water supply services in Lusaka district.

In terms of data collection, the framework informed the selection of appropriate methods and sources to gather information on the identified variables. This included secondary data sources, such as, government or statutory bodies, and water sector cooperating partners which were implemented, as well as primary data collected through interviews with experts in the water supply sector. During the data analysis phase, the framework provided a structure for organizing and interpreting the collected data. The study will evaluate the performance of the Lusaka Water Supply and Sanitation Company in providing improved water supply services. This assessment will consider factors such as water quality, reliability of water supply, and the company's capacity to meet the growing water demand in Lusaka District. The framework also guided the interpretation of the findings, enabling the researcher to draw meaningful conclusions about the factors impacting water supply services in Lusaka district.

3.3 Conclusion

This chapter established the theoretical and conceptual foundation central to this research inquiry. The relationships between the key elements of the conceptual framework were crucial for understanding the dynamics of water supply services in Lusaka District. Population growth, land development, and climate variability directly impact the availability and quality of water supply services, which in turn affect the overall sustainability and resilience of the water supply sector.

In conclusion, the theoretical and conceptual framework based on Integrated Water Resources Management (IWRM) theory provided a robust foundation for this study on the assessment of factors impacting water supply services in Lusaka District. The framework guided the research methodology, analysis, and interpretation, ensuring a comprehensive and systematic approach to understanding the complex interactions between population growth, land development, climate variability, and water supply services.

Furthermore, the IWRM framework provided a structured approach to analysing the factors impacting water supply services, helping to identify key variables and their relationships. This structured approach enabled a more focused and targeted analysis, leading to a deeper understanding of the factors influencing water supply services in Lusaka District.

CHAPTER FOUR
METHODOLOGY

4.0 Introduction

This chapter details the methodology employed in this study. It covers the research design, study location, methods of data collection, and data analysis techniques. A clear grasp of the methodology is essential for a methodical and cohesive approach to addressing the research questions and achieving the study's objectives.

4.1 Research Philosophy

The research philosophy for this study is grounded in the interpretivist paradigm. Interpretivism aligns with the qualitative nature of this research, aiming to understand the complex social constructs and subjective meanings attached to water supply services in Lusaka District (Denzin & Lincoln, 2018). This approach acknowledges the role of human experiences, perceptions, and interactions in shaping the factors influencing water supply (Creswell, 2013). By adopting an interpretivist perspective, this study seeks to gain deeper insights into the experiences of experts regarding water supply services, allowing for a more nuanced analysis of the factors impacting these services.

4.2 Research Design

For this study, a qualitative case study approach is adopted to examine the factors impacting water supply services in Lusaka District, with a focus on the Lusaka Water Supply and Sanitation Company. This research design is deemed appropriate for several reasons. Firstly, a case study approach allows for an in-depth exploration of a specific phenomenon within its real-life context, providing rich and detailed insights into the complexities of the factors influencing water supply services (Yin, 2018).

Secondly, the qualitative nature of the case study aligns with the research objectives, which aim to understand the nuanced interactions between population growth, land development, climate variability, and water supply services in Lusaka. Qualitative methods, such as expert interviews, are well-suited for

exploring complex and dynamic issues, allowing for a deeper understanding of the subject matter (Creswell & Poth, 2018).

Thirdly, the use of expert interviews as a primary data collection method is justified by the need to gather insights from individuals with specialized knowledge and experience in the water supply sector. Experts can provide valuable perspectives on the factors impacting water supply services, as well as insights into potential solutions and strategies for improving service delivery (Marshall & Rossman, 2016).

Overall, the qualitative case study approach, supplemented by expert interviews, is considered the most suitable research design for this study, as it allows for a comprehensive and detailed analysis of the factors influencing water supply services in Lusaka District.

4.3 Study Site

The research focused on the workforce in Lusaka, Zambia, particularly employees of the Lusaka Water Supply and Sanitation Company (LWSC) and the National Water Supply and Sanitation Council (NWASCO). The population size was determined based on the staffing levels within the technical and commercial divisions, consisting of 25 employees from LWSC and 5 from NWASCO. These organizations were selected due to their pivotal roles in managing and overseeing water supply services in Lusaka, with their employees possessing valuable insights related to the research objectives.

Selecting a smaller, focused population helped maintain a clear research direction and ensured that the study remained on target to deliver specific, actionable recommendations. Additionally, focusing on these key organizations allowed for a more in-depth understanding of the factors impacting water supply services in Lusaka, compared to a broader population where individuals might be less willing to participate or have less relevant experiences. This approach minimized survey fatigue and contributed to higher response rates.

4.4 Research Sample Selection (Sample Size and Techniques)

The process of selecting an appropriate sample size and design for this research project at the LWSC and NWASCO involved a thoughtful consideration of the organization's unique characteristics and the specific expertise required to address the research question. LWSC boasts a total workforce of 888 employees (LWSC, 2023) while NWASCO has a much smaller workforce of 22 employees (NWASCO, 2022); however, it is essential to note that not all of them possess the expertise necessary to provide valuable insights for our research objectives.

To ensure the precision and reliability of our findings, we opted for a purposeful sample, selection approach that focused on the key technocrats within the organization. Purposeful sampling is a method in research where researchers deliberately select specific individuals, groups, or data points to be included in a study based on predefined criteria or characteristics that align with the research objectives (Creswell, 2017). These technocrats primarily have their in-depth knowledge of water supply services, as well as their familiarity with relevant regulations, make them pivotal informants for our study. This approach aligns with the recommendations of Patton (2002), which emphasize selecting participants based on their relevance to the research objectives. Ultimately, our chosen sample size consisted of 25 employees from LWSC and 5 employees from NWASCO, determined based on the staffing levels within the LWSC and NWASCO. The employees were chosen based on their direct involvement in water supply services and their roles' alignment with the study objectives.

4.5 Sources of Data Collection

The sources of data collection encompass both primary and secondary data, each playing a distinctive role in contributing to the research objectives. Primary data refers to original data collected directly from its source for the purpose of a specific research study or investigation while secondary data is pre-existing data that has been collected by someone else for a purpose other than the researcher's current study (Cooper & Schindler, 2019).

4.5.1 Primary Data Sources

Unstructured questionnaires were administered to both the water service provider (LWSC) and the regulatory body (NWASCO) responsible for the regulation water supply services in Zambia. A survey instrument or data collection method where the questions are open-ended and not pre-defined with specific response options. These instruments were meticulously crafted to extract quantitative data concerning various aspects, including water consumption patterns, access to water supply services, water pollution, and land development. The construction of the questionnaire was closely aligned with the research objectives.

4.5.2 Secondary Data Sources

Official reports and publications from government ministries and agencies, including the Ministry of Water Development and Sanitation, were meticulously reviewed. These reports served as rich repositories of statistical information pertaining to water supply infrastructure, policies, and regulations. Furthermore, a comprehensive search encompassed an array of sources, including books, fieldwork reports, research papers, theses, and dissertations, all focused on water supply services within the Zambian context and analogous settings.

Additionally, insights and data were gleaned from reports and publications issued by organizations such as the World Health Organization (WHO), United Nations (UN), and UNESCO. To better understand the spatial dynamics and vulnerabilities associated with water supply, geospatial data was harnessed. This encompassed maps, satellite imagery, and hydrological data, which were sourced from Geographic Information System (GIS) databases and specialized agencies. GIS tools were then employed to dissect spatial patterns and identify potential vulnerabilities in the water supply infrastructure.

The pursuit of statistical data, reports, and publications pertaining to water supply services extended to the digital realm. Robust online databases and repositories, both national and international, were accessed for the retrieval of relevant information. These virtual resources further enriched the research by providing a contemporary and comprehensive perspective on water supply services.

4.6 Data Collection Techniques

A pivotal component of our primary data collection strategy involved the use of unstructured questionnaires. These questionnaires were meticulously designed to extract qualitative data from key stakeholders, including the LWSC and the NWASCO. The questionnaires were administered to selected employees within these organizations, the questionnaires were designed to align seamlessly with our research objectives, ensuring the systematic collection of relevant data.

4.6.1 Qualitative Approach

In the qualitative phase of our study, we employed a comprehensive approach to gather and analyze qualitative data. The techniques and methods used in our qualitative approach were In-depth interviews. These interviews were semi-structured, allowing for open-ended questions that encouraged participants to share their experiences, insights, and perspectives regarding water supply services in the Lusaka district.

Constant comparative analysis was used to continuously compare and contrast data as it was collected. This iterative process helped in refining emerging themes, concepts, and categories within the qualitative data. It also ensured that data saturation was achieved. In some instances, ethnographic observations were conducted. This technique provided additional context and insights into the day-to-day operations, challenges, and dynamics within LWSC and NWASCO.

4.7 Data Analysis

The data collected through interviews and document analysis were analyzed using thematic analysis. Thematic analysis is a qualitative method that involves identifying, analyzing, and reporting patterns (themes) within the data (Braun & Clarke, 2006). The analysis process involved data familiarization. This was done by reading and re-reading the interview transcripts and documents to gain a thorough understanding of the content.

Initial codes were generated to label interesting features of the data. This process involved identifying and labeling relevant sections of the data that related to the research questions. Themes were searched for by organizing codes into potential themes and sub-themes. Themes were patterns found in the data that were relevant to the research questions.

The identified themes were reviewed to ensure they accurately reflected the content of the data. Themes were refined and adjusted as needed. Once the themes were finalized, they were defined and named to clearly represent the content they encompassed. The final step involved writing up the analysis from the interviews and references to the documents, to support the identified themes. This thematic analysis allowed for a comprehensive exploration of the factors impacting water supply services in Lusaka District, providing valuable insights that informed the study's conclusions and recommendations.

4.7.1 Validity and Reliability of the Study Tool

To ensure the robustness of the study, measures were taken to enhance the validity and reliability of the research tools used in the assessment of factors affecting water supply in the Lusaka district. The study tool, including the interview guide was developed based on an extensive review of existing literature on water supply services in similar contexts. Additionally, expert feedback was sought to refine the questions and ensure their relevance and comprehensiveness.

The interview questions were designed to align closely with the research objectives, ensuring that they accurately captured the factors influencing water supply services in the Lusaka district. To ensure the reliability of the study tool, a standardized approach was adopted for data collection, including interview techniques and survey administration. This approach helped minimize variability in data collection and analysis, enhancing the reliability of the study findings.

By addressing these aspects of validity and reliability, the study tool used in this research was able to effectively capture and analyze the factors impacting water supply services in the Lusaka district, contributing to the credibility and trustworthiness of the study results.

4.8 Ethical Consideration

In conducting this research, informed consent of participants was considered during data collection, individuals participating in the research study were informed of the nature of the study so that they may choose whether to participate or not. The participants were also assured that privacy, confidentiality and anonymity would be mentioned to ensure that no identifying information about the individual would be revealed in written or other communication in this study without their consent. The research was

4undertaken with integrity at the highest standards by ensuring that data was precise and presented fairly.

4.9 Summary of Chapter Four

In this chapter, we meticulously outlined the critical aspects of our research design, providing a comprehensive foundation for our study on water supply services in the Lusaka district. We delved into the various components of our research framework, from the type of study employed, to our data sources, research population, data collection techniques, and ethical considerations.

CHAPTER FIVE
RESULTS AND PRESENTATION OF THE FINDINGS

5.0 Introduction

This chapter endeavours to present the outcomes derived from primary and secondary data sources, with the aim of addressing the research objectives. The data encompasses responses obtained from key informants at NWASCO and Lusaka Water Supply and Sanitation Company, coupled with an analysis of secondary data documents. The methodology employed a qualitative approach, which involves qualitative research methods within a single study or research project (Creswell, 2017). This approach enables researchers to obtain a more nuanced and thorough understanding of various aspects related to water supply services in the Lusaka district. The chapter is organized to systematically delve into each of the research objective, culminating in a summarization that synthesizes the key findings.

5.1 Demographic Information

This section of the chapter delves into the demographic information of the respondents from the NWASCO and LWSC. The analysis of demographic data is crucial as it provides context to the perspectives and insights shared by these respondents. Their backgrounds, roles, and years of experience contribute significantly to the depth and relevance of the information they provide, especially concerning the water supply service performance in Zambia. To illustrate this, Table 5 is presented below. It summarises the demographic details of the respondents, outlining their roles, tenure, and primary responsibilities. This table serves as a foundation for understanding the calibre and scope of the insights gathered from these officials.

Table 2 Demographic Information of participants

No	Role	Experience	Main Responsibilities
1	Technical Inspector Water	12 years	Monitoring and regulation of water supply
2	Sanitation Officer	3 year	Monitoring and regulation of sanitation
3	Inspector Rural and Onsite Sanitation	1 years	Monitoring and regulation of rural water supply and on site sanitation
4	Consumer Affairs Officer	10 years	Consumer affairs and complaints handling
5	Technical Inspector Sanitation	5 years	Monitoring and regulation of sanitation
6	GIS Engineer	10 years	Develop and maintain geographic information system (GIS) databases

7	GIS Engineer	7 years	Develop and maintain geographic information system (GIS) databases
8	Senior GIS Engineer	14 years	Oversee advanced GIS projects and guide junior engineers.
9	Branch Manager	7 years	Manage overall operations and performance of the branch.
10	Commercial Officer	5 years	Handle commercial transactions and client relationships for the organization.
11	Planning Engineer	7 years	Plan and design engineering projects for effective implementation.
12	Senior Planning Engineer	8 years	Plan and design engineering projects for effective implementation.
13	Consumer Affairs Officer	9 years	Consumer affairs and complaints handling
14	Billing Officer	2 years	Manage billing processes and customer invoicing.
15	Senior Billing Officer	7 years	Oversee and enhance billing operations for efficiency.
16	Senior GIS Engineer	14 years	Develop and maintain geographic information system (GIS) databases
17	Consumer Affairs Officer	3 years	Handle commercial transactions and client relationships for the organization.
18	Consumer Affairs Officer	3 years	Handle commercial transactions and client relationships for the organization.
19	Branch Manager	7 years	Manage overall operations and performance of the branch.
20	Branch Manager	11 years	Manage overall operations and performance of the branch.
21	ICT Officer	6 years	Manages data and analyses data
22	Billing Officer	4 years	Manage billing processes and customer invoicing.
23	Billing Officer	2 years	Manage billing processes and customer invoicing.
24	Branch Manager	8 years	Manage overall operations and performance of the branch.
25	Branch Manager	13 years	Manage overall operations and performance of the branch.

5.2 Analysis of Questionnaire Responses

5.2.1 Factors Impacting Water Supply Services

The objective of this sub section is to examine the factors affecting water supply in Lusaka district. The analysis draws from the participant's perspectives: NWASCO's and LWSC's viewpoint, represented by

various roles within their respective institutions. The ensuing Table 6 encapsulates these perspectives, outlining factors influencing water supply in Lusaka district.

Table 3 Factors Impacting Water Supply Services

Theme	Analysis
Aging infrastructure	The interviewees noted that aging infrastructure is a significant challenge affecting water supply services in Lusaka District. This suggests that the infrastructure may be in need of repair or replacement, which could impact the reliability and efficiency of water supply services.
Inadequate maintenance	The mention of inadequate maintenance indicates that there may be a lack of regular upkeep of water supply infrastructure. This can lead to issues such as leakages and breakdowns, affecting the overall performance of the system. With some sources indicating the lack of readily available raw material to undertake maintenance exercises.
Water wastage due to leakages	The presence of water wastage due to leakages suggests that there may be inefficiencies in the water distribution system, leading to the loss of water resources. This highlights the need for improved infrastructure and maintenance practices to reduce wastage especially in areas with aged infrastructure.
Inadequate storage and production capacity	Despite boosting production through the rehabilitation of the Iolanda treatment plant. The interviewees indicated that LWSC still faces Inadequate storage and water production challenges. Inadequate storage capacity indicates that the current water storage facilities may not be sufficient to meet the demand during peak periods or in emergencies. This can lead to issues such as water shortages and disruptions in service. In many instances, the utility has resolved in rationing water among consumers.
Limited access to clean water	Limited access to clean water suggests that there are areas within Lusaka District where residents do not have reliable access to safe drinking water. This is a critical issue that needs to be addressed to ensure the health and well-being of the population.
Illegal connections	The mention of illegal connections indicates that there may be unauthorized access to the water

	supply system, leading to issues such as water theft and overloading of the system. This can impact the overall reliability and efficiency of water supply services. Above all, affecting the utility's cost recovery mechanism.
Inadequate funding and lack of cost reflective tariffs.	Inadequate funding suggests that there may be insufficient financial resources allocated to the water supply sector in Lusaka District. Coupled with the lack of cost reflective tariffs. This entails that LWSC treating and supply water to users at great cost. This has hindered efforts to improve infrastructure, maintenance, and service delivery.
Need for improved governance and management	The mention of the need for improved governance and management practices suggests that there may be issues related to the overall management and administration of the water supply services in Lusaka District. With the majority of the interviewees indicating that this is mainly attributed to poor corporate governance practices by officials. This highlights the importance of corporate governance, effective leadership and decision-making to address the challenges facing the sector.
Urbanization and population growth	Urbanization and population growth were identified as factors straining the existing water supply infrastructure. This indicates that the increasing demand for water due to urbanization and population growth are key challenges that needs to be addressed through infrastructure expansion and improved management practices.
Climate change impacts	Climate change impacts, such as erratic rainfall patterns and prolonged droughts, were mentioned as affecting water supply services. With some boreholes in the dry season drying up. This suggests that climate change is a factor that is already influencing water availability and quality in Lusaka District, highlighting the need for adaptation measures in the water sector.
Land development impacts	The interviewees noted that land development can affect the occurrence and quality of groundwater especially unplanned settlements. This indicates that land use changes, such as urbanization and deforestation, can have significant implications for

	groundwater recharge and quality, underscoring the importance of sustainable land use practices for water resource management.

While the research primarily focuses on assessing the influence of climate change, population growth, and land development on water supply services in Lusaka District, other factors were also identified as impacting the water supply services. These additional factors included aging infrastructure, inadequate maintenance, water wastage due to leakages, inadequate storage and production capacity, limited access to clean water, illegal connections, inadequate funding and lack of cost-reflective tariffs, need for improved governance and management.

These additional factors, along with climate change, population growth, and land development, contribute to the complex challenges facing water supply services in Lusaka District. Addressing these factors will require a comprehensive approach that considers infrastructure upgrades, maintenance practices, governance reforms, and financial sustainability to ensure reliable and sustainable water supply services for all residents.

5.2.2 Population Growth and Water Supply

This sub section aims to shed light on population growth and water supply. The analysis is based on perspectives from both NWASCO and LWSC. Rapid population growth has put immense pressure on water supply systems. Findings show that on average technocrats from both LWSC and NWASCO indicated that LWSC averagely equipped to address the demand caused by population growth.

Table 4 Population Growth and Water Supply

Theme	Analysis
Perception of the relationship between population growth and demand for water supply services	Interviewees' perceptions of the relationship between population growth and the demand for water supply services varied. Some interviewees believed that population growth directly correlates with an increased demand for water supply services, citing the need for more infrastructure and resources to meet the growing demand. Others mentioned that population growth alone may not significantly impact the demand for water supply services, as it depends on various factors such as consumption patterns and efficiency of water use. Overall, there was a recognition that population growth can contribute to increased demand for water supply services, but the extent of the impact may vary.
Impact of increasing population on the ability to provide reliable water supply services	Interviewees generally agreed that the increasing population has had an impact on the ability to provide reliable water supply services in Lusaka District. They noted that the growing population has led to increased pressure on existing water

	supply infrastructure, resulting in challenges such as water shortages, low water pressure, and unreliable service delivery. This indicates a consensus among interviewees that population growth has indeed strained the ability to provide reliable water supply services.
Specific areas where population growth has strained water supply infrastructure	Interviewees identified specific areas within Lusaka District where population growth has put a greater strain on water supply infrastructure. These areas are typically characterized by rapid urbanization, informal settlements, and high population density such as garden, gorge compund. The increased demand for water in these areas has led to challenges in maintaining adequate water supply and quality, highlighting the need for targeted interventions to address infrastructure and service delivery issues in these locations.
Financial sustainability of Lusaka Water and Sanitation Company (LWSC) in meeting increasing demands due to population growth	Interviewees were asked to rate the financial sustainability of LWSC in meeting the increasing demands for water supply services due to population growth on a scale of 1 to 5. The ratings varied, with most interviewees indicating that LWSC is not financially sustainable. This suggests that there are concerns about the financial sustainability of LWSC in meeting the increasing demands for water supply services due to population growth, highlighting the need for financial planning and management to address these challenges.

5.2.3 Land development and Water Supply

The process of land development plays a pivotal role in shaping the demand and functionality of water supply services. As urban areas expand and infrastructure evolves, the effects on water supply become pronounced. This subsection illuminates the intricate relationship between land development and water supply within the Lusaka district, drawing insights from perspectives at NWASCO and LWSC.

Table 5 Land development and Water Supply

Theme	Analysis
Impact of land development on water supply services	Interviewees highlighted various ways in which land development affects water supply services in Lusaka District. They mentioned that land development increased surface runoff, which can carry pollutants into water sources, affecting water quality. Additionally, changes in land use, such as

	deforestation or paving, reduced the infiltration of water into the ground, impacting groundwater recharge. This indicates a recognition among interviewees that land development has a significant impact on water supply services, particularly in terms of water quality and availability.
Instances where land development has caused issues related to water supply or water quality	Interviewees reported instances where land development has caused issues related to water supply or water quality in Lusaka District. They mentioned examples such as pollution of water sources due to inadequate waste management practices in urban areas. These examples highlight the direct impact of land development on water supply and quality, underscoring the need for effective land use planning and management practices.
Practices or regulations to manage land development's impact on water supply	Interviewees were asked about specific practices or regulations in place to manage land development's impact on water supply. Some mentioned the existence of regulations related to waste management and land use planning, aimed at minimizing the adverse effects of land development on water supply. However, others noted that enforcement of these regulations is often lacking, indicating a gap between policy and implementation in managing land development's impact on water supply.
LWSC's mechanisms for coordinating with Lusaka City Council for sustainable land development practices	Interviewees were asked whether LWSC has implemented specific mechanisms to coordinate with Lusaka City Council to promote sustainable land development practices. Responses varied, with some indicating that there are mechanisms in place, such as joint planning and monitoring initiatives. However, others mentioned that coordination between LWSC and the city council is limited, highlighting the need for improved collaboration to address the impacts of land development on water supply.
Belief in the extent to which land development affects groundwater occurrence and quality	Interviewees were asked to rate their belief in the extent to which land development affects the occurrence and quality of groundwater in Lusaka

	District on a scale of 1 to 5. The ratings varied, with most indicating a high impact (rating 4).

5.2.4 Climate Change and Water Supply

Climate variations, including shifts in precipitation patterns and extreme weather events, play a central role in shaping water supply demands and infrastructure functionality. This subsection delves into the nuanced interplay between climate dynamics and water supply within the Lusaka district, gathering insights from perspectives at NWASCO and LWSC. Findings suggests a perception of a significant impact of climate dynamics on groundwater occurrence and quality, emphasizing the need for targeted strategies to address these challenges.

Table 6 Climate Change and Water Supply

Theme	Analysis
Perception of the impact of climate change on water supply services	Interviewees were asked about their perception of the extent to which climate change affects the reliability and quality of water supply services in Lusaka District. Responses varied, with some indicating a very high impact (rating 5) and others indicating a low or moderate impact (rating 4 or 3). This suggests that there are differing perceptions among interviewees regarding the impact of climate change on water supply services, highlighting the complexity of the issue and the need for further research and monitoring.
Specific challenges or disruptions in water supply services attributed to climate-related factors	Interviewees reported specific challenges or disruptions in water supply services in Lusaka District that can be attributed to climate-related factors. These include instances of drought leading to reduced water availability, increased temperatures affecting water quality, and extreme weather events causing damage to infrastructure. Some participants indicating that in some instances ground water is likely to be contaminated in the rain season. These examples highlight the direct impact of climate change on water supply services, underscoring the need for climate adaptation measures.
Climate adaptation measures or strategies	Interviewees were asked about climate adaptation measures or strategies that have been implemented or should be considered to mitigate the impact of climate change on water supply services in Lusaka. Responses included the need for improved water resource management, investment in

	alternative water sources such as groundwater and rainwater harvesting. These measures are aimed at enhancing the resilience of water supply services to climate change impacts.
Perception of the long-term resilience of Lusaka's water supply infrastructure	Interviewees were asked about their perception of the long-term resilience of Lusaka's water supply infrastructure in the face of climate variability and change. Responses varied, with some expressing concerns about the infrastructure's ability to withstand future climate impacts, while others were more optimistic, citing ongoing efforts to improve infrastructure and adapt to climate change. Overall, there was a recognition of the need to enhance the resilience of water supply infrastructure to ensure reliable and sustainable water supply services in the long term.

5.2.5 Key Challenges

Table 7 Key Challenges

Key Challenges	Description
Aging Infrastructure	The water supply infrastructure in Lusaka District is aging and in need of rehabilitation and replacement, leading to reliability and efficiency issues.
Population Growth	Rapid population growth in urban areas is increasing the demand for water supply services, straining existing infrastructure and resources.
Climate Change	Climate change is leading to erratic rainfall patterns and prolonged droughts, impacting water availability and quality, and requiring adaptation measures.
Land Development	Unplanned land development is affecting water supply services by increasing surface runoff, reducing groundwater recharge, and causing pollution of water sources.
Political Intervention and Poor Corporate Governance	Lack of approval of tariffs due to political intervention has affected the utility's ability to meet operational costs, hindering efforts to improve infrastructure and service delivery. This highlights issues of poor corporate governance within the water supply sector in Lusaka District.

5.2.6 Suggestions for Improvement

These recommendations aim to address the challenges faced by the water supply sector in Lusaka District and ensure sustainable and reliable water supply services for all residents. They are drawn from the recommendations provided by the interviewees.

Table 8 Recommendations

Recommendation	Description
Invest in Infrastructure Upgrades	Allocate resources for the rehabilitation and replacement of aging water infrastructure to improve reliability and efficiency of water supply services.
Enhance Maintenance Practices	Implement regular maintenance schedules and ensure the availability of raw materials to address maintenance needs promptly and prevent water wastage due to leakages.
Improve Water Storage and Production Capacity	Increase water storage and production capacity to meet the growing demand for water supply services, especially in areas experiencing rapid population growth.
Address Illegal Connections	Implement measures to detect and address illegal connections to the water supply system to reduce water theft and overloading of the system.
Implement Cost-Reflective Tariffs	Review and adjust water tariffs to reflect the true cost of water supply services, ensuring financial sustainability and adequate funding for infrastructure development and maintenance.
Implement Climate-Resilient Infrastructure	Design and construct water supply infrastructure that can withstand the impacts of climate change, such as increased flooding and droughts.
Diversify Water Sources	Invest in alternative water sources, such as groundwater and rainwater harvesting, to reduce reliance on surface water sources that may be more susceptible to climate variability.
Enhance Water Conservation Practices	Promote water conservation measures among residents and industries to reduce water demand and mitigate the impacts of population growth on water supply services.
Strengthen Land Use Planning	Develop and enforce land use planning regulations that consider the impact of land development on water resources to protect water quality and availability.

5.3 Document Analysis of Factors Affecting Water Supply in Lusaka District

This section is dedicated to presenting the findings derived from data collected through documentation from various sources, including the Ministry of Water Development and Sanitation, NWASCO, WARMA, collaborating partners within the water supply and sanitation sector, non-governmental organizations (NGOs), scholars, and other stakeholders. The assessment seeks to unravel the factors influencing water supply in the Lusaka district, in alignment with the overarching and specific objectives of this research.

In pursuing a comprehensive understanding of water supply services within the Lusaka district, the research has set out to evaluate the influence of climate change on water supply services, examine the impact of population growth, and scrutinize the effects of land development on water supply services. These specific objectives collectively contribute to the broader goal of proposing recommendations for the enhancement and sustainability of water supply management in the Lusaka District.

5.3.1 National Water Supply and Sanitation Policy 2020

The National Water Supply and Sanitation Policy 2020 in Zambia aims to provide guidelines and strategies for the sustainable management of water resources and the provision of safe and adequate water supply services. In Zambia, waterborne diseases such as cholera and dysentery are common and are directly related to poor hygiene practices and inadequate water supply (MWDS, 2020).

Speaking to the first objective, the policy recognizes the need for climate change adaptation measures in water resources management. It emphasizes the importance of sustainable water management practices to address the challenges posed by climate change, such as erratic rainfall patterns and prolonged droughts. The policy advocates for the integration of climate change considerations into water and sanitation planning and management, suggesting that it does address this objective.

For Second objective, the policy emphasizes the need for equitable access to safe water and sanitation services for all, including rapidly growing urban populations. It highlights the importance of prioritizing marginalized and vulnerable groups, which may be disproportionately affected by population growth. Therefore, the policy does address this objective by advocating for strategies to meet the increasing demand for water supply services due to population growth.

Regarding the impact of land development on water supply services (third objective), the policy recognizes the importance of land use planning in protecting water resources. It emphasizes the need for integrated water resources management that considers the impact of land development on water quality and availability. The policy also encourages the adoption of sustainable land use practices to mitigate the negative effects of land development on water supply services. Therefore, it does address this objective by promoting sustainable land use planning and management practices.

5.3.2 Lusaka City State of Environment Outlook Report

The Lusaka City State of Environment Outlook Report highlights several key factors affecting water supply in Lusaka District. One of the primary challenges identified is rapid population growth, which has led to an increased demand for water supply services. The report indicates that Lusaka city relies on both surface and groundwater sources for its water supply, with the Lusaka Water and Sewerage Company (LWSC) supplying between 200,000m³ to 220,000m³ of water per day.

Despite the increasing demand for water, the report notes that the quantity of water supplied by LWSC has remained relatively constant over the years. For example, in 1993, LWSC supplied approximately 210,000m³ of water per day, a quantity that was still being supplied by the company in 2005 (UN Habitat, 2009). This suggests a potential mismatch between supply and demand, which could be exacerbated by the city's rapid urban growth and increased economic activities.

Urban growth in Lusaka has also led to an increase in waste generation, which poses a significant threat to groundwater contamination. The report highlights that a substantial portion of Lusaka's population resides in informal and unplanned settlements, where waste management practices may be inadequate. As a result, waste serves as a major contributor to groundwater contamination, further complicating the city's water supply challenges.

This cements objective 2, the data in the report highlights how rapid population growth in Lusaka has increased the demand for water supply services, putting pressure on the existing infrastructure and resources. The fact that the quantity of water supplied by the Lusaka Water and Sewerage Company (LWSC) has remained relatively constant despite the increasing population indicates a potential mismatch between supply and demand, further emphasizing the need to assess the impact of population growth on water supply services in the district.

Overall, the Lusaka City State of Environment Outlook Report underscores the need for proactive measures to address the factors affecting water supply in the city. This includes efforts to improve water resource management, enhance waste management practices, and ensure sustainable urban development to meet the growing demand for water supply services in Lusaka District.

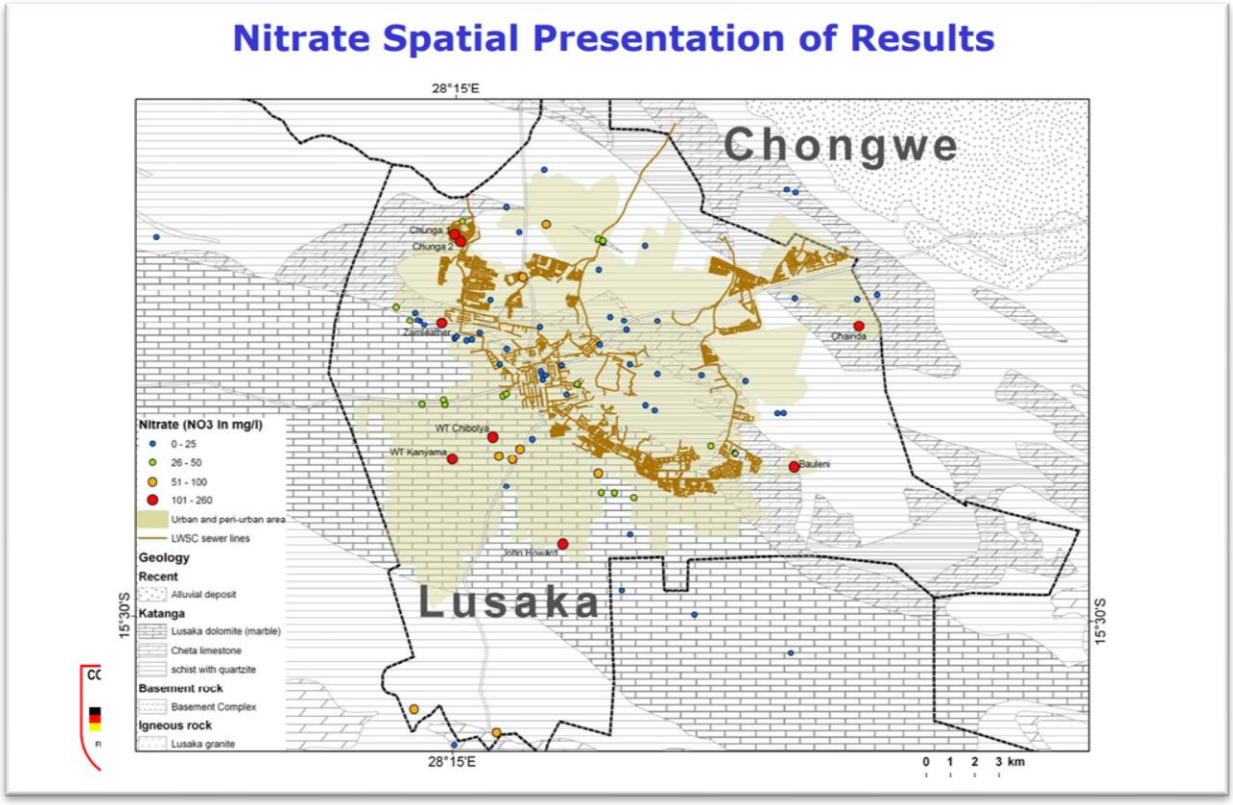
5.3.3 Ground Water Lusaka Report (BGR, GReSP Project)

In 2012, the Groundwater Resources Management Support Programme (GReSP), a cooperation project between the Department of Water Affairs (DWA), Zambia, and the Federal Institute for Geosciences and Natural Resources (BGR), Germany, issued the groundwater report for Lusaka Province, Zambia. It was observed that areas with shallow water tables like Kanyama, which are very vulnerable to groundwater pollution, were among the hotspots of the cholera outbreak. The project study furthermore found that cholera hotspots might not only be caused by groundwater pollution at site but also within the recharge area of the respective groundwater abstraction point. It has to be emphasized that groundwater in moderately vulnerable areas might also be polluted, either because of:

a) Inflow of polluted groundwater from areas of higher vulnerability,
b) High risk of contamination (e.g., dense settlements with inappropriate sanitation) or,
c) Contamination directly at site (e.g., when a borehole is built next to a septic tank).

Land-use activities commonly responsible for groundwater pollution use activities commonly responsible for groundwater pollution in the urban area (BGR, 2012). This further cementing objective 2 and 3, as the report goes on to indicate that the recent situation in many peri-urban settlements surrounding Lusaka presents several challenges to water supply services and public health. These settlements are characterized by uncontrolled settlement patterns, with a predominant use of on-site sanitation facilities. Uncontrolled waste dumping is common, further exacerbating the risk of groundwater contamination. Water supply in these areas is predominantly sourced from shallow wells or open water ponds, which are highly susceptible to contamination. As a result, extensive contamination by nitrate, nitrite, ammonia, and fecal bacteria has been observed, leading to a frequent outbreak of water-borne diseases such as diarrhea and cholera.

Figure 5 Nitrate Spatial Map



5.3.4 Millennium Challenge Cooperation Lusaka's Water Sector Report

According to the Millennium Challenge Cooperation Lusaka's Water Sector Report in 2010, only about 30 percent of Lusaka residents had household-level connections to the municipal water supply. An additional 40 percent could draw water from the municipal supply at a community water point, bringing the level of service to approximately 70 percent. However, these community water points were poorly designed and maintained, frequently vandalized, and generally without clear ownership. Furthermore, the municipal water utility (LWSC) pumped an insufficient volume of water into the system each day when compared to demand. If the water system had been functioning well, it could have met about 85 percent of the demand; however, LWSC was unable to account for roughly half of the water it produced. These enormous losses known as non-revenue water, which seriously undermined the utility's financial viability and exacerbated continuity of service problems, leaving Lusaka residents without water periodically throughout the day.

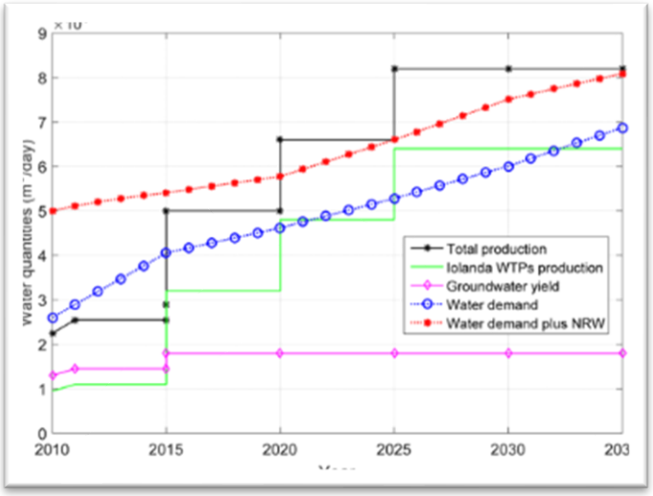
Lusaka's climate and geology amplifies these water supply and sanitation challenges (MMC, 2020). The aquifer beneath the city is as little as two meters below the land surface, making shallow wells an accessible water source. But this same accessibility renders the aquifer extremely vulnerable to contamination (MMC, 2020). In addition, the ground underneath the city is highly permeable due to the rocky limestone/marble bedrock with numerous fissures, sinkholes, and underground flow paths (a geology known as "karst"). This means that ubiquitous, unlined pit latrines, leaking sewers, and even drainage ditches impact the city's groundwater with fecal contaminants and nitrates from human waste (MMC, 2020).

5.3.5 IWA Water Practice and Technology

Lusaka's water is supplied from both ground and surface water sources. More than 116 boreholes within and around the city provide 57% of the total supply (LWSC, 2018). The remaining 43% is surface water abstracted from the Kafue River and treated at Iolanda water treatment plant (WTP), about 50 km from the city (Ndongwe, 2013). While groundwater yield is limited, the river has unlimited yield for domestic purposes.

Population growth and urbanization in Lusaka cause many service provision problems. These are amplified by poor governance aspects of land allocation that promote the mushrooming of peri-urban areas. More than 60% of Lusaka's population lives in such areas (MWDS, 2010), which have been developed on plots obtained by residents illegally because of the failure of the formal land delivery practices (LCC, 2008).

Figure 6 Water Production in Lusaka District



Source: Republic of Zambia 2011

5.4 Discussion of the findings

5.4.1 To assess the influence of climate change on water supply services in Lusaka district:

The research findings indicate that climate change is a significant factor influencing water supply services in Lusaka. Erratic rainfall patterns and prolonged droughts have led to challenges in water availability and quality. This is consistent with studies in the water sector (Bates et al., 2008; IPCC, 2014) which highlight the impact of climate change on water resources, particularly in arid and semi-arid regions like Lusaka.

Similar sentiments were echoed by the interviewees during this research, with many noting the observable effects of climate change on water supply services. Indicating that prolonged droughts have led to lower groundwater levels, making it challenging to access water from boreholes. These responses align with the research findings and further emphasize the impact of climate change on water supply services in Lusaka.

5.4.2 To assess the impact of population growth on water supply services in Lusaka district:

Rapid population growth in Lusaka has increased the demand for water supply services, putting pressure on the existing infrastructure. The current water supply capacity is insufficient to meet the growing demand, especially in rapidly urbanizing areas. This is supported by studies in the water sector (Fisher et al., 2009; UNDP, 2015) which emphasize the challenges posed by population growth on water supply infrastructure and management. The findings reveal that current water production does not meet the

current demand. The water demand for Lusaka stands at over 420,000 cubic metres per day (FRACTAL, 2019). Current, LWSC produces 250,000 cubic metres per day been 170,000 less the water demand (LWSC, 2021). Furthermore, the data also showed that LWSC's total number of connections is below the total number of households in Lusaka district. Lusaka alone is home to 687,923 houses; however, LWSC has established only 134,807 household connections as of 2022 (NWASCO, 2022). This also validates interviewee's responses, indicating that LWSC is not financially sustainable to meet the water demand arising from population growth. Responses from the interviewees also highlighted the impact of poor corporate governance on LWSC's operations, particularly concerning the approval of cost-reflective tariffs. The data further revealed that LWSC has been confronted with the issue of illegal connections, leading to incidents of water theft and overloading of the system.

5.4.3 To assess the impact of land development on water supply services in Lusaka district:

Unplanned land development in Lusaka has led to challenges in water supply services. Areas with shallow water tables are particularly vulnerable to groundwater pollution, which has been linked to cholera outbreaks. This is in line with studies in the water sector (Kalemba et al., 2017; BGR, 2011) which highlight the impact of land development practices on groundwater quality and availability. Furthermore, responses from interviewees indicated that enforcement of these regulations is often lacking, indicating a gap between policy and implementation in managing land development's impact on water supply. The data also showed that Lusaka is grappling with unplanned settlement. Land-use activities commonly responsible for groundwater pollution use activities commonly responsible for groundwater pollution in the urban area (BGR, 2012). The data also indicates that Lusaka heavily relies on groundwater, which happens to be the same water resource at high risk of contamination due to inadequate faecal sludge management practices.

5.5 Implications

The findings underscore the urgent need for climate change adaptation strategies in Lusaka's water supply management. Erratic rainfall patterns and prolonged droughts are expected to continue, posing significant challenges to water availability and quality. Therefore, implementing sustainable water management practices is crucial to mitigate the impact of climate change on water resources. The data reveals a mismatch between water supply capacity and the growing demand, especially in rapidly urbanizing areas. This highlights the need for immediate infrastructure upgrades and expansion to meet the current and future water demand. Additionally, the financial sustainability of water utilities needs to be addressed to ensure reliable water supply services for the growing population.

Unplanned land development is a major contributor to groundwater pollution, posing serious health risks to the population. The findings suggest a need for stricter enforcement of land use regulations and sustainable land management practices to protect groundwater quality. Additionally, addressing inadequate faecal sludge management practices is essential to prevent further contamination of groundwater sources.

These findings collectively emphasize the need for integrated and sustainable water resource management strategies in Lusaka. Addressing the challenges posed by climate change, population growth, and land development requires a multi-faceted approach that involves stakeholders at all levels. Improving water supply infrastructure, enhancing corporate governance and regulatory frameworks, and promoting sustainable land use practices are essential steps towards ensuring access to safe and reliable water supply services for all residents of Lusaka.

5.6 Conclusion

In this chapter, we delved into the intricate dynamics of water supply services in the Lusaka district, focusing on the multifaceted impacts of climate change, population growth, and land development. The insights were gathered through a survey that included perspectives from 25 participants, comprising staff from both NWASCO and LWSC. The research questions were thoughtfully addressed, shedding light on the complexities and challenges faced by the water supply sector in this region. Both NWASCO and LWSC technocrats acknowledge a moderate to high impact of climate change on the reliability and quality of water supply services. Respondents indicate a need for enhanced financial sustainability to meet increasing demands, with varying perceptions of LWSC's current state. Also the chapter interrogated how land development has contributed to increased demand for water infrastructure and ground water contamination.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This pivotal chapter encapsulates the essence of our study, drawing conclusions from extensive research on the myriad factors influencing water supply in the dynamic landscape of the Lusaka district. Beyond merely summarizing findings, this chapter delves into actionable recommendations crafted to address identified challenges and propel enhanced and sustainable water supply management practices in Lusaka District. The research journey illuminated critical insights into the intricate web of factors impacting water supply services. These key conclusions form the foundation for informed decision-making and strategic planning.

6.1 Conclusions

The research has highlighted that climate change significantly influences water supply services in Lusaka. Erratic rainfall patterns and prolonged droughts have led to challenges in water availability and quality. The National Water Supply and Sanitation Policy 2020 acknowledges the impact of climate change on water resources and emphasizes the need for sustainable water management practices. However, there is a need for more proactive measures to mitigate the effects of climate change on water supply services in the district.

Rapid population growth in Lusaka has increased the demand for water supply services, putting pressure on the existing infrastructure. The current water supply capacity is insufficient to meet the growing demand, especially in rapidly urbanizing areas. This is supported by studies in the water sector which emphasize the challenges posed by population growth on water supply infrastructure and management. It is imperative for LWSC to invest in infrastructure upgrades and enhance maintenance practices to meet the increasing demand for water supply services due to population growth.

Unplanned land development in Lusaka has led to challenges in water supply services, particularly in areas with shallow water tables that are vulnerable to groundwater pollution. The National Water Supply and Sanitation Policy 2020 recognizes the importance of land use planning in protecting water resources and encourages the adoption of sustainable land use practices. However, there is a need for better enforcement of regulations to manage land development's impact on water supply services. Also, a significant gap exists in coordinating land planning with water supply planning, leading to LWSC's inability to effectively address unplanned settlements.

6.2 Recommendations

Based on the findings of this research, the following recommendations are proposed to improve and sustain water supply management in Lusaka District:

a) Invest in Climate-Resilient Infrastructure: Allocate resources for the development of infrastructure that can withstand the impacts of climate change, such as flooding and droughts.
b) Diversify Water Sources: Explore alternative water sources, such as rainwater harvesting, to reduce reliance on surface water sources.
c) Enhance Water Conservation Practices: Promote water conservation measures among residents and industries to reduce water demand and mitigate the impacts of population growth on water supply services.
d) Strengthen Land Use Planning: Improve land use planning regulations to consider the impact of land development on water resources, ensuring sustainable land use practices.
e) Improve Governance and Enforcement: Enhance governance and enforcement mechanisms to ensure compliance with water supply regulations and promote sustainable water management practices.
f) Address Illegal Connections: Implement measures to detect and address illegal connections to the water supply system to reduce water theft and overloading of the system.
g) Implement Cost-Reflective Tariffs: Empower the regulatory body by allowing it to operate autonomously minus the invisible hand of government official to review and adjust water tariffs to reflect the true cost of water supply services, ensuring financial sustainability and adequate funding for infrastructure development and maintenance.
h) Planning and coordination: Implement a comprehensive coordination mechanism between land planning and water supply planning authorities to ensure alignment of development plans and infrastructure provisioning. This should involve regular communication, joint planning sessions, and the establishment of clear protocols for addressing issues related to unplanned settlements and infrastructure development.

Overall, these recommendations aim to address the challenges posed by climate change, population growth, and land development, and to enhance the sustainability and resilience of water supply services in Lusaka District.

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APPENDICES

APPENDIX A

AN INTERVIEW GUIDE

Section 1: General Information

1. Position/Role:
2. Organization (LWSC or NWASCO):
3. How long have you been working in the water supply sector in Lusaka district?

Section 2: Factors Impacting Water Supply Services

4. In your opinion, what are the most significant challenges affecting water supply services in Lusaka district?
5. Do you believe that urbanization and population growth are straining the existing water supply infrastructure? Please explain.
6. Have you observed any changes in water supply services that could be attributed to climate change? If so, please describe.
7. How do you believe land development may affect the occurrence and quality of groundwater in Lusaka district?

Section 3: Population Growth and Water Supply

8. How do you perceive the relationship between population growth and the demand for water supply services in Lusaka district?
9. In your experience, has the increasing population had an impact on the ability to provide reliable water supply services? Please elaborate.
10. Are there specific areas within Lusaka district where population growth has put a greater strain on water supply infrastructure?
11. On a scale of 1 to 5, please rate the financial sustainability of Lusaka Water and Sanitation Company in meeting the increasing demands for water supply services due to population growth in Lusaka district:
    (1 = Not Financially Sustainable, 2 = Slightly Financially Sustainable, 3 = Neutral, 4 = Financially Sustainable, 5 = Highly Financially Sustainable)
    Answer: ☐

Section 4: Land Development and Water Supply

12. How does land development affect water supply services in Lusaka district?
13. Have you observed any instances where land development has caused issues related to water supply or water quality?
14. Are there specific practices or regulations in place to manage land development's impact on water supply?
15. Has LWSC implemented specific mechanisms for effectively coordinate with Lusaka City Council to promote sustainable land development practices?

16. On a scale of 1 to 5, please rate your belief in the extent to which land development affects the occurrence and quality of groundwater in Lusaka district:
    (1 = Very Low Impact, 2 = Low Impact, 3 = Neutral, 4 = High Impact, 5 = Very High Impact)
    Answer: ☐

Section 5: Climate Impact on Water Supply Services in Lusaka

17. To what extent do you believe climate change affects the reliability and quality of water supply services in Lusaka district?
    (1 = Negligible Impact, 2 = Low Impact, 3 = Moderate Impact, 4 = High Impact, 5 = Very High Impact)
    Answer: ☐
18. In your experience, have you observed any specific challenges or disruptions in water supply services in Lusaka district that can be attributed to climate-related factors? Please describe.
19. Are there any climate adaptation measures or strategies that have been implemented or should be considered to mitigate the impact of climate change on water supply services in Lusaka?
20. How do you perceive the long-term resilience of Lusaka's water supply infrastructure in the face of climate variability and change? Please elaborate.

Section 5: Recommendations

21. Based on your experience and insights, what specific recommendations can you propose to improve and sustain water supply management in Lusaka District?
22. How can water supply services be made more resilient to the challenges posed by climate change, population growth, and land development?

Section 6: Additional Comments

23. Is there any additional information or insights you would like to share regarding water supply services in Lusaka district?

Thank you for your participation in this survey.