# EXPLORING THE INFLUENCE OF LOADSHEDDING ON WATER GOVERNANCE IN THE MANGAUNG METROPOLITAN MUNICIPALITY

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We, Bade, Tshabalala, and Strydom declare that this Honours Research that we herewith submit to the University of the Free State, is our independent work and that we have not previously submitted it for qualification at another institution of higher education.

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| | |
|---|---|
| DWS | Department of Water and Sanitation |
| E. COLI | Escherichia Coli |
| EAF | Energy Availability Factor |
| GHREC | General Human Research Ethics Committee |
| GPS | Global Positioning System |
| INGO | International Non-Governmental Organization |
| IWRM | Integrated Water Resource Management |
| MMM | Mangaung Metropolitan Municipality |
| MSA | Municipal Systems Act |
| NGO | Non-Governmental Organization |
| NRF | National Research Foundation |
| NWA | National Water Act |
| PE | Population Equivalent |
| RET | Renewable Energy Target |
| SALGA | South African Local Government Association |
| SADC | South African Development Community |
| SDG | Sustainable Development Goal |
| ToGG | Theory of Good Governance |
| TVA | Tennessee Valley Authority |
| UFS | University of the Free State |
| WSA | Water Services Authority |
| WSP | Water Services Provider |
| WSS | Water Supply System |

## SUMMARY

Loadshedding poses a critical problem at the Mangaung Metropolitan Municipality (MMM) by disrupting water infrastructure and subsequently causing water scarcity. This study explored the influence of loadshedding on water governance at the MMM. Employing a qualitative research approach with inductive reasoning, this desktop study utilised secondary data sources and applied thematic analysis for data interpretation. The research findings indicate that loadshedding has a significant impact on water governance by the MMM, as it hinders the operation of boost pumps that are essential for water circulation in the water supply system, ultimately inducing water shortages in higher-lying areas of the municipality. Considering these findings, the study recommends the implementation of renewable energy sources, such as rooftop solar panels, to complement electricity to the grid and power the water infrastructure. In addition, we recommend the construction of solar farms to supply power to wastewater treatment plants operated by Bloemwater. These measures can improve the resilience of water governance systems in the face of loadshedding.

**Keywords:** Loadshedding; Energy crisis; Water-energy nexus; Water governance; Water security

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# 1. CHAPTER ONE: INTRODUCTION

## 1.1. INTRODUCTION

This study explores the influence of loadshedding on water governance in the Mangaung Metropolitan Municipality (MMM) between 2017 and 2023. The focus on the infrastructure component of water governance is clearly postulated with a focus on how infrastructure as a component can lead to innovative ways of restructuring the influence of loadshedding on water governance. In addition, Nxumalo and Majozi (2020) argue that poor-planning and lack of maintenance causes water supply interruptions in MMM. Electricity infrastructure also plays a critical role in ensuring the continuous purification and provisioning of potable water, thus affecting water governance (Subramoney, 2023). Making the maintenance of water-related infrastructure a top priority is crucial in ensuring that water governance is efficient, economic, and effective. A key infrastructural component to ensure good governance is the continuous supply of electricity to water purification plants and water pumps. A closer look at what South Africa has faced in terms of the worst rolling blackouts in its history reflects that the compounded effect on unmaintained infrastructure has hindered the ability of MMM to provide potable water (Bloemwater, 2023). This in turn has negatively affected water governance at MMM. Thus, this study focused on the influence that loadshedding has on water governance in the Mangaung Metropolitan Municipality.

## 1.2. RESEARCH CONTEXT: BACKGROUND AND RATIONALE

Mangaung Metropolitan Municipality is the biggest municipality in the Free State. It has a population of over 750,000 people (Statistics South Africa, 2019). The municipality is responsible for the provisioning of water services to its residents. Water governance at MMM is governed by various legislative frameworks, including the National Water Act of 1998 (NWA), the Water Services Act of 1997 (WSA), and the Municipal Systems Act of 2000 (MSA). MMM is a Water Services Authority (WSA), tasked with overseeing the management of water service provisioning, and is responsible for the direct delivery of services. The municipal entity, Bloemwater, is responsible for the treatment and purification as well as supply of potable water to MMM's inhabitants (Bloemwater, 2023). Furthermore, Bloemfontein, the capital city of the Mangaung Municipality, sources its water from the same sources as the municipality. These sources include surface water, groundwater, and recycled water (Magudumani, Oke, & Gumede, 2023: 3). Bloemfontein receives its surface water from the Vaal Dam, which is located 180 km north of the city (Mangaung Metropolitan Municipality, 2017). The city also sources its water from groundwater reserves. The groundwater is extracted from boreholes that are drilled in various aquifers located in and around the city. The city has implemented several water recycling projects to increase the availability of water resources, like rainwater harvesting at the University of the Free State. These projects include the treatment of effluent from wastewater treatment plants to produce high-quality water for industrial use and irrigation (Department of Water and Sanitation, 2019). Furthermore, the municipality has upgraded its wastewater treatment plant at the Botshabelo Industrial Park (Department of Water and Sanitation, 2019). Bloemwater shares joint responsibility with the municipal council in ensuring that the ability to provide potable water is uncompromised. This is achieved through risk-management and strategic-planning. Mangaung Municipality is in a semi-arid region with low and unpredictable rainfall, which makes it vulnerable to drought (National Drought Management Centre, 2016).

According to the South African Weather Service (2016), the region receives an average of 450mm of rainfall per year, which is below the national average of 500mm. In addition, the municipality has experienced several drought episodes in recent years (South African Weather Service, 2016). This has had an impact on the availability and security of water. Water is not only lost as a resource, but also as an economic commodity, necessitating the implementation of effective water management practices MMM. The Department of Water and Sanitation (DWS) submits that there are various factors causing challenges in potable water supply (Mdakane, 2016).

According to Mdakane (2016), the Department of Water and Sanitation (DWS) team identified factors that contributed to the shortage of potable water supply which included drought episodes that decreased water availability, ageing infrastructure that needed maintenance, rapid population growth that strained the existing infrastructure, and significant water losses due to various factors such as leaks and inefficient use practices. Thus, major electricity disruptions have negative implications on the purification and pumping of water. Despite efforts to improve water governance, the challenges have persisted. This includes ageing infrastructure, inadequate funding, and water losses due to leakages and illegal connections (Mangaung Metropolitan Municipality, 2017). Loadshedding has further exacerbated the challenges faced by the municipality in providing water services to its residents. Frequent loadshedding has disrupted the functioning of water treatment plants, pumping stations, and distribution networks, leading to water shortages and service interruptions (Nxumalo & Majozi, 2020).

The lack of an anticipatory and adaptive water resource management policy has caused MMM and its inhabitants to be vulnerable to frequent water supply interruptions. The municipality has taken steps to enhance water governance in recent times, which encompasses the building of freshwater treatment facilities, fitting of water meters, and formation of a program aimed at water conservation and management (Mangaung Metropolitan Municipality, 2017). SAPA (2015) reports that the municipality has been facing financial constraints and a lack of technical expertise, which have hindered its efforts to improve water governance. The major factors contributing to these challenges include poor financial management, corruption, and inadequate human resources. Furthermore, the municipality has been struggling to generate revenue from water services owing to various factors, such as low tariffs and high levels of non-payment, as noted by the Water Research Commission (2019).

The Council for Scientific and Industrial Research (2021) is of the view that the escalating duration of loadshedding will continue to negatively impact the supply of potable water in urban areas. CSIR senior civil engineer, Odwa Badi, has cautioned that there will be a drastic water supply deficit by 2030 if the country does not act now to curb and stabilise energy supply (Subramoney, 2023). The impact of sustained loadshedding means that the government will not be able to reach Sustainable Development Goal (SDG) 6. This goal aims to improve access to clean, reliable drinking water to all South Africans by 2030 (Ndabeni-Abrahams, 2021).

Against this, it becomes clear that the study is of utmost relevance. It provides valuable insight into the water governance issues facing MMM, allowing for the formulation of recommendations, which could ameliorate these issues. Furthermore, the governance of water resources in MMM has been characterised by a lack of transparency and accountability, with little public participation. Thus, the municipality has failed to consult citizens on water and sanitation services, resulting in lack of trust and confidence in the municipality's ability to ensure good water governance (Mangaung Metropolitan Municipality, 2020).

## 1.3. RESEARCH PROBLEM

Mosebetsi (2022) argues that residents in MMM have experienced potable water supply interruptions due to the escalated loadshedding schedules implemented by Eskom. The potable water supply interruptions are inevitable because the pump station that supplies water to MMM is manually operated and occasionally trips after loadshedding, resulting in supply interruptions or low pressure (Mosebetsi, 2022). Subramoney (2023) also argues that the potable water supply interruptions are exacerbated by old water pipes that frequently burst after water pressure is restored, resulting in extended water supply interruptions. Thus, the residents of MMM, such as those in Brandkop, Langenhoven Park, and Botshabelo, have experienced far too many potable water outages in recent years. As a result, the frequency of water supply interruptions has increased yearly. The situation is made worse by the forced water supply interruptions owing to MMM's non-payment of its bulk water supply to Bloemwater. MMM owes Bloemwater more than R270 million (Mitchley, 2021). According to Nkunyane (2022), MMM loses 46 percent of bulk water purchased from Bloemwater through old and unmaintained pipes, further highlighting the need to approach potable water as a scarce commodity. Especially because chapter 2 of the Constitution (1996) makes access to water a human right.

Luvengo (2023) states that a new disaster management strategy has been implemented to address the water supply interruptions induced by loadshedding. This strategy is known as water-shedding. It is a process where the flow rate of water to certain areas is periodically decreased or restricted to ensure that the remaining water levels within reservoirs do not fall under a critical level (Luvengo, 2023), effectively giving the water purification system and water pumps time to replenish water levels within reservoirs. Water-shedding, hints at the possible future on how the provisioning of potable water by MMM will look. A water-shedding schedule would have to be implemented for the entire MMM (Mosebetsi, 2022). This possible reality showcases the importance of effective infrastructure maintenance, highlighting how in terms of water governance, water-shedding could have catastrophic consequences for the quality of life in MMM.

## 1.4. AIM OF THE STUDY

The aim of the study was to explore the influence of loadshedding on water governance in MMM.

## 1.5. RESEARCH OBJECTIVES

The Objectives of the study were:

- To establish the influence of loadshedding on water governance in MMM;
- To determine how loadshedding has influenced the infrastructural ability of MMM to have good water governance, and
- To recommend implementable strategies to improve the relationship between loadshedding and water governance.

## 1.6. RESEARCH QUESTIONS

The research questions were:

- What is the influence of water governance on loadshedding in MMM?

- How has loadshedding influenced the infrastructural ability of MMM to provide good water governance?
- What strategies can be implemented to improve the relationship between loadshedding and water governance?

### 1.7. SIGNIFICANCE OF THE STUDY

The entitlement to water access is secured by the provision in section 27(1) of the Constitution of the Republic of South Africa (1996). Consequently, municipalities are obligated to ensure that residents enjoy ample access to water and sanitation services. Thus, water transcends being merely a fundamental amenity; it represents a fundamental human right. This is underscored by its role in human consumption, cooking, cleaning, and washing (United Nations Office of the High Commissioner for Human Rights, 2023).

This means that potable water must be sustainable for human consumption, which must be free of harmful tastes or other potentially harmful elements. Water infrastructure has been one of the main issues facing the government due to ageing and improper maintenance and is at the risk of failing; for example, pipes that leak along the main water lines, causing significant actual water losses which may result in water scarcity. To control storm water run-off and prevent flooding, infrastructure is required to treat, collect, and release wastewater as well as to provide businesses, citizens, and industries with potable water. The level of negligence or lack of proper maintenance are proving that the water service-related infrastructure maintenance practices need to be enforced to greatly boost the economy, protect the environment and significantly reduce the amount of water and energy used, resulting in lower greenhouse gas emissions and less demand on natural resources which will reduce water pollution that hurts wildlife, people’s health, and ecosystems. Interruptions in the power supply also influence the pump stations supplying water to different regions, which trip out following a loadshedding. This has terrible repercussions on people’s lives, communities, and businesses. Therefore, this study explores the influence of loadshedding on water governance in the MMM.

### 1.8. PRELIMINARY LITERATURE REVIEW

This chapter delves into an analysis of two components- Integrated Water Resource Management (IWRM) and Theory of Good Governance (ToGG). The conceptual synthesis of IWRM and ToGG highlights how the two variables of electricity and water are interrelated, allowing the research topic to be addressed. This chapter also discusses the legislative frameworks relevant to the study:

- The Constitution of the Republic of South Africa (1996);
- the Municipal Systems Act (Act 32 of 2000);
- the National Water Act (Act 36 of 1998), and
- the Water Services Act (1997).

### 1.8.1. Theoretical framework

The conceptual framework validates the exploration by establishing a connection between the research subject and a relevant theory. It substantiates the area of investigation by presenting a theoretical construct that elucidates the significance of the subject matter (Adom, Hussein, & Adu-Agyem, 2018: 438)

#### 1.8.1.1. Constructing the theory of Integrated Water Resource Management

The commitment of the South African government to Integrated Water Resource Management (IWRM) is evident in its dedication to United Nations Sustainable Development Goal 6. IWRM gives a holistic approach to water management. It views the water provisioning system as a holistic cycle. This cycle is dependent on existing natural water resources and the maintenance of the urban water cycle. Therefore, as a water management theory, it focuses on the provisioning of water to communities in a sustainable manner (Jonker, 2014: 5-13).

Integrated Water Resource Management was first introduced in 1933 by the Tennessee Valley Authority. The theory includes the following aspects in 1933: (i) Public health and welfare systems, (ii) Flood control, (iii) Power production, and (iv) Erosion control (Freie Universität Berlin, 2013). The theory only became mainstream after the 1977 International Water Conference at Mar de Plata. At this conference, the need to integrate and coordinate between different role-players in the water cycle was recognised. The theory covers the following areas: (i) Water supply, (ii) Stormwater management, (iii) Water conservation, and (iv) Wastewater treatment (American Planning Association, 2022). The theory provides a framework that explains how water quality, economics, and the environment are interrelated (Global Water Forum, 2013). The main features of the theory are set out in the Dublin Principles, namely (i) Freshwater is a finite resource, (ii) Water is an economic resource, (iii) Women play a leading role in water management, and (iv) Water management should be participatory (United Nations Economic and Social Commission for Western Asia, 2020). By comparing Fulazzaky (2014: 2000-2020) with Molinga and Subramanian (2009: 76-86), the shortcomings of the theory are identified as: (i) It requires an enabling legislative environment for Integrated Water Resource Management to be implemented, (ii) It assumes that the institutional roles for managing water resources are clearly defined, (iii) It assumes that the actors and institutions at the local level are capacitated, and (iv) The implementation of water resource management instruments are premised on the existence of good governance principles.

The theory is connected to the research topic through its explanation of the urban water cycle. The urban water cycle is a modification of the natural water cycle that consists of (i) Water supply system, (ii) Wastewater system, and (iii) Stormwater system (Murray Darling Basin Authority, 2020). IWRM embodies a comprehensive approach to the management of water resources, acknowledging the interrelated nature of water systems and the diverse stakeholders engaged in the process. It aims to ensure sustainable and equitable use of water resources while also considering social, economic, and environmental factors. Loadshedding can have a significant influence on water governance. It affects the urban water cycle and its composite systems, such as water supply, wastewater treatment, and storm water control. Considering that electricity is needed for the systems listed above to function optimally, it becomes clear that there could be significant disruptions in the ability of MMM to execute good water governance. For example, lack of electricity can affect the operation of water treatment plants, leading to decreased water quality and supply. It can also lead to the accumulation of untreated wastewater, which is a biological hazard to residents. In addition, the functioning of water pumps could be hindered, causing damage to critical infrastructure. All these would negatively influence water governance in MMM.

IWRM can be applied to address the challenges posed by loadshedding. It does this by taking an integrated and holistic systems-based approach to managing water resources. IWRM is also participatory in line with Habermas' theory, which means that stakeholders can work together to identify water governance issues and loadshedding issues from an institutional perspective (Brown, 2014: 1-16). This allows strategies to be developed to mitigate the risks that loadshedding has on water governance. For example, IWRM can help prioritise the allocation of limited water resources during periods of loadshedding to ensure that critical water needs are met. In addition, IWRM can help promote sustainable practices for managing water and energy resources. Considering that loadshedding will most likely not be fixed in the short-term and that water demand will increase in the future, IWRM allows stakeholders to focus on renewable energy sources to alleviate the influence of loadshedding on water governance (Nuwater, 2023), allowing water governance to be more resilient and sustainable. Overall, IWRM provides the study with a framework through which it can address the interdependency between water and energy systems, which is essential for effective water governance in the face of loadshedding.

The theory was chosen because it applies strict parameters to water governance, namely sustainable water provisioning through the management of the environmental water cycle and urban water cycle. The theory contributes to the development of knowledge pertaining to water provisioning, water retention, and capacity in relation to the possible influence that interrupted energy generation capacity has on the urban water cycle. IWRM boasts strengths in its comprehensive approach to societal water management, perceiving it as an integrated system. It also recognizes the governance dimension as a significant influence on water management. Moreover, by conceptualizing water management holistically, it underscores the importance of infrastructure in both retaining and providing water (Vásquez, 2017: 2-11). Effectively allowing a firm theoretical basis upon which the topic under question can be explored.

The IWRM posits that there is a direct dependency between water resource management and the quality of water resource governance. The Global Water Partnership (2020) adds that the IWRM is a coordinated water resource management process that reflects the interconnected and cross-sectoral nature of water resource management. As a water management theory, it has shifted the focus from expanding government's ability to supply water to managing and improving the demand aspect of water management (Claassen, 2013: 323-338). Interesting to note is the conceptualisation of adaptive IWRM by Palmer and Munnik (2018: 1). They supplement the meaning of IWRM by positing that the IWRM is an adaptive water management system that sets out processes that enable us to understand socio-ecological issues in relation to water resource management. The theory is underpinned by the following set of principles: (i) It ensures alignment between formal governing institutions and informal water management practices, (ii) It acknowledges the interrelation between water and energy, and (iii) It pursues water equity (Bahri, 2012: 18-25). The current approach towards IWRM is built upon the Dublin Statement on Water and Sustainable Development (1992), which sets out four guiding principles.

- The first Dublin principle recognises that water is essential to sustaining life. In doing so, it envisions a balanced approach between socio-economic development and environmental sustainability.
- The second principle views public participation and institutional awareness as essential in ensuring efficient water utilisation.
- The third recognises the role of women in managing water resources. In doing so, it links with the second principle by demanding that women are included in decision-making.

- The fourth principle recognises that water is a human right and should be treated as a scarce commodity. This changes institutional behaviour towards safeguarding scarce water resources through the efficient and effective management of available supply (United Nations Documents, 1992).

IWRM has three main policy objectives, namely ecological integrity, equity, and efficiency (Meran, Siehlow, & von Hirschhausen, 2020: 23-121). Equity denotes the fundamental human right to access an adequate quality and quantity of water. Ecological integrity means that in provisioning the required quantity and quality to sustain human activities, regard should be given to preserving the total available amount of water within the environment, empowering and enabling future generations to meet their own water demands. This ensures sustainable use of water through appropriate collection and retention methods. IWRM consists of two interrelated and interdependent cyclical systems, known as the natural and human systems. Whereby the human system refers to the part of the water cycle in which humans consume water for their sustenance and agricultural, industrial, recreational, and sanitation needs. Thus, the human system involves the use of infrastructure to alter the natural water system, allowing for urbanisation (Meshesha & Khare, 2019: 2). The natural system refers includes the processes of water vaporisation, water condensation, and rainfall. The natural system is mainly composed of natural bodies of water. The bodies of water are affected by the human system, through water pollution and waterlogging. The human system also diminishes the total capacity of the natural system by failing to retain water within urban environments (Meshesha & Khare, 2019: 2).

IWRM seeks to transform the traditional method of managing water resources. It does this by amalgamating water storage, distribution, treatment, recycling, and disposal into a single water management cycle. The amalgamated cycle is known as the urban water cycle. It comprises six stages, encompassing source, water treatment, water storage, water distribution, collection, and water treatment, with each stage contributing to the overall water management process (Jensen, 2019). In being a cross-sectoral and multi-stakeholder process of water management, IWRM requires a strong good governance component to ensure successful implementation. Water governance is conceptualised as the rules and processes pertaining to the management of water resources. It is a participatory approach that includes stakeholders in water resource management projects enabling accountability of outcomes (OECD, 2015). The Stockholm International Water Institute (2023) posits that water governance is an interrelated process composed of political, economic, and administrative components.

The fundamental governing aspects concerning Integrated Water Resources Management (IWRM) encompass: (i) Formulation and Tactics, (ii) Synchronization, (iii) Strategizing and Readiness, (iv) Financial Support, (v) Administrative Structures, (vi) Surveillance, Assessment, and Knowledge Enhancement, (vii) Oversight, and (viii) Enhancement of Competencies (Jiménez et al., 2020: 6-7). The functions should be embedded within the following good governance principles: (i) Participation, (ii) Rule of Law, (iii) Transparency, (iv) Responsiveness, (v) Consensus Oriented, (vi) Equity and Inclusiveness, (vii) Effectiveness and Efficiency, and (viii) Accountability (United Cities and Local Governments Asia-Pacific, 2021).

In comparing Jimenéz *et al.* (2020: 6-7) with the Department of Water Affairs (2013: 15-16), the advantages are as follows. Initially, it facilitates the establishment of an all-encompassing structure for overseeing water resources. This structure guarantees the equitable, sustainable, and socially acceptable management of water resources. The framework ensures that all the involved stakeholders have common objectives, allowing their actions to be coordinated to achieve good water governance. Secondly, it enhances transparency, accountability in water governance. This can be achieved by making use of a participatory approach that enables all stakeholders to participate in an informed manner. Thirdly, it builds trust between the different stakeholders, allowing them to work towards achieving shared objectives. Fourthly, it helps to ensure that water governance is sustainable in the long term. This is achieved by developing sustainable financing mechanisms and ensuring that water management plans are aligned with long-term environmental goals. Finally, it ensures that water governance is adaptable to changing circumstances.

Varis et al. (2014: 436-438) sets out the shortcomings of water governance as (i) Sectoral fragmentation, (ii) Institutional and coordination issues, (iii) Weak law enforcement capabilities, (iv) Lack of a demand management approach, (v) Lack of water reuse and water saving, (vi) Legislative centralisation versus decentralisation issues, and (vii) Crisis-management approach. The human system within IWRM in the South African context is influenced by administrative decisions taken by municipal councils. The stages that are especially vulnerable to the effects of poor governance practices are water storage, water distribution, and water collection, providing the necessary theoretical link between IWRM and Theory of Good Governance (ToGG).

#### 1.8.1.2. Theory of good governance from the "efficiency and effectiveness" perspective

The most notable introduction of good governance theory was done in the essay Farang Sakdina, by M.R. Kukrit Pramoj in 1957 (Waters, 2022: 1-11). The theoretical proposition suggests that the ethical and acceptable execution of governmental responsibilities is contingent upon officials adhering to the principles of good governance like being responsive to community needs, being transparent and upholding the rule of law. This means that government works for the betterment of the people (Council of Europe, 2023). The theory of good governance suggests that a public service guided by values such as accountability, social responsibility, transparency, public participation, and ethics will result in government policies and services that are more attuned and responsive to the needs of the community. Good governance consists of three distinct dimensions that regulate behaviour. These are the rule of law dimension, the institutional dimension, and the democracy dimension (Addink, 2017: 1-5).

Good governance theory provides an implementable framework that ensures ethical and moral governance, though with shortcomings. First, it ignores the influence of power dynamics. The inequalities present in different societies, classes, and institutions distort the degree to which effective participation can take place, thus limiting good governance. Secondly, the principles of good governance are culturally insensitive. They are developed according to the characteristics of Western liberal democracies, meaning that there could be a misalignment with non-Western cultures (Asefa & Wang, 2018: 131-153). Thirdly, it focuses heavily on transparency and accountability, overlooking non-procedural elements. Next, it overlooks the underlying issues that cause poor governance, such as political culture. Rather, it focuses on trying to improve governance by improving technical issues like institutional efficiency. Lastly, it is argued that good governance ignores the implications of asymmetrical power relationships. Multinational corporations, politically connected individuals, or extremely wealthy individuals have the means to subvert good governance (Moon, 2019: 1-9).

ToGG was chosen because it allows the study to explore how existing governance relationships within the Mangaung Metropolitan Municipality affect water governance and service delivery. It further provides categories for assessment that can be comparatively applied to MMM. These areas for assessment allow the study to extract contributory reasons for poor water governance in MMM. Whilst, providing a set of recommendations based on theory, which would allow the MMM to improve its water governance. The main strength of this theory is that it broadens the theoretical base from an infrastructural base to a human behavioural base (Katusiime & Schütt, 2020: 1-22). It is this theoretical shift that allows the study to showcase how ineffective water governance leads to poor management, which in turn causes resource limitations, operational challenges, ineffective service delivery, and inefficient policy implementation. Good governance theory thus allowed the study to evaluate the management of the environmental water cycle and urban water cycle.

#### 1.8.1.3. Theory triangulation

The reality that the human system is influenced at the municipal level means that governance plays a role in the practical execution of IWRM. Therefore, the need arose to use IWRM as the theoretical basis for the study, though approaching it from the governance perspective. This is because good governance theory can assist the study to discern how the decisions made by the municipal council affect water governance. In layman's terms, IWRM relates to the infrastructural aspect of water governance, whereas theory of good governance relates to the decisions of role-players that affect the infrastructural aspect and hence water governance. The reason this study did not use only IWRM is that it does not allow the study to include the aspects of efficiency and effectiveness in water governance. Therefore, to explore the causal relationship between degrading infrastructure and water governance, the issue of good water governance in MMM was explored using two theories, Integrated Water Resource Management (IWRM) and the Theory of Good Governance (ToGG). IWRM allows for a conceptual delineation between the natural system within the water cycle and the human system. This study exclusively focuses on the maintenance of the human system in isolation from the natural system. ToGG allows the study to explore the human behavioral aspects that contribute to poor maintenance of water infrastructure. This allowed the study to achieve its aim: to discern the effect of loadshedding on water governance.

### 1.8.2. Conceptual framework

The conceptual framework sets out to explain the theoretical framework and how it is related to the larger research study. It enables the synthesis of the separate theories into a singular, rational explanation, provided in the form of a visual model, showcasing, the argumentative flow of information and concepts explored (DeMarco, 2020).

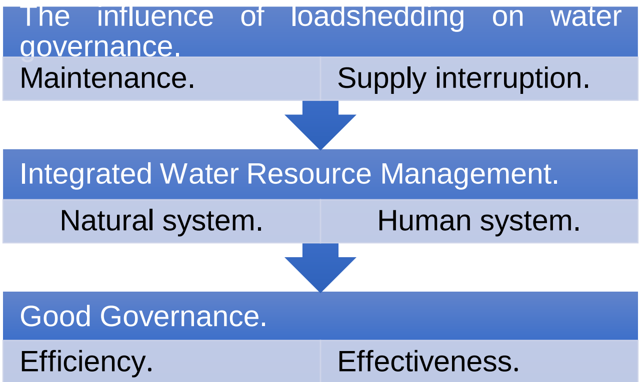


Figure 1: Conceptual outline

(Source, Researchers' own, 2023).

Figure 1 above showcases how infrastructure breakdowns contribute to supply disruptions in MMM's ability to provide potable water. IWRM is the official government approach towards managing the country's water resources. This approach splits between the natural system and the human system. The human system was the focus of this study, and it consists of (i) source, (ii) water treatment, (iii) water storage, (iv) water distribution, (v) collection, and (vi) water treatment (Jensen, 2019). IWRM is both vertically and horizontally integrated between different industries, stakeholders, and governmental role-players. It provides the perfect theoretical base to explore the contributing effects of loadshedding on the general maintenance of the human system, and the wider supply effect that it has. IWRM also acknowledges the role of human behaviour in the maintenance of the human system. That is why good governance was used as an evaluative theory, enabling this study to pinpoint human-error in the wider context of IWRM.

### 1.8.3. Legislative frameworks

The Constitution of the Republic of South Africa, 1996 states in Section 27 that access to water is a fundamental human right and makes it a government mandate. National government and local government's administrative jurisdiction over water resources is split. When comparing the Constitution of the Republic of South Africa, 1996 and the Municipal Systems Act (Act 32 of 2000), it becomes clear that the national government has both legislative and executive authority over freshwater resources. This implies that it has authority over the administration of the natural water cycle. However, it is local government, that has administrative authority over the urban water cycle through its responsibility to collect, treat and purify wastewater to provide potable water to communities (Toxopeüs, 2019). By legal extension, this includes the maintenance and expansion of the water retention, purification, and provisioning infrastructure. For this study, the legislative frameworks were on local government, given that the case study is the Mangaung Metropolitan Municipality.

The National Water Act of 1998 (NWA) was promulgated to give effect to the above constitutional mandates. It does this through mandating the Minister of Water and Sanitation to develop a National Water Resource Strategy that sets out how water collection, retention, and use are regulated. This framework is a five-year strategy that must be updated after the validity period to ensure that current and emerging water resource management threats are accurately addressed. The Integrated Water Resource Management strategy is in line with achieving the goals set out in the Sustainable Development Goal 6 agreed to at the United Nations Conference on Environment and Development (United Nations, 2023).

The Water Services Act of 1997 (WSA) clarifies the responsibilities of local government in its capacity to deliver a water resource as a basic service. It further empowers municipalities to effectively carry out their water and sanitation functions through clarifying their roles and responsibilities as water service authorities. In line with regulating the use of water by consumers, the WSA instated the following regulations on minimum basic water supply. A minimum of 25 litres of potable water per person per day with a minimum flow rate of 10 litres per minute (WSA, 1997). Additionally, the water source must be situated within a 200-meter radius of a household and must efficiently supply water to ensure that no residents experience a shortage for more than seven days per year (Joubert, 2022).

## 1.9. RESEARCH METHODOLOGY

It refers to the method employed through which research can be done. There are many ways in which research can be conducted. To successfully conduct research, an approach must be followed. The approach helps one on how to go about gathering information, thereby addressing the research questions. There are two approaches that can be used, namely qualitative and quantitative research (Mackey & Grass, 2022). This study makes use of the qualitative research methodology. Qualitative research is about collecting data that is of a high quality and is widely varied. This entails looking extensively at data that is non-numerical (Mishra & Alok, 2022: 3). Statistical analysis or empirical calculations are not used in qualitative research, because this research method is synthetic (Hussain, 2022: 2). However, it involves a case study, discourse analysis, grounded theory, logic, and comparative methods (Cibangu, 2012, as cited in Hussain, 2022: 3).

### 1.9.1. Research paradigm

Is a structure used to observe and understand what we see and how we relate to it (Babbie, 2022: 30). This study makes use of the interpretivist paradigm because it is used along with the qualitative research approach. Interpretivism also known as relativism, is a paradigm that focuses on philosophical beliefs of idealism and humanism. One can only experience the reality of the world through personal perceptions. Hence, the researcher looks at different ways to interpret a situation (Walliman, 2022). This paradigm will enable the study to gain more knowledge about the different aspects of power blackouts and the general water situation at the MMM.

### 1.9.2. Research approach

This study employed the qualitative approach. It is a scientific research approach that tries to find answers to information that is incomplete; proof is gathered systematically, and findings are constructed (Dubey & Kothari, 2022: 129). It is used to gather and understand certain information about opinions, values, and social aspects about a specific community. This type of research allows flexibility and adoption to a variety of scenarios, and this allows one to brainstorm and look at the situation in different ways (Dubey & Kothari, 2022: 129). The approach this study used is inductive reasoning. Inductive reasoning begins with certain observations or experiences and then from there a general conclusion can be formed (Walliman, 2022). This study was a desktop study. The study will simply explore the case of the MMM by referring to credible sources and previous research to ensure that the study has the correct information.

### 1.9.3. Research design

Research design is a plan that assists to get answers to the research questions. This outlines how the researcher goes about writing the hypothesis, with the implementation and the data analysis. The research design serves as a guide for data collection. Its significance lies in facilitating various research processes, all the while considering factors like time and financial resources (Dubey & Kothari, 2022). This research adopted a qualitative approach, complemented by an exploratory research design. The utilization of an exploratory research design was deemed appropriate for this study, as its objective is to delve into the influence of loadshedding on water governance within the Mangaung Metropolitan Municipality (MMM). The exploratory nature of the research design allowed for an in-depth exploration of the subject.

### 1.9.4. Data collection method

Data can be gathered through a primary or secondary data collection method. In this study data were collected through a secondary data collection method. Secondary data are data or information that have been collected by someone else that is used in a study or research. A desk review was done to gather data from different secondary sources (Abu-Taieh, El Mouatasim, & Al Hadid, 2020: 29). Data for this study was collected through the examination of historical data sourced from books, peer-reviewed scholarly journals addressing topics related to water governance and load shedding. Additionally, credible institutional websites, including Statistics South Africa, the South African Local Government Association (SALGA), and official government documents from the Mangaung Metropolitan Municipality (MMM) website (www.mangaung.co.za) were utilized as valuable resources.

### 1.9.5. Data analysis

The study focused on a thematic approach because it used the qualitative approach and these two-go hand in hand. The study focused on a variety of data to derive a conclusion. The study followed the 6-steps of qualitative data analysis as highlighted below:

Step 1: Familiarization

This phase entailed becoming acquainted with the data and reviewing it multiple times. Throughout this stage, the researchers documented the primary concepts that surfaced from the data.

Step 2: Coding

After establishing the themes, the researchers assigned codes corresponding to these themes, laying the groundwork for a holistic exploration of the data. All data was coded by pinpointing the pertinent information requiring categorization.

Step 3: Searching for themes

This step encompassed conducting thematic analysis. Data pertinent to the objectives were structured according to relevance and alignment. The researchers categorized the data into various themes and sub-themes.

Step 4: Reviewing themes

After identifying themes, the researchers conduct a thorough examination, considering whether to merge, enhance, segregate, or eliminate initial themes. It is essential for data within each theme to connect logically, while maintaining distinct boundaries between themes. This process typically involves two phases: initially validating themes against the coded extracts (Phase 1), followed by assessing the entire dataset for coherence (Phase 2).

Step 5: Refining and naming themes

It entails “fine-tuning and specifying” the themes and possible sub-themes found in the data. Continual analysis was carried out to enrich the established themes. The researchers crafted names for these identified themes and precise definitions that succinctly encapsulate the core of each theme.

Step 6: Producing the report

Ultimately, the researchers translated the analysis into an understandable written piece by incorporating vivid and compelling examples extracted from the data that directly tie to the themes, research questions, and existing literature. This approach surpasses a simple portrayal of themes; it presents an analysis substantiated by factual evidence that tackles the research question and objectives. It is crucial to articulate this within the context of the outlined theoretical framework and underlying assumptions.

### 1.9.6. Trustworthiness and credibility of qualitative data

In using qualitative content analysis in this study, the trustworthiness of the study was determined by the following criteria dependability, confirmability, credibility, and transferability (Nowell et al., 2017: 1-13). The dependability of the study pertains to the consistency of its results or findings when applied to a comparable scenario. This emphasizes the research's reliability and uniformity. The study is dependable if it clearly showcases the research processes used by researchers. Confirmability in research refers to the extent to which data can be employed to support the research findings. The confirmability of the study is ascertained by evaluating its dependability, credibility, and transferability. It specifically centres on the researcher's interpretive process concerning the analysis of data. The study's credibility pertains to whether the research elicits a shared experience within the work of other researchers (Korstjens & Moser, 2018: 120-124). Credibility was ensured by observation of the findings by the research supervisor and through data triangulation. Transferability refers to how generalisable the findings of the research are. In other words, can the knowledge produced by the findings be applied to other research cases? Transferability was achieved through a thick description of the potable water challenges within MMM and providing the context of the research's transferability for other municipalities.

### 1.9.7. Ethical considerations

This study is characterized as a desktop study, devoid of direct involvement with individuals or subjects. Employing inductive reasoning, the research concentrated on a specific problem and progressed towards a conclusion or solution grounded in reliable and credible secondary data. Due to the absence of human participants, the study carried minimal risk. Nevertheless, ethical clearance from the University of the Free State Research Ethics Committee was sought, adhering to the necessary protocols and procedures.

## 1.10. STUDY OUTLINE

Chapter 1:

Chapter 1 lays the groundwork for the study by detailing the context, the research problem, objectives, limitations, key concepts, the preliminary literature review, and the research approach. It is a guiding roadmap that not only introduces the study's purpose but also reveals the theoretical framework. Essentially, it is the cornerstone offering a deep dive into the study's intent and the contributions that it aims to make.

Chapter 2:

This chapter dives into the extensive literature on the water crisis in MMM. The focus is to review existing studies and to thoroughly examine the complex challenges within this crisis. The chapter aims to provide a detailed understanding of these challenges, analysing their interconnections and complexities. The aim is to provide readers with an understanding of the seriousness and complexities of the water crisis in MMM.

Chapter 3:
This chapter reviews the research objectives, and it explains the research methodology.

Chapter 4:
Chapter four is dedicated to analysing the data that was gathered. This includes the research design, study location, data analysis, and collection methods. The primary aim is to answer the research questions. This chapter is critical for interpreting information and reaching conclusions, to meet the research objectives.

Chapter 5:
Chapter five gives an overview of what was found in the study. It serves as the conclusive section, offering a comprehensive summary of the research conducted and the interpretations of the findings. This chapter provides insights into the implications of the findings and suggests recommendations based on the study’s outcomes, bringing the whole research project to a conclusion.

# 2. CHAPTER TWO: LITERATURE REVIEW

## 2.1. INTRODUCTION

The previous chapter introduced the study. Besides covering the problem statement, research objectives and research questions, the chapter did a preliminary discussion of theories, methodology and ethical considerations. This chapter delves into an analysis of two components- Integrated Water Resource Management (IWRM) and Theory of Good Governance (ToGG). It thus enables an exploration of the influence that loadshedding has on water governance in MMM. To do this, the chapter elucidates the fundamental concepts relevant to the research, primarily focusing on loadshedding and water governance. The chapter the introduced a conceptual framework that highlights the relationship between loadshedding and water governance. The conceptual synthesis of IWRM and ToGG highlights how the two variables of electricity and water are interrelated, allowing the research topic to be addressed. Moving forward, the empirical framework examines the research topic from multiple perspectives, namely international, regional, national, and local, thus aligning with the research objectives of the study. Lastly, the legislative frameworks related to the research topic are discussed. The legislations that are discussed include:

- The Constitution of the Republic of South Africa, 1996;
- the National Energy Act (Act 34 of 2008);
- the Municipal Systems Act (Act 32 of 2000);
- the National Water Act (Act 36 of 1998);
- the National Water Resource Strategy, and
- the Water Services Act (1997).

## 2.2. THE KEY CONCEPTS

This section explains the key concepts that are relevant to the study. The key concepts, which are also the key variables are loadshedding, water governance, and local government.

### 2.2.1. Understanding loadshedding

Loadshedding entails scheduled and intentional power interruptions, where specific sections of the electrical distribution system are deliberately turned off (Walsh, Theron, & Reeders, 2021:1). This measure is taken to prevent damage to the grid and mitigates the potential threat of a complete nationwide power outage (Walsh, Theron, & Reeders, 2021:1). Loadshedding is a measure employed by Eskom to alleviate strain on its electricity supply when the demand surpasses the available amount. This action can be executed either with or without notice in advance to the people (Botha, 2019: 1). Eskom implements loadshedding by temporarily discontinuing the distribution of electricity in specific areas, impacting both businesses and households (Botha, 2019: 1). Koirala and Acharya (2022: 1) define loadshedding as the incidence of planned or unplanned power cuts that are caused when domestic energy demand exceeds the supply of available energy. From the above, loadshedding is a scheduled interruption in the power supply, and it occurs when energy demand exceeds the available energy supply.

### 2.2.2. The importance of electricity

Dube and Moyo (2022: 9-12) state that there is no explicit constitutional right to electricity. Rather, they argue that the right to electricity is bound up in Section 115 of the Constitution of the Republic of South Africa, 1996. This position is confirmed by the Constitutional Court's majority ruling in the case: *Eskom v Vaal River Development Association (Pty) Ltd and Others*, where the Court ruled that the right to electricity is implicitly bound to the right to dignity and right to life (The Constitutional Court of South Africa, 2022: 4-122).

Eskom is a state-owned entity that has a *de facto* monopoly over the South African energy sector (Mkhize & Nel-Sanders, 2023: 1-13). The provision of electricity by Eskom plays a critical role in supporting various business functions in South Africa. Stern *et al.* (2019: 2-9) highlight the centrality of electricity to economic development. Electricity underpins modern society and is used for transportation, manufacturing, water distribution, and food production (United Nations Habitat, 2023). Loadshedding, since its introduction in 2008, has posed a significant challenge for small businesses because they lack the necessary resources to mitigate the impact of power outages. As a result, their capacity to operate productively has been hindered, jeopardising their survival (Botha, 2019: 2). Thus, the economy is directly dependent on the supply of electricity.

### 2.2.3. Impact of loadshedding on local government

The water-energy nexus describes the interrelation of water and energy systems. The nexus is composed of two perspectives, the water for energy perspective and the energy for water perspective (Mathetsa *et al.*, 2019: 12-13). The nexus is highlighted by the impact that loadshedding has had on local government. According to Langeberg Municipality (2022), the escalation in loadshedding has impacted the municipal Wastewater Treatment Works because pump stations can no longer function. This prevents water from being purified and pumped through the water supply system (WSS) into reservoirs. The South African Local Government Association (2022) acknowledges the negative impact that loadshedding has on pumping water, and the collection and treatment of wastewater. This highlights how loadshedding causes a low-pressure system in the WSS, where treated water cannot be pumped from reservoirs to households. Thus, loadshedding interferes with the constitutional mandate of the local government sphere.

### 2.2.4. Water governance

According to Kalair *et al.* (2019: 10-24), water governance encompasses the collective arrangement of socio-economic, political and administrative systems that impact the administration of transboundary water resources. It entails determining the allocation of water and associated benefits such as electricity generation. Effective water governance plays an important role in mitigating conflicts over water and fostering harmony between states upstream and downstream in a river basin.

### 2.2.5. Influence of loadshedding on water governance

Electricity plays an important role in the water industry, powering various operations such as pumping, treatment of raw water, distributing water, and collecting and treating wastewater. In reservoirs, certain pumps force water into a tower, generating sufficient pressure to distribute the water network, particularly in elevated regions (SALGA, 2022). According to Herold, Van Dijk, and Potgieter (2020: 33), the likelihood of a power outage impacting the water supply is considerable, carrying significant economic and socio-political consequences. Loadshedding has a huge impact on how water is pumped. Significant fluctuations in pressure within water pumps and turbine sets may occur. When the tail-water level is lower, the minimum water hammer force at the draft pipe's shaft exceeds the evaporation force. The introduction of pulsating pressure can expedite the force's ascent to the evaporation pressure (Yang *et al.*, 2021: 1). During loadshedding, the interruption of pumping water operations results in water distribution disruptions. The challenge of dealing with power cuts is further exacerbated by the absence of water supply (Moodliar & Davidson, 2023: 1115-1125).

The primary challenges in meeting the growing daily demand and accommodating the increasing number of critical base loads are the introduction of additional power quality resources and the rise in electricity consumption. Owing to the sudden and unexpected surge in consumers and lack of construction of new micro-energy power plants in distribution systems overall, it is vital to operationalize measures to ensure the efficient functioning of the distribution systems. The utilisation of proper computational loadshedding strategies becomes crucial for achieving this objective (Madiba *et al.*, 2021: 653).

### 2.2.6. Local government

Local government consists of municipalities, who must fulfil certain duties to provide necessary services to the public. According to the Constitution of the Republic of South Africa, 1996, the municipal level of government comprises local governing bodies, known as municipalities, which are required to take the initiative throughout the entire region of the Republic of South Africa. The municipal council holds the executive and legislative authority within a municipality. A municipality possesses the autonomy to govern the local affairs of the community independently, within the framework of national and provincial laws as defined in the Constitution. Neither the national nor a provincial government is allowed to undermine or obstruct a municipality's capacity or entitlement to exercise its power and fulfil its responsibilities.

South Africa has 257 municipalities, including metropolitan, district, and local municipalities (South African Government, 2021). The main objective of these municipalities is to grow their economies and maintain infrastructure and provide services. According to the Constitution of 1996, the Municipal Structures Act of 1998 delineates the parameters for determining the classification of municipalities. It stipulates the formation of category-A municipalities (referred to as metropolitan municipalities) in specific regions, designating other areas as either category-B (referred to as local municipalities) or category-C (district municipalities). Additionally, the Act explicitly states that category-A municipalities are exclusively permissible in metropolitan areas. As an illustration, Bloemfontein is encompassed within the Mangaung Metropolitan Municipality. Metropolitan councils have the option to devolve powers and functions, but it is important to note that the ultimate authority for authentic municipal, legislative, and executive powers lies with the metropolitan council itself. Within metropolitan areas, there are two executive systems to choose from. The mayoral executive system involves the mayor holding executive authority, whereas in the collective executive committee system, these powers are endowed in the executive committee. Non-metropolitan areas are composed of district councils and local councils. The focus of district municipalities is on enhancing capabilities and engaging in planning activities at the district level (South African Government, 2023).

## 2.3. CONCEPTUAL FRAMEWORK

A conceptual framework is a visual representation illustrating how the concepts of a study interrelate. It is a structure that encompasses the aspects of a study like underlying ideas, plans, practices, structures, and implementation (Luft *et al.*, 2022: 1-8). Essentially, the conceptual framework encompasses the ideas about identifying the research topic, defining the problem to be investigated, formulating research questions, conducting literature review by applying relevant concepts, selecting appropriate methodology, employing specific methods, processes, tools, analysing data, interpreting findings, and formulating recommendations and conclusions. In essence, the conceptual framework provides a rational conceptualisation of the complete research; it is an orderly map of your whole research study (Mensah, Agyemang, Acquah, Babah, & Dontoh, 2020: 55).

Africa has experienced a rise in climate-related issues. Which has had an adverse effect on food security and water security (Bisca *et al.*, 2021: 68). This is because of sub-Saharan Africa being a drought prone area, with alternating periods of wet and dry climate (Klug, 2021: 220). Water scarcity endangers the lives of millions in sub-Saharan Africa (Leal Filho *et al.,* 2022). Since water is a basic amenity for the survival of humans, effective water management is paramount.

Therefore, when local government fails to provide water to communities, they will find it difficult to perform everyday tasks. Community members will then walk long distances to find water sources like communal taps or rivers. This is a time-consuming process that results in people collecting and drinking dirty river water, which could cause them to fall ill. Thus, lack of access to potable water lowers the quality of life. MMM is no stranger to water supply interruptions. Appendices one to six highlight that MMM has experienced six water supply interruptions over a period of one year.

Mangaung has encountered severe water supply issues (Kusakana, Coetzee, & Oke, 2019: 104-108). On the one hand, the municipality's water supply system (WSS) is under significant strain owing to aging infrastructure. Water provision to the municipality is the responsibility of Bloemwater and MMM. Bloemwater processes and provides water to the municipality, which is then distributed to residents. Mangaung is responsible for water treatment and the delivery of purified water to residents of MMM (Kusakana, Coetzee, & Oke, 2019: 104-108). Appendices one, two, and three are water supply interruption notices issued by MMM. These stated that the supply of water will be interrupted for a period of 36 hours owing to maintenance, showing that the water infrastructure in MMM is overburdened. Maintenance results in large-scale water outages.

On the other hand, there is loadshedding. Electricity plays an integral role in the WSS, including: (i) pumping, (ii) raw water treatment, (iii) distribution of clean water, (iv) wastewater collection and treatment, and (v) water discharge. In reservoirs, pumps are utilised to push water into towers, which generate sufficient pressure to supply water to elevated areas within the network. The pipelines within this network transport water to households, hospitals, schools, and businesses. The operation of pumps is dependent on the availability of electricity. Power outages caused by loadshedding have significant implications for the uninterrupted provision of water services. The impact of electricity disruptions on the availability of clean water is so severe that in extreme situations, it can lead to complete disruptions of water supply and compromise the quality of the water itself (SALGA, 2022).

### 2.3.1. The relationship between good water governance, legislation, and maintenance

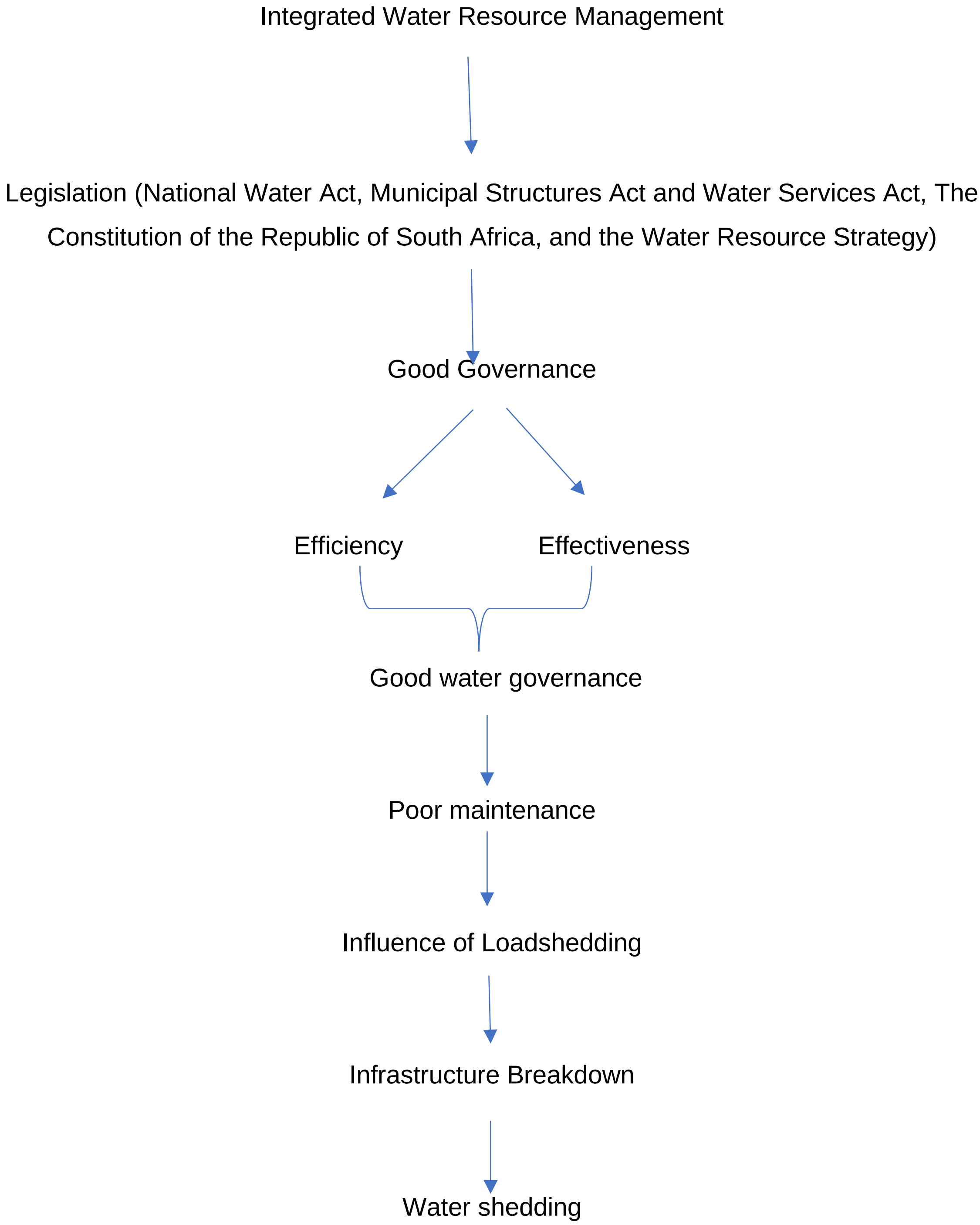


Figure 2: Relationship between good water governance, legislation, and maintenance (Source, Researchers' own, 2023).

South Africa is committed to the Integrated Water Resources Management (IWRM) through SDG 6, which aligns with the National Water Act (NWA) 36 of 1998 (South African Government, 2023). The Water Services Act (Act 108 of 1997) tries to ensure the entitlements of individuals to access essential water and sanitation services, to establish national benchmarks and criteria for tariffs, to offer financial aid to water service organisations and to establish a comprehensive national information system for data collection and dissemination (South African Government, 2023). The implementation of this is dependent on good governance. Good governance is about providing services to the citizens in the most effective and efficient manner. Consistently, it has been recognised that effective governance (good governance) plays a vital role in attaining sustainable development and fostering inclusive economic progress, as well as ensuring government transparency and accountability to the people they serve (Schoeberlein, 2020: 1). Good water governance is hindered by poor maintenance and lack of regulation. Loadshedding has in turn been caused by poor maintenance. This is evidenced by the White paper on the Energy Policy of the Republic of South Africa (1998) that warned government on the dwindling supply of electricity. This warning went unheeded by government. To this effect, the existing surplus in Eskom's generation capacity was fully used by 2007, resulting in the implementation of loadshedding as a proactive measure to decrease electricity demand (Department of Minerals and Energy, 1998: 53). The frequency and duration of loadshedding has increased since its introduction. The implementation of stages five and six of loadshedding means that municipalities are without electricity for up to nine hours a day. This accelerates the wear and tear of infrastructure, resulting in water shedding.

### 2.4. EMPIRICAL FRAMEWORK

Henrique and Filho (2020: 429-449) define the term 'empirical' as the method through which information is collected and analysed using direct or indirect inspection. 'Empirical' also refers to studies based on observations of the real world. In addition, the term supports the claim that "field-based" experiences are described using empirical papers rather than laboratory or simulation research, which use data collection techniques from naturally occurring scenarios (Henrique & Filho, 2020: 429-449). Empirical research supports both theory development and theory validation (Bhatia & Gangwani, 2021: 24722). In addition, they claim that any paper containing empirical research may include one or more of the following empirical research designs: (i) multiple case studies, (ii) single case studies, (iii) focus group studies, (iv) panel studies, and (v) surveys (Bhatia & Gangwani, 2021: 24722).

Every study that examines empirical research should have the goal of either theory development or theory validation (Siangchokyoo, Klinger, & Campion, 2020: 1-18). To elaborate on new concepts and produce new contributions, theory development must draw upon previously produced theories and methods (Henrique & Filho, 2020: 429-449). Before an empirical study's results can be used to develop a new theory, they must first be validated or refuted, then further supported by other research theory verification, before being called a new theory (Siangchokyoo, Klinger, & Campion, 2020: 1-18). Moreover, owing to their existence, ability to be perceived, and use of specific terminology, the ideas in empirical concepts have independent meaning in a theory and are real (Majeed, Mukhtar, & Ehsan, 2023: 147-156).

### 2.4.1. Empirical literature: analysing challenges and solutions from international, regional, national, and local case studies

#### 2.4.1.1. International experience

Nepal faces issues with providing potable water to its citizens, with certain urban and many rural parts of the country struggling to meet industry standards in the water treatment process (Palikhe *et al*., 2019: 1-13). To this day, the necessary infrastructure for providing clean drinking water remains inadequate in Nepal's rural areas despite the country's abundant water resources (Palikhe *et al*., 2019: 1-13). Consequently, some people still lack access to safe and clean drinking water in Nepal (Palikhe *et al*., 2019: 1-13).

Nepal depends on obsolete technology, necessitating an upgrade to state-of-the-art GIS technologies for the efficient expansion of water supply, irrigation, and hydropower projects (Hashemi, 2021: 105-124). There is no metering connection and no private taps, and it was also discovered that there is a possibility of water waste (Nepali *et al.*, 2023: 35-49). When the water supply is cut off, they employ rainwater gathering systems that were built prior to the start of the hydropower project (Mishra, Sudarsan, & Nithiyanantham, 2023). The water tariff is ineffective, and there are not enough fixtures and tools for maintenance work (Mishra, Sudarsan, & Nithiyanantham, 2023: 1479-1488).

#### 2.4.1.2. International solutions

The Nepali government knows that switching from pumping water using electric power systems to solar power systems is urgently needed in the water sector (Mishra et al., 2023: 1479-1488). This nation possesses a vast number of resources that are available in the form of flowing water or water resources (Palikhe *et al.*, 2019: 1-13). Most of Nepal's water resources produce hydroelectricity, support irrigation, and provide enough clean drinking water for its population (Palikhe *et al.*, 2019: 1-13). Nepal has recently undertaken substantial efforts to embrace a range of Renewable Energy Technologies (RETs), as highlighted by (Suman, 2021: 1-14). This initiative includes the adoption of hydroelectric power, wind energy, solar energy, modernized water mills, and biogas plants. These various RETs aim to enhance the living standards of rural communities in Nepal while simultaneously addressing the challenges of climate change through the utilization of locally available, clean energy sources. (Suman, 2021: 1-14). With assistance from its government and other groups, the nation advances in installing various RETs every year (Suman, 2021: 1-14). In some recently constructed large irrigation projects, modern irrigation equipment, such as water lifting systems, pumps, sprinklers, and drippers are used (Palikhe *et al.*, 2019: 1-13).

International non-governmental organisations (INGOs) and non-governmental organisations (NGOs) are continually providing contributions to distant areas of Nepal to make drinkable water easily accessible for the local population (Karki, 2020: 30). The government has implemented initiatives like “Water and Sanitation for Everyone with Sustainable Management” to increase the mobilisation of organisational structures for water delivery and add efforts in continuity for expanding the water network without compromising water quality (Karki, 2020: 30).

Nepal recently implemented a GPS monitoring system for its water supply network (Lindmark et al., 2022: 9164-9181) and has updated it with the latest technology for an online billing and collection system. However, in Nepal, there are still numerous water supply stations and pipelines that could benefit from intelligent technology upgrades, enabling better management and more effective operation (Palikhe et al., 2019: 1-13). In many hilly villages without access to electricity, solar-powered water pumping systems have emerged as practical solutions for water supply (Mishra et al., 2023: 1479-1488). The community has occasionally requested dual systems, recognising that solar-powered water pumps are more effective during midday when sunlight is abundant. The demand and necessity for drinking water have thus increased significantly when there is ample daylight (Mishra et al., 2023: 1479-1488).

#### 2.4.1.3. Regional experience

The national energy utility in Kitwe, Zambia, had increased loadshedding throughout the entire nation. More than 50 percent of respondents of a study in high- and low-income areas believed loadshedding was connected to disruptions in their local water supply (Umar *et al.,* 2021). Citizens in the low-income areas only have access to water through communal taps, which are in public areas. These taps serve as the main supply of water in all three residential areas (Umar *et al*., 2021). A local sub-station that follows the same loadshedding schedule as the residential area powers a water tank that stores the water provided to residential areas (Khan, 2019: 1-17). When the supply of energy to homes is cut off, the water reservoir is also impacted and cannot pump water to the surrounding region (Umar *et al.*,2021).

#### 2.4.1.4. Regional solutions

To receive water in Kitwe, Zambian households must pay a nominal fee to the neighbourhood water utility. Residential areas receive water that is then kept in a water tank that is powered by a nearby substation that follows the same load-shedding schedule as the neighbourhood (Umar *et al.*, 2021). The Zambian government started a project that involves building the country's vital water supply infrastructure like water treatment plants and the WSS (Muchadenyika, 2020). The planned project improved the city's water supply to be more dependable (African Development Bank Group, 2023). After implementation, the initiative will enhance beneficiaries' health by reducing water-borne illnesses, including cholera, which have been endemic in the area (African Development Bank Group, 2023). In addition, the initiative had given the locals access to a consistent supply of potable water, which they previously lacked as they were typically the last to receive water and lost it when the system broke (African Development Bank Group, 2023).

#### 2.4.1.5. National experience

In South Africa, water infrastructure has been left unmaintained for decades, compounding the issues brought on by loadshedding. In addition, the amount of water available is insufficient to meet the rising demand (Du Plessis, 2023: 89-170). The worst recorded series of power outages in South Africa occurred in 2022 (Du Plessis, 2023: 89-170). A record 205 days' worth of electricity were lost by the nation overall because of frequent failures at Eskom's power plant that is powered by coal (Du Plessis, 2023: 89-170). The power plants have aged, and they have not received enough maintenance.

The nation's water distribution and processing networks have been one of the major victims of the country's more than ten years of catastrophic power outages (Du Plessis, 2023: 89-170). Water utilities in several sections of the country have issued warnings regarding damage to water distribution infrastructure and procedures because of recent and intensifying outages (Allegrante & Sleet, 2021: 1-8). There are numerous detrimental implications on the water supply, as water and energy are linked, which means that electricity is needed for the water reticulation framework, the conveyance of water from the source, the purification of wastewater and water, as well as the supply and distribution of water to residents (Ahmad *et* *al.*, 2020: 1-18). There have been severe water cuts in several cities, including Johannesburg and City of Cedarberg, as well as smaller communities.

Power outages have worsened the condition of the aging and decaying water infrastructure (Allegrante & Sleet, 2021: 1-8). One example is the City of Cape Town. To prevent further harm, new investments must be made in the city's systems (Muller, 2020: 1054-1072). In addition, it has slowed water delivery because the water reticulation system uses energy to run pumps. Water cannot be supplied and delivered to consumers in a pumping-based transmission and distribution system without maintaining the necessary pressure (Du Plessis, 2023: 89-170). In addition, the infrastructure of the water services provided by Cedarberg Municipality, which governs an area of Western Cape province, has been significantly impacted by power outages (Madondo *et al.*, 2023: 14-39). In addition, power outages have not only damaged already existing equipment but have also made it necessary to buy additional equipment (such as water storage tanks and sewage storage tanks (Winter, 2011). Power failures have caused several water service interruptions for the UGU District. This has directly affected the water supply for nearby residents and businesses (Madondo *et al.*, 2023: 14-39). A local fish processing business was forced to shut down for four days during the 2-week period when water delivery (via pipe) was disrupted, incurring a cost of R70,000 (Madondo *et al.*, 2023: 14-39).

In different areas where citizens are facing similar situations, such Siphumele/Thokoza informal settlement in Ekurhuleni, Gauteng, the residents are at a severe health risk due to numerous sewage overflows caused by loadshedding at the Howick West pump station (Madondo et al., 2023: 14-39). High levels of *Escherichia coli* (E. coli), which can lead to severe diarrhoea and stomach pain, pose a significant threat to young children, potentially harming their red blood cells and kidneys (Madondo et al., 2023: 14-39).

#### 2.4.1.6. National solutions

The City of Cedarberg purchased fifteen storage tanks, each with a capacity of 5000 litres, and this cost the municipality R22,500 (Madondo *et al.*, 2023: 14-39). These are positioned in critical areas to guarantee that residents have access to drinkable water when power outages adversely affect the water supply. Some R12,000 was spent on the acquisition of four sewage storage tanks, each having a capacity of 5000 gallons (Madondo *et al.*, 2023: 14-39). During power outages, portable sewage storage tanks are deployed to prevent sewage overflow into the environment, minimising the risk to human health and the ecosystem (Mafuya, 2022). To guarantee access to potable water for neighbouring towns, the municipality in the UGU District deployed 20 water tankers strategically positioned in key locations (Madondo et al., 2023: 14-

39). These tankers had to be transported from a town over 50 kilometres away, making the logistics challenging (Madondo et al., 2023: 14-39). Despite the complexity, the tankers were successfully placed throughout the area. However, this effort came at a substantial cost, totalling over R200,000 in contracting and travel expenses for two weeks (Madondo et al., 2023: 14-39).

#### 2.4.1.7. Local experience

Mangaung has been dealing with severe water shortages. In 2016, Nomvula Mokonyane, the then Minister of Water and Sanitation, attributed her budgetary decision to the significant factor of water supply shortages, a situation exacerbated by drought and power cuts (Kusakana, Coetzee, & Oke, 2019). Water shortages, occasionally lasting for extended periods, have recently affected residents of Bloemfontein and the surrounding areas (Kusakana, Coetzee, & Oke, 2019). Electricity is a critical component to the water supply system (WSS). Pumping consumes the most electricity among the various stages of water supply, increasing the system's reliance on it (Matamanda et al., 2022: 309-327). Consequently, power outages can impact the availability, quality, and treatment of water. Also, water supply outages have resulted from loadshedding progression up to stage six. Thus, as the municipality tries to acquire backup generators, the Mangaung Metropolitan Municipality (MMM) has urged people to use water carefully when there is loadshedding or maintenance being performed on the power networks (Mosebetsi, 2022).

Unfortunately, Bloemfontein ranks as one of the places where water supply and demand issues arise because of infrastructure repairs and improvements (Green Bloemfontein, 2023). Citizens in Bloemfontein and neighbouring towns have experienced water shortages more often recently, sometimes for days (Green Bloemfontein, 2023). Citizens have recently observed an increase of brown water coming out of their taps (Matamanda, Dunn, & Nel, 2022: 309-327). The municipality initially claimed that this was caused by the repair of ruptured pipes and advised residents in the affected districts to boil their water before drinking it (Motsau & van Wyk, 2022). This is a result of the community's poor water access within municipalities.

#### 2.4.1.8. Local solutions

Addressing the water crisis involves the completion of a reservoir construction at Pellissier, as proposed by Mosebetsi in 2022. This reservoir, once finished, will serve as a pivotal supply point, aiding Bloemwater, which currently fulfils approximately 69 percent of the metro's water demand (Mosebetsi, 2023). After realising that Eskom could not efficiently generate and distribute electricity to the broader MMM, the Mangaung Metropolitan Municipality (MMM) founded Centlec, a public entity, to distribute electricity inside the province of the Free State (Manele, 2021). This organisation was established to generate electricity from Eskom and supply it to nearby communities (Manele, 2021). When conserving water, greywater harvesting, and rainwater collection systems are the two most significant options (Green Bloemfontein, 2023). Grey water harvesting devices provide residents with the chance to give semi-used auxiliary water a fresh use, while rainfall collecting equipment enables users to gather, preserve, and reuse rainwater in and around their home that might have been wasted or simply drained down (Green Bloemfontein, 2023).

## 2.5. THEORETICAL FRAMEWORK

The theoretical framework serves to validate the research investigation by establishing a connection between the research topic and a relevant theory. It substantiates the chosen topic of inquiry by presenting a theoretical model that elucidates the significance and necessity of exploring the subject matter (Adom, Hussein & Adu-Agyem, 2018: 438). Luft *et al.* (2022: 1-8) states that the theoretical framework is the main method through which the research problem is understood, and this by linking it to the selected theory of the study.

### 2.5.1. Constructing the theory of Integrated Water Resource Management

The 2030 Agenda for Sustainable Development came into effect in 2016. Sustainable Development Goal (SDG) 6.5 obligates South Africa to implement integrated water resource management (IWRM) (United Nations, 2016). In addition to SDG 6.5 mandating IWRM, the National Water Act (1998) also commits the state to IWRM (Department of Water and Sanitation, 2015). The United Nations Environment Programme (2021: 2) views IWRM as an approach to water management that balances the competing demands of human consumption, the economy and environmental sustainability. Jonker (2014: 5-13) views the system of water supply and demand as a holistic, integrated system. Thus, it is dependent on the management of existing natural water resources as well as the maintenance of the urban water cycle.

Integrated Water Resource Management was conceptualised by Gifford Pinchot. Pinchot recognised the systemic balance in nature and how humans could affect this by extracting and using natural resources (Mansfield, 2014: 10-12). Thus, Pinchot argued that the management of our rivers, forests, lands, and wildlife is interrelated. His theory of IWRM was first operationalised in 1933 by the Tennessee Valley Authority (TVA). The theory includes the following aspects in 1933: (i) Public health and welfare systems, (ii) Flood control, (iii) Power production, and (iv) Erosion control (Freie Universität Berlin, 2013). The theory only became mainstream after the 1977 International Water Conference at Mar de Plata. At this conference, the need to integrate and co-ordinate between different role-players in the water cycle was recognised. Today, the theory covers (i) Water supply, (ii) Storm water management, (iii) Water conservation, and (iv) Wastewater treatment (American Planning Association, 2022). The long-term viability of IWRM is highlighted by the success of the TVA. Mansfield (2014: 10-12) points out that the TVA can manage its 49 dams, 29 hydro-electric power plants and reservoirs along the Tennessee river in an integrated manner. By using IWRM, the TVA has been able to generate 16.1 million megawatt hours of electricity in 2019 (Tennessee Valley Authority, 2022). In line with IWRM, the TVA has been able to protect the Tennessee River by preserving its ecological integrity and provide water to local governments and manufacturing industries. Thus, the TVA showcases how IWRM can be used to manage electricity demand and how to incorporate sustainability and ecological preservation into water governance.

IWRM provides a framework that explains how water quality, economics, and the environment are interrelated (Global Water Forum, 2013). The four principles of water management form the main features of IWRM, namely that (i) Freshwater is a finite resource; (ii) Water is an economic resource; (iii) Women play a leading role in water management, and (iv) Water management should be participatory (United Nations Economic and Social Commission for Western Asia, 2020). By comparing Fulazzaky (2014: 2000-2020) with Molinga and Subramanian (2009: 76-86), the shortcomings of the theory are identified as: (i) it requires an enabling legislative environment for Integrated Water Resource Management to be implemented; (ii) it assumes that the institutional roles for managing water resources are clearly defined; (iii) it assumes that the actors and institutions at the local level are capacitated, and (iv) the implementation of water resource management instruments is premised on the existence of good governance principles.

Herrfahrdt-Pähle (2014: 3) introduces the issue of spatial fit to water management. Spatial fit refers to the misalignment of institutional arrangements and ecosystem properties. This is based on the historical trend to establish water administration institutions along jurisdictional boundaries rather than hydrological boundaries. This issue affects MMM's water services authority, which is Bloemwater. Bloemwater executes its operations through three water schemes (Bloemwater, 2023). Two different provincial Water and Sanitation departments are responsible for the allocation of water to Bloemwater. This creates the main issues of spatial mismatch, namely unequal access, and institutional redundancies (Herrfahrdt-Pähle, 2014: 3). Galvez and Rojas (2019: 179-191) refer to IWRM as a "wicked problem". A "wicked problem" is a policy issue that exhibits a high level of uncertainty about the nature or solution, a high level of complexity, and value divergence between stakeholders (DeFries & Nagendra, 2017: 265-270). Addressing IWRM as a “wicked problem” requires a shared understanding of the issue. In other words, it requires public participation and collaboration. Functionally speaking, this overlaps with the fourth principle of water management, that is, public participation. Galvez and Rojas (2019: 179-191) set out the conditions for when collaboration, a central feature of IWRM, should occur, namely (i) The issue must be a stakeholder priority, (ii) The issue is a community priority; (iii) Senior management cannot agree on a solution; (iv) Lack of resources to resolve the issue; (v) The agency requires the help of others to resolve the issue, and (vi) Other stakeholders can solve the issue.

IWRM is connected to the research topic through its explanation of the urban water cycle. The urban water cycle is a modification of the natural water cycle that consists of three systems, namely water supply, wastewater, and storm water systems (Murray Darling Basin Authority, 2020). IWRM embodies a comprehensive approach to the management of water resources, acknowledging the interrelated nature of water systems and the diverse stakeholders engaged in the process. It aims to ensure the sustainable and equitable use of water resources while also considering social, economic, and environmental factors. Loadshedding can have a significant influence on water governance. It affects the urban water cycle and its composite systems, namely water supply, wastewater treatment, and storm water control. Considering that electricity is needed for the systems to function optimally, it becomes clear that there could be significant disruptions in the ability of MMM to execute good water governance. For example, lack of electricity can affect the operation of water treatment plants, leading to decreased water quality and supply. It can also lead to the accumulation of untreated wastewater, which is a biological hazard to residents. In addition, the functioning of water pumps could be hindered, causing damage to critical infrastructure, all of which would negatively influence water governance in MMM.

The issues raised above are based on the water-energy nexus, which can be approached from two perspectives, the energy for water perspective or the water for energy perspective (Villamayor-Tomas, 2017: 105-122). On one hand, the energy for water perspective highlights how energy is used in the different stages of the urban water cycle. Energy is needed for the extraction of groundwater, the purification of raw water, as well as the pumping of treated water to consumers (Wakeel & Chen, 2016: 123-128). This is pertinent because according to Wille, van der Merwe-Botha, and Steytler (2020: 2-18), 25 percent of municipal energy use is towards water purification and water supply, showing the centrality of electricity to effective water governance. According to Huber Technology (2023), the average wastewater treatment plant uses between 20 and 45 kWh per population equivalent (PE). Wastewater treatment plants serving more than 100 000 PE use 20 kWh whilst treatment plants serving less than

100 000 PE use 45 kWh (Huber Technology, 2023). Mesnard (2021) states that treating surface water is more energy efficient than treating groundwater or seawater. This is because surface water can be purified at a lower pressure by using ultraviolet filtration or chlorination. Surface water treatment technologies use less than 0.05 kWh/m$^3$of water, whereas groundwater and seawater use over 6 kWh/m$^3$ of water (Mesnard, 2021). The high energy use is attributed to the extreme pressure that is required for reverse osmosis.

On the other hand, the water for energy perspective highlights how the generation of electricity is reliant on the availability of water. Kings *et al.* (2013: 117-215) posits that thermoelectric power plants are dependent on the availability of water. Thermoelectric power generation extracts high volumes of freshwater, which is heated and converted into steam to turn turbines, resulting in kinetic energy. In addition, freshwater is a central part to the cooling systems involved in thermoelectric power generation (Pan *et al.*, 2018: 26-41). This is especially important in the context of South Africa because the country's energy mix consists primarily of energy generated from burning coal. Akinbami, Oke, and Bodunrin (2021: 5077-5093) state that 85 percent of the country's energy is generated through burning coal. Thus, the country is overly reliant on thermoelectric power generation. Markus (2018: 8992-8996) sheds light on the relationship between the availability of water and the generation of thermoelectric power in South Africa. Eskom generates 44134 MW of energy, of which 36441 MW are generated by thermoelectric power plants (Markus, 2018: 8992-8996). The thermoelectric power plants required between 245000 and 292000 mega litres of water in 2019 (Hattingh, 2021: 15). The energy generation shortfall varies between two to six Gigawatts depending on Eskom's energy availability factor (EAF), which stood at 58 percent in 2022 (Council for Scientific and Industrial Research, 2023).

The introduction of stage five and six loadshedding has resulted in loadshedding occurring more frequently and for longer durations. Under these stages, municipalities face up to nine hours of power interruptions. By nature, gravity fed WSS are more likely to experience negative trade-offs when the energy subsystem of the water-energy nexus is disrupted. This is highlighted by the fact that water distribution accounts for 75 percent of energy used by wastewater treatment plants and the WSS (Sharif *et al.*, 2019: 520-521). The inherent risk associated with gravity fed WSS are recognised by Rand water (2022: 19). The water supplier views infrastructure failure as the second biggest risk to its business operations, highlighting the potential failure of pump stations and reservoirs as causal events that could disrupt its ability to supply customers with potable water (Rand Water, 2022: 19). Outages at pump stations, coupled with outages at booster pumps, would prevent water from being distributed among the WSS network (Water Research Commission, 2019: 74-92). These cease the transfer of water into reservoirs, which could create a situation where the reserves in the reservoirs are depleted, thus necessitating the implementation of preventative measures like water-shedding to protect the available supply of water in reservoirs. To this effect, the Department of Water and Sanitation (2023) has proposed the implementation of water-shifting. This means that water will be shifted between low-lying areas with high water pressure, to high-lying areas with low water pressure.

Therefore, loadshedding contributes to water inequality because it prevents boost pumps from pumping water to residents in higher-lying areas (City of Tshwane, 2022). This creates a service delivery challenge because potable water is not provided to households in an equitable or sustainable manner. Rather, the delivery of water and sanitation services is sporadic and depends on the duration of loadshedding, water demand, and water-shedding measures.

Figure 3 below shows the water-energy nexus from the energy for water perspective. First, Figure 3 shows out that loadshedding causes primary water pump stations to stop functioning. As consumers use the existing supply of water within the system, the internal pressure of the WSS starts to decrease. Secondly, loadshedding is instituted city-wide and not just limited to a specific neighbourhood, causing booster pumps to sporadically go offline. The booster pumps play an integral role to the functioning of the gravity fed WSS. As they fail, consumers in higher areas will be left without water because functionally speaking, it is impossible for the existing supply of water in the WSS to reach them, thus inducing water-shedding. However, low-lying areas will still receive water flowing from reservoirs into the WSS via gravity. However, to protect the remaining water supply, water-shedding is implemented as a preventative measure, thus ensuring that the reservoirs do not reach critically low levels.

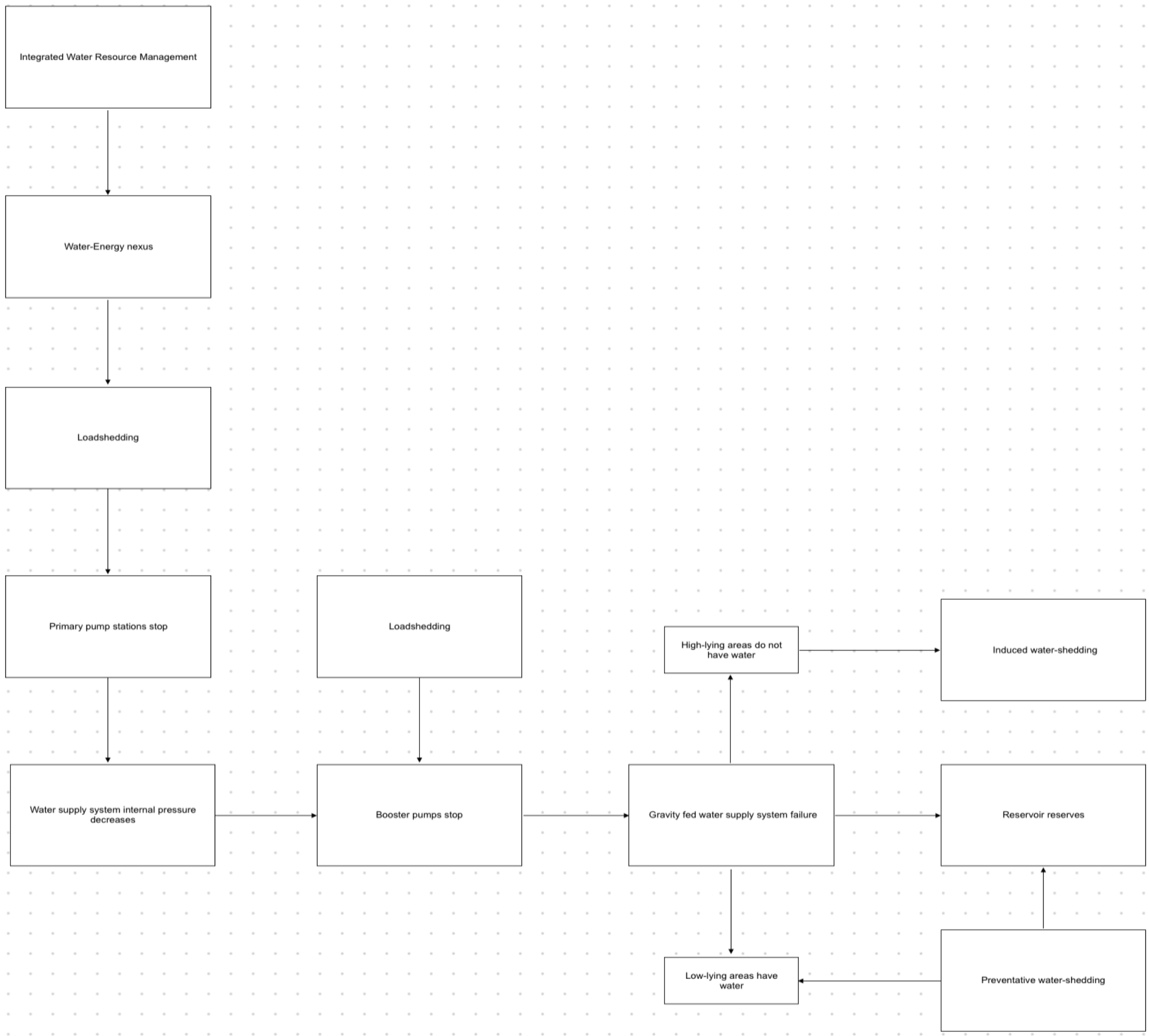


Figure 3: The impact of loadshedding on the water supply system
(Source, Researchers' own, 2023).

IWRM can be applied to address the challenges posed by loadshedding. It does this by taking an integrated and holistic, systems-based approach to managing water resources. IWRM is also participatory, in line with Habermas's theory, meaning that stakeholders can work together to identify water governance issues and loadshedding issues from an institutional perspective (Brown, 2014: 1-16). This would allow strategies to be developed to mitigate the risks that loadshedding has on water governance. For example, IWRM can help prioritise the allocation of limited water resources during periods of loadshedding to ensure that critical water needs are met. In addition, IWRM can help promote sustainable practices for managing water and energy resources. By considering that loadshedding will not be fixed over the short-term and that water demand will increase in the future, IWRM allows stakeholders to focus on renewable energy sources to alleviate the influence of loadshedding on water governance

(Nuwater, 2023). Overall, IWRM provides the study with a framework through which it can address the interdependency between water and energy systems, which is essential for effective water governance in the face of loadshedding.

The theory was chosen because it applies strict parameters to water governance. The parameters that it applies are sustainable water provisioning through the management of the environmental water cycle and urban water cycle. The theory contributes to the development of knowledge pertaining to water provisioning, water retention, and capacity in relation to the possible influence that interrupted energy generation capacity has on the urban water cycle. IWRM boasts strengths in its comprehensive approach to societal water management, perceiving it as an integrated system. It also recognizes the governance dimension as a significant influence on water management. Moreover, by conceptualizing water management holistically, it underscores the importance of infrastructure in both retaining and providing water (Vásquez, 2017: 2-11). Effectively allowing a firm theoretical basis upon which the topic under question is explored.

IWRM posits that there is a direct dependency between water resource management and the quality of water resource governance. Global Water Partnership (2020) adds that IWRM is a coordinated water resource management process that reflects the interconnected and cross-sectoral nature of water resource management. As a water management theory, it has shifted the focus from expanding government's ability to supply water to managing and improving the demand aspect of water management (Claassen, 2013: 323-338). Interesting to note is the conceptualisation of adaptive IWRM by Palmer and Munnik (2018: 1). They supplement the meaning of IWRM by positing that IWRM is an adaptive water management system that sets out processes that enable us to understand socio-ecological issues in relation to water resource management. The theory is underpinned by the following set of principles: (i) it ensures alignment between formal governing institutions and informal water management practices; (ii) it acknowledges the interrelation between water and energy, and (iii) it pursues water equity (Bahri, 2012: 18-25). The current approach towards IWRM is built upon the Dublin Statement on Water and Sustainable Development (1992), which sets out four guiding principles as indicated below:

- The first Dublin principle recognises that water is essential to sustaining life. In doing so, it envisions a balanced approach between socio-economic development and environmental sustainability.
- The second Dublin principle views public participation and institutional awareness as essential in ensuring efficient water utilisation.

- The third recognises the role of women in managing water resources. In doing so, it links with the second principle by demanding that women are included in decision-making.
- The fourth principle recognises that water is a human right and should be treated as a scarce commodity. This changes institutional behaviour towards safeguarding scarce water resources through the efficient and effective management of available supply (United Nations Documents, 1992).

Galvez and Rojas (2019: 179-191) set out the following drivers that influence public participation under the second Dublin principle:

1. Conditions for success- Existence of tangible resources (human, financial and physical), setting clear goals for the participatory process, and the existence of a conducive legislative environment.
2. Obstacles- Lack of institutional, political, and financial will for public participation, lack of clarity on what the role of inputs will be in crafting the final policy, and a lack of clear, decisive leadership.
3. Benefits- The policy will be accepted; participants will trust the policy solution that has been crafted, and the system will be more sustainable.
4. Costs- Slow decision-making process, disagreement, and social conflict among stakeholders and logistical expenses.

Derman and Prabhakaran (2016: 644-661) critique the third Dublin principle for failing to structurally change the role of women in IWRM. In the Southern African Development Community (SADC), the following challenges remain: (i) Limited integration of gender in IWRM; (ii) Inadequate participatory capacity of women; (iii) Inadequate capacity of service providers to consult women, and (iv) Non-recognition of women's role in IWRM. Derman and Prabhakaran (2016: 644-661) posit that access to water in the commercial sense is limited by access to land. Access to land is a contentious issue in South Africa and women are usually excluded from holding land in traditional areas. Thus, customary law should be implemented to give recognition to women's right to use water.

IWRM has three main policy objectives, namely ecological integrity, equity, and efficiency (Meran, Siehlow, & von Hirschhausen, 2020: 23-121). Equity denotes the fundamental human right to access an adequate quality and quantity of water. Ecological integrity means that in provisioning the required quantity and quality to sustain human activities, regard should be given to preserving the total available amount of water within the environment, empowering and enabling future generations to meet their own water demands. This ensures the sustainable use of water through appropriate collection and retention methods. IWRM consists of two interrelated and interdependent cyclical systems, known as the natural and human systems. Whereby the human system refers to the part of the water cycle in which humans consume water for their sustenance and agricultural, industrial, recreational, and sanitation needs. Thus, the human system involves the use of infrastructure to alter the natural water system, allowing for urbanisation (Meshesha & Khare, 2019: 2).

The natural system includes the processes of water vaporisation, water condensation, and rainfall. The natural system is mainly composed of natural bodies of water. These bodies of water are affected by the human system, through water pollution and waterlogging. The human system also diminishes the total capacity of the natural system by failing to retain water within urban environments (Meshesha & Khare, 2019: 2). In this regard, Galvez, and Rojas (2019: 179-191) differentiate between integration in the natural system versus integration in the human system. On one hand, integration in the natural system entails (i) Integrating land and water; (ii) Integrating the management of surface and groundwater; (iii) Integrating the differing interests of stakeholders up-stream and down-stream, and (iv) Integrating the management of freshwater and seawater. On the other hand, integration in the human system entails (i) A holistic institutional approach; (ii) Incorporating poverty alleviation in resource planning; (iii) Making water resource planning a national security issue; (iv) Integrating across management levels, and (v) Involving stakeholders in the planning and decision-making processes (Galvez and Rojas, 2019: 179-191).

IWRM seeks to transform the traditional method of managing water resources. It does this by amalgamating water storage, distribution, treatment, recycling, and disposal into a single water management cycle. The amalgamated cycle is known as the urban water cycle. It comprises six stages, encompassing source, water treatment, water storage, water distribution, collection, and water treatment, with each stage contributing to the overall water management process (Jensen, 2019). In being a cross-sectoral and multi-stakeholder process of water management, IWRM requires a strong good governance component to ensure successful implementation. Water governance is conceptualised as the rules and processes pertaining to the management of water resources. It is a participatory approach that includes stakeholders in water resource management projects enabling accountability of outcomes (OECD, 2015). The Stockholm International Water Institute (2023) posits that water governance is an interrelated process composed of political, economic, and administrative components.

The fundamental governing aspects concerning Integrated Water Resources Management (IWRM) encompass: (i) Formulation and Tactics, (ii) Synchronization, (iii) Strategizing and Readiness, (iv) Financial Support, (v) Administrative Structures, (vi) Surveillance, Assessment, and Knowledge Enhancement, (vii) Oversight, and (viii) Enhancement of Competencies (Jiménez et al., 2020: 6-7).The functions should be embedded within the following good governance principles: (i) Participation, (ii) Rule of Law, (iii) Transparency, (iv) Responsiveness, (v) Consensus Oriented, (vi) Equity and Inclusiveness, (vii) Effectiveness and Efficiency, and (viii) Accountability (United Cities and Local Governments Asia-Pacific, 2021). In comparing Jimenéz *et al.* (2020: 6-7) with the Department of Water Affairs (2013: 15-16), the advantages are derived as follows. First, it allows for the development of a comprehensive framework for managing water resources. This framework ensures that water resources are administered equitably and sustainably. The framework ensures that all the involved stakeholders have common objectives, allowing their actions to be coordinated to achieve good water governance. Secondly, it enhances transparency and accountability in water governance. This can be achieved through a participatory approach that enables all stakeholders to participate in an informed manner. Thirdly, it builds trust between the different stakeholders involved in water governance, which ensures that all parties involved in water governance are committed to working towards achieving shared objectives. Fourthly, it helps to ensure that water governance is sustainable in the long term. This is achieved by developing sustainable financing mechanisms and ensuring that water management plans are aligned with long-term environmental goals. Finally, it ensures that water governance is adaptable to changing circumstances.

Varis et al. (2014: 436-438) sets out the shortcomings of water governance as (i) Sectoral fragmentation, (ii) Institutional and coordination issues, (iii) Weak law enforcement capabilities, (iv) Lack of demand management, (v) Lack of water reuse and water saving, (vi) Legislative centralisation versus decentralisation issues, and (vii) Crisis-management approach. The human system within IWRM in the South African context is influenced by administrative decisions taken by municipal councils. The stages that are especially vulnerable to the effects of poor governance practices are water storage, water distribution, and water collection, providing the necessary theoretical link between IWRM and Theory of Good Governance (ToGG).

### 2.5.2. Theory of good governance from the "efficiency and effectiveness" perspective

The idea of government is not new. Governance is the process of making decisions and how those decisions are carried out. Good governance includes political actors and the internal administrative structures that impact the attainment of established objectives (United Nations

Office of the High Commissioner for Human Rights, 2023). The theory of governance in water governance, from an efficiency and effectiveness standpoint, focuses on fulfilling optimal resource allocation, reducing waste, and making sure the desired objectives are attained with the available resources.

The most notable discussion of good governance theory was done in the essay *Farang Sakdina* by M.R. Kukrit Pramoj in 1957 (Waters, 2022: 1-11). The theoretical proposition suggests that the ethical and acceptable execution of governmental responsibilities is contingent upon officials adhering to the principles of good governance like being responsive to community needs, being transparent and upholding the rule of law. This means that government works for the betterment of the people (Council of Europe, 2023). The theory of good governance suggests that a public service guided by values such as accountability, social responsibility, transparency, public participation, and ethics will result in government policies and services that are more attuned and responsive to the needs of the community. The United Nations Office of the High Commissioner for Human Rights (2023) posits that good governance is determined by the degree to which political and administrative institutions implement cultural, economic, civil, and social rights. Good governance consists of three distinct dimensions that regulate behaviour. These are the rule of law dimension, the institutional dimension, and the democracy dimension (Addink, 2017: 1-5).

How is good water governance ensured then? The effective participatory management of water requires effective co-production. This is the collective process in which organisational decisions are made on how to bring different stakeholders together in the policy-making cycle. Daniel (2012) suggests the following to improve water governance:

- Monitoring and Evaluation: For evaluating the efficacy of governance strategies, regular monitoring and evaluation of water management techniques are essential. Indicators of performance, data collection, and analysis should be used to track accomplishment of objectives, pinpoint areas for improvement, and create adaptive management methods.
- Adaptive Management: Governance systems must be adaptable and agile given the changing problems and the dynamic nature of water resources. Governance is kept efficient and responsive by routinely reviewing and revising policies and management strategies considering new knowledge, scientific developments, and evolving conditions.

It is crucial to keep in mind that governance theories may overlap and that some ideas may be more appropriate to certain situations. These principles can improve efficiency and effectiveness in water governance frameworks.

Good governance theory provides an implementable framework that ensures ethical and moral governance, though with shortcomings. First, it ignores the influence of power dynamics. The inequalities present in different societies, classes, and institutions distort the degree to which effective participation can take place, thus limiting good governance. Secondly, the principles of good governance are culturally insensitive. They are developed according to the characteristics of Western liberal democracies, meaning that there could be a misalignment with non-Western cultures (Asefa & Wang, 2018: 131-153). Thirdly, it focuses heavily on transparency and accountability, overlooking non-procedural elements. Next, it overlooks the underlying issues that cause poor governance, such as political culture. Rather, it focuses on trying to improve governance by improving technical issues like institutional efficiency. Lastly, it is argued that good governance ignores the implications of asymmetrical power relationships. Multinational corporations, politically connected individuals, or extremely wealthy individuals have the means to subvert good governance (Moon, 2019: 1-9).

ToGG was chosen because it allows the study to explore how existing governance relationships within the Mangaung Metropolitan Municipality affect water governance and service delivery. It further provides categories for assessment that can be comparatively applied to MMM. These areas for assessment allow the study to extract contributory reasons for poor water governance in MMM. Whilst, providing a set of recommendations based on theory, which would allow the MMM to improve its water governance. The main strength of this theory is that it broadens the theoretical base from an infrastructural base to a human behavioural base (Katusiime & Schütt, 2020: 1-22). It is this theoretical shift that allows the study to showcase how ineffective water governance leads to poor management, which in turn causes resource limitations, operational challenges, ineffective service delivery, and inefficient policy implementation. Good governance theory thus allowed the study to evaluate the management of the environmental water cycle and urban water cycle.

Good governance requires government to be responsive to the needs of citizens and to be effective in its execution of policies and programmes (Linde & Peters, 2020: 291-304). The South African government was not responsive or effective in the way that it addressed the warnings of the White paper on the Energy Policy of the Republic of South Africa (1998). The White Paper warned government that the existing surplus in the supply of electricity would be used up by 2007. Rather than being proactive, the government took a reactive approach and only commenced with the construction of the Medupi and the Kusile power stations in 2007 and 2008, respectively (Eskom, 2023). The slow response from government has resulted in worsening loadshedding, which has ultimately affected the operational capacity of Wastewater Treatment plants and water supply systems.

This has been compounded by the lack of regular maintenance in municipalities. Subban and Jarbandhan (2019: 134-157) state that the absence of infrastructure maintenance points to poor public sector management and a disregard for good governance principles.

Poor governance is evident in the dire state of wastewater treatment plants. Out of 824 wastewater treatment plants, only 60 are fully operational and providing municipalities with safe drinking water (Gumede, 2022). Worryingly, 60 percent of the wastewater treatment plants in the country have been identified as being in a critical condition (Gumede, 2022). Mutamba (2019: 51-53) highlights the dire state of water infrastructure in South Africa as set out in the 2017 SAICE infrastructure report card, where national water resources infrastructure scored a D, urban infrastructure scored a $D^-$ and bulk regional infrastructure scored a $C^+$.

| A | B | C | D | E |
|---|---|---|---|---|
| World class | Fit for the purpose | Satisfactory for now | At risk of failure | Unfit for purpose |
| Infrastructure is comparable to the best internationally in every respect. It is in excellent condition and well maintained, with capacity to endure pressure from unusual events. | Infrastructure is in good condition and properly maintained. It satisfies current demands and is sufficiently robust to deal with minor incidents. | Infrastructure condition is acceptable, although stressed at peak periods. It will need investment in the current medium-term expenditure framework period to avoid serious deficiencies. | Infrastructure is not coping with demand and is poorly maintained. It is likely that the public will be subjected to severe inconvenience and even danger without prompt action. | Infrastructure has failed or is on the verge of failure, exposing the public to health and safety hazards. Immediate action is required. |

Figure 4: SAICE infrastructure score card
(Mutamba, 2019: 51-53).

The 2022 South African Institution of Civil Engineering (SAICE) infrastructure report card indicates that the country's water infrastructure has deteriorated further, with 72 percent of WSAs failing to score a good Green Drop rating (South African Institution of Civil Engineering, 2022: 24-28). Hence, it is not surprising that only 40 percent of the country's WSS comply with microbiological water quality standards (South African Institution of Civil Engineering, 2022: 24-28).

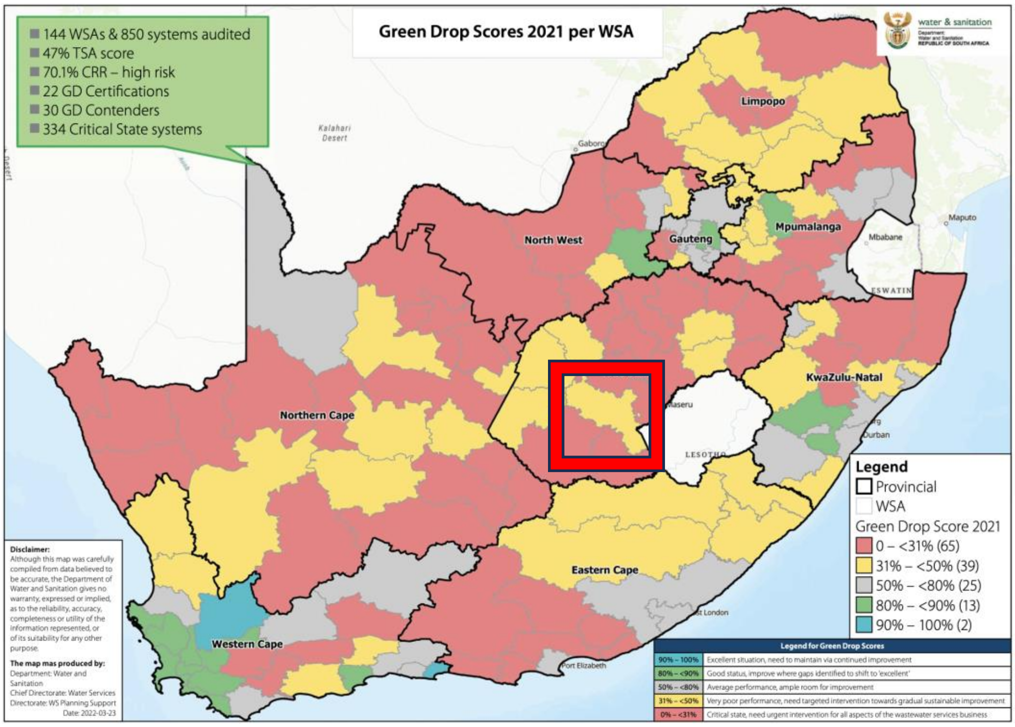


Figure 5: WSA Green Drop scores

Source: South African Institution of Civil Engineering (2022).

Figure 5 shows MMM that has poor water infrastructure and thus needs targeted intervention. This is because MMM has relied on the gravity fed Welbedacht pipeline for 70 percent of its potable water supply, despite the pipeline having reached its design life cycle (Department of Water and Sanitation, 2023). Thus, lack of foresight by MMM and Bloemwater has subjected the citizens of MMM to an unreliable water supply. The Welbedacht pipeline can only provide 187 million litres of water per day; however, the demand is roughly 248 million litres of water per day (Department of Water and Sanitation, 2023). To Bloemwater's credit, it is nearly completed with phase one of the Welbedacht pipeline's augmentation and it has made the construction of the pipeline between the Lieuwkop junction and the Brandkop reservoir a priority project. It has also finished the construction of the Brandkop hydropower plant, which can generate 96 kilowatts of renewable energy (Bloem Water, 2023). Once fully operational, it will allow the Brandkop reservoir to pump water through the WSS, which will minimise the impact of loadshedding on the WSS in MMM.

### 2.5.3. Theory triangulation

Effective water resource management is crucial at the municipal level, where governance plays a pivotal role in its practical execution. To comprehensively understand the dynamics and impacts of water governance, this study adopted a unique approach by integrating two theories, namely the Integrated Water Resource Management (IWRM) and the Theory of

Good Governance (ToGG). IWRM serves as the fundamental theoretical basis for this study, focusing on the infrastructural aspects of water governance. It facilitates a conceptual distinction between the natural system within the water cycle and the human system responsible for managing water resources. However, relying solely on IWRM would have limited our ability to address important factors like efficiency and effectiveness in water governance.

To address these limitations and gain deeper insights into the decision-making processes and human behaviour influencing water governance, the Theory of Good Governance was integrated into the study. By leveraging ToGG, we could analyse the role-players' decisions and actions that impact the infrastructural aspect of water governance. In simpler terms, IWRM emphasises the physical and engineering aspects of water resource management, while ToGG focuses on the social, political, and behavioural dimensions that influence the maintenance of water infrastructure.

The primary objective of this study was to explore the causal relationship between loadshedding and water governance in Mangaung Metropolitan Municipality. By employing both IWRM and ToGG, we can holistically assess how decisions made by the municipal council and human behavioural factors contribute to the challenges faced in water infrastructure maintenance. Ultimately, the integration of these two theories allowed us to achieve a holistic understanding of how loadshedding influences water governance. By shedding light on the interplay between the natural system, the human system, and decision-making processes, this study contributes valuable insights to support the development of more effective and sustainable water management strategies.

## 2.6. LEGISLATIVE FRAMEWORKS

This section discusses legislation relating to the influence of loadshedding on water governance in the Mangaung Metropolitan Municipality. The Constitution of the Republic of South Africa, 1996; the Municipal Systems Act (Act 32 of 2000); the National Water Act (Act 36 of 1998); the National Water Resource Strategy, and the Water Services Act (1997) are discussed.

### 2.6.1. The Constitution of the Republic of South Africa, 1996

The Constitution of the Republic of South Africa, 1996 (the Constitution), articulated in Chapter 2, Section 27(1)(b), asserts the entitlement of every person within the nation's borders to an adequate supply of water. Consequently, the highest law of the Republic stipulates that the state must enact laws to actualize these fundamental rights. In terms of the study, this means that MMM is constitutionally obligated to ensure effective water governance. In effect, MMM is mandated to take emergency measures during loadshedding to ensure that water services are not disrupted. Local government's duties in the realm of water governance encompass stormwater management systems in urbanized areas, municipal public works, and the provision of water and sanitation services, including the supply systems for potable water, domestic wastewater, and sewage disposal (Department of Justice and Constitutional Development, 2017). In contrast to the right to access to water, the Constitution does not explicitly guarantee the right to electricity. Rather, the right to electricity is implicitly bundled up within the right to life and the right to dignity (The Constitutional Court of South Africa, 2022).

Chapter 3, Section 40 (1) of the Constitution establishes the three spheres of government, namely the National, the Provincial and the Local. The three spheres are described as being interrelated, interdependent, and distinctive. In this regard, Chapter 3, Section 41 (1)(h) mandates that the three spheres of government coordinate with one another by maintaining friendly relations; providing support; collaborating on common interests; coordinate policies; abiding by intergovernmental processes and refraining from taking legal action against one another. To ensure that all three spheres of government effectively work together, Chapter 3, Section 41 (2)(a) mandates parliament to enact legislation that establishes institutions to facilitate intergovernmental relations.

This highlights how the interrelatedness of different spheres of government can be a functional weakness. Water governance is largely the responsibility of local government. However, as discussed in the literature review, there is a water-energy nexus. Eskom is a state-owned entity under the jurisdiction of the national government, thus highlighting how loadshedding could have cascading effects on other spheres of government.

### 2.6.2. National Energy Act (Act 34 of 2008)

Section 2 of the National Energy Act (Act 34 of 2008) sets out the objectives of the Act: (i) Ensure a constant supply of energy; (ii) Ensure the effective management of energy demand; (iii) Balance the optimal supply of energy with sustainable development, consumer protection, economics and energy security; (iv) Facilitate access to energy, allowing quality of life improvements; (v) Energy supply, consumption and transportation should be underpinned by effective planning, and (vi) Contribute to sustainable development in South Africa. Thus, the National Energy Act (the Energy Act) emphasises sustainable development through the effective planning and management of electricity supply. Section 5(1) of the Energy Act (2008) mandates the Minister to put measures into effect that ensure universal access to energy. The measures should consider (i) Availability of energy resources; (ii) Optimisation of existing energy infrastructure; (iii) Sustainability; (iv) Affordability; (v) Cost-effectiveness, and (vi) Governance procedures as highlighted in the Public Finance Management Act (1999). Therefore, universal access to energy can be restricted on the basis that there are inadequate energy resources available.

### 2.6.3. National Electricity Act (Act 41 of 1987)

The National Electricity Act (Act 41 of 1987) makes provision for the establishment and continuation of the Electricity Control Board. The Electricity Control Board is empowered by Section 4(1)(a) of the National Electricity Act (the Electricity Act) to control the supply and distribution of electricity. Section 17 of the Electricity Act gives the Electricity Control Board the authority to limit the right of local jurisdictions to distribute electricity. In essence, the Electricity Act regulates the construction of new power plants, including electricity transmission lines.

### 2.6.4. Municipal Systems Act (Act 32 of 2000)

The Municipal Systems Act (Act 32 of 2000), Chapter 2, Section 3(1) mandates municipalities to exercise their legislative and executive authority in line with chapter 2, Section 41 of the Constitution. National government's and local government's administrative jurisdiction over water resources is split. In comparing the Constitution and the Municipal Systems Act (2000), it becomes clear that national government has both legislative and executive authority over freshwater resources. This means that it has authority over the administration of the natural water cycle. However, it is local government that has administrative authority over the urban water cycle through its responsibility to collect, treat, and purify wastewater to provide potable water to communities (Toxopeüs, 2019). In other words, local government is responsible for effective water governance in its jurisdiction. By legal extension, this includes the maintenance and expansion of the water retention, purification, and provisioning infrastructure. For this study, the legislative focus was on local government, given that the case study is the Mangaung Metropolitan Municipality.

### 2.6.5. National Water Act (Act 36 of 1998)

The purpose of the National Water Act (Act 36 of 1998) is set out in Chapter 1, Section 2 of the National Water Act (the Water Act). The act sets out to protect and manage the country's water resources by ensuring equitable access to water, sustainable water use, planning for increased water demand, and preventing water pollution. Chapter 1, Section 3(1), affirms that the national government serves as the custodian of the nation's water resources and executes this role through the Minister of Water and Sanitation. Thus, the Water Act gives effect to Chapter 2, Section 27 (1)(b) of the Constitution of the Republic of South Africa, 1996. The Water Act achieves this by mandating, in part 1 of Chapter 2, Section 5(1), that the Minister establishes a national water resource strategy (National Water Act, 1998).

### 2.6.6. National Water Resource Strategy

In line with Chapter 2, Section 6 (1) of the National Water Act (Act 36 1998), the national water resource strategy contains the objectives, procedures and plans of the Minister to protect water resources; actions taken to meet future water needs; establish water management areas, and objectives for water management institutions. The national water resource strategy is updated every five years to ensure that it accurately addresses the risks to the nation’s water resources. The national water resource strategy is in line with achieving the goals set out in the Sustainable Development Goal 6 agreed to at the United Nations Conference on Environment and Development (United Nations, 2023). The goals are (i) access to safe drinking water; (ii) hygiene to all; improve water quality, (iv) improve water use efficiency across all sectors; (v) implement integrated water resource management at all levels and restore water-related ecosystems (United Nations Development Programme, 2023).

The third national water resource strategy encompasses three overarching goals. The initial goal emphasizes that water and sanitation should bolster economic development for poverty eradication. This objective entails augmenting water supply, efficiently managing water and sanitation services, and regulating the water and sanitation sector. The second goal focuses on the contribution of water and sanitation to economic growth and job creation. This is realized through initiatives such as diminishing water demand, ensuring equitable water redistribution, and fostering international cooperation. The third goal emphasizes the imperative to safeguard, conserve, and sustainably manage water in an equitable manner. This goal is achieved by adaptively managing water and sanitation in relation to climate change, improving the quality of raw water, and restoring and protecting water-related ecological systems (Department of Water and Sanitation, 2022).

### 2.6.7. Water Services Act (Act 108 of 1997)

The primary goals outlined in Chapter 1, Section 2 of the Water Services Act (Act of 1997) include (i) ensuring the right to basic water supply and basic sanitation, (ii) fostering effective water resource management, (iii) establishing regulations, and (iv) setting up water boards. Chapter 3, Section 11 of the Act highlights the responsibilities of water service providers.

These include to ensure equitable and sustainable water services, avoid not providing water services to any customer or would be customer in its jurisdiction on unreasonable grounds, take reasonable measures in an emergency to provide basic water services and basic sanitation to any person within its jurisdiction, and impose reasonable limitations on water services if required. This allows MMM to carry out its duties as a water services authority. MMM acts in this capacity through the municipal entity, Bloemwater. Considering the occurrence of water-shedding in other municipalities in the country, the WSA allows for the following limitations on minimum basic water supply (Ntuli, 2023). A minimum of 25 litres of potable water per person per day with a minimum flow rate of 10 litres per minute (WSA, 1997). The water source must be within 200 meters of a household and must effectively supply water so that no resident is without water for more than seven days per year (Joubert, 2022).

## 2.7. CONCLUSION

This chapter explained the study's key concepts, namely loadshedding, water governance, and local government. Loadshedding was defined as the process entailing scheduled and intentional power interruptions, where specific sections of the electrical distribution system are deliberately turned off. Water governance was defined as encompassing the collective arrangement of socio-economic, political and administrative systems that impact the administration of transboundary water resources. It entails determining the allocation of water and associated benefits such as electricity generation and agricultural production. Local government was defined as being the closest sphere of government, responsible for service delivery. The conceptual framework set out how integrated water resource management is related to good governance and the research topic through poor infrastructure maintenance which has caused loadshedding. The empirical framework discussed the issue of loadshedding and water governance from the international, regional, national, and local perspectives, highlighting the applicability of the research study in a wider context. The theoretical framework discerned and analysed all the literature relating to integrated water resource management and theory of good governance. It set out the main features of both theories and their shortcomings, highlighting their applicability to the research topic at hand. The chapter concluded with a discussion of the legislative frameworks relating to the research topic, namely the Constitution, the Municipal Systems Act, the National Water Act, the National Water Resource Strategy, and the Water Services Act, thus highlighting the legislative foundation upon which the study is built.

# 3. CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1. INTRODUCTION

This section deals with the methodology used in the study, commencing with a thorough examination of the research objectives. Following this, the chapter delves into various components of the research methodology, providing detailed discussions on the research design, research philosophy, chosen research methods, approaches to data collection, procedures for data analysis, considerations of trustworthiness and credibility in qualitative data, as well as an exploration of its scope and delimitations. The ethicality of the research process is also addressed to ensure the responsible conduct of the study.

## 3.2. REVIEW OF RESEARCH OBJECTIVES

For Mangaung Metropolitan Municipality (MMM) to better serve its residents, it is important that political decision-makers and administrative staff understand the influence that loadshedding has on water governance in the municipality. The study sets out to determine the influence that loadshedding has on water governance at MMM. This allows for a possible formulation of mitigatory strategies to minimise the influence of loadshedding on water governance. Moreover, the study aims to assess the influence of loadshedding on the infrastructural capacity of the Mangaung Metropolitan Municipality (MMM) and its ability to uphold effective water governance. Thus, the study would be able to pinpoint infrastructural components that are most susceptible to the possible negative influence of loadshedding, thus enabling corrective measures to be devised, so that the affected infrastructural components can remain functional during loadshedding, by extension ensuring good water governance in MMM. This achieves the study's objective of recommending implementable strategies to improve the relationship between loadshedding and water governance. The proposed strategies would accurately address the energy and water issues faced by MMM. This is done by considering the interconnection between energy and water, allowing the relationship between the two variables to be improved in MMM.

## 3.3. RESEARCH METHODOLOGY

It refers to the manners and methods through which research can be done. There are many ways in which research can be conducted. To conduct research, an approach must be followed. The approach helps one to gather information that will address the study's research objectives. There are two approaches that can be used, namely the quantitative and the qualitative research approaches (Mackey & Grass, 2022). This study makes use of the qualitative research methodology. Qualitative research is about collecting data that are of high quality and is widely varied, which entails looking extensively at data that are non-numerical

(Mishra & Alok, 2022: 3). Statistical analysis or empirical calculations are not used in qualitative research, and this is because this research method is synthetic (Hussain, 2022: 2). However, it involves case study, discourse analysis, grounded theory, logic, and comparative methods (Cibangu, 2012, as cited in Hussain, 2022: 3). The influence of loadshedding on water governance in MMM was investigated using the qualitative research approach. This allowed the research problem to be approached from different perspectives, which guided the study.

### 3.3.1. Research design

The research design serves as a blueprint enabling the researcher to obtain answers to the research questions. It delineates the approach to formulating hypotheses, along with the procedures for implementation and data analysis. Research design is the outline for data collection, measurement, and data analysis. This is important because it allows different research processes to take place, while considering time, funds, and the availability of resources (Dubey & Kothari, 2022). This study used the qualitative research approach and an exploratory research design. Exploratory research refers to an investigation into an unknown issue for which the researcher possesses limited or no knowledge. Often this type of research takes the shape of a preliminary study. The aim of exploratory research is to refine problem formulations, bring clarity to concepts, acquire clarification, gain valuable understanding, discard unrealistic opinions, and to develop speculations (Swaraj, 2019: 665-670). This study used exploratory research because the study sought to explore the effect loadshedding has on water governance in Mangaung Metropolitan Municipality (MMM). Exploratory research empowered the study because it allowed the study to discern the nature of the research problem, allowing it to be ameliorated.

### 3.3.2. Research philosophy

A research philosophy constitutes a set of principles that guide the planning and execution of a study. Different research philosophies offer diverse perspectives on how to interpret scientific research, reflecting the varied approaches to understanding the research process (Tamminen & Poucher, 2020). Research philosophy is additionally characterized as a collection of assumptions regarding the process through which knowledge is developed (Muhaise *et al.*, 2020). When a scholar starts the procedure of conducting research, they are on a quest to gain knowledge in the specific topic or area of study, resulting in a new body of knowledge in the form of a theory. Simultaneously, the researcher attempts to formulate a solution to an existing problem (Muhaise *et al.*, 2020).

All scholarly endeavours are predicated on philosophical tenets, and it is widely held that every methodology employs philosophical presumptions and practices (Abu-Alhaija, 2019: 122-128). The following are the tenets held by scholars who follow the positivist research philosophical paradigm. The character of reality ontology is a reality that exists outside of ourselves and is unrelated to our cognitive processes (Ganesha & Aithal, 2022: 42-58). There is only one real reality. The social world and universalism are composed of discrete, constant elements (Ganesha & Aithal, 2022: 42-58). Positivists emphasise on only rigorously scientific empiricist methods that produce accurate information free from bias or human interpretation (Muhaise *et al.*,2020).

The following are the philosophical tenets held by researchers who adopt the interpretivist study paradigm. Actuality's essence ontology is intricate and rich. It has many different meanings, theories, and experiences, and is socially produced through culture and language. A variety of procedures, events, and customs are under revolution (Ganesha & Aithal, 2022: 42-58). In addition, the epistemology that derives from theories and notions is oversimplified in terms of the nature of knowledge (Ganesha & Aithal, 2022: 42-58). Reality may be seen and measured (Ganesha & Aithal, 2022: 42-58). Narratives, stories, perspectives, and meanings must be the centre of attention.

Since people construct meaning, interpretivism emphasises how people vary from phenomena (Muhaise *et al.*, 2020). It is a pertinent intellectual tradition for conceptualising qualitative studies (Huddleston, Jamieson, & James, 2022). Interpretivists examine these implications; therefore, the body of knowledge they create is likewise influenced by their perspectives and beliefs. This ties their work to social construction (Huddlestone, Jamieson & James, 2022).

### 3.3.3. Research method

Research methodology refers to the manner through which information regarding a specific topic is identified, selected, processed, and analysed (Parsons *et al.*, 2023: 902-910). Thus, the research method explains how relevant data were captured and how these data were analysed to form valuable information. Ultimately, it is the information generated out of data analysis that is used to address the study' research questions (Sileyew, 2019: 1-12).

The study used the qualitative research method. As a research approach it allowed the researchers to collect data regarding the influence of loadshedding on water governance at Mangaung Metropolitan Municipality (MMM). The qualitative research approach suited this study because it was a desktop study that used secondary sources of data. Busetto, Wick, and Gumbinger (2020: 1-3) characterize qualitative research as an examination of the essence of phenomena, emphasizing aspects such as quality, variations of manifestations, context, and perspective. Thus, qualitative research allows explanations to be formulated for newly identified observed patterns. Interpretivism is one of the main paradigms associated with qualitative research. Interpretivism entails the researcher understanding the "world" within which the researched "phenomena" is taking place. This includes understanding the subjective intentions of actors, concepts, ideas, images, and thoughts (Sanchez *et al.*, 2023: 2-3). This allows for the life-world perspective to be observed. However, applying the interpretivist lens requires that the focus should be on the actor's experience; observations should be non-prejudicious, and (iii) observations should expand the researcher's belief-system premised on theory (Sanchez *et al.*, 2023: 2-3). Thus, interpretivism entails investigating a phenomenon from different perspectives and describing the phenomena in a subjective manner.

In this study, the interpretivist approach was augmented with inductive reasoning. There are two models of inductive reasoning, namely the similarity-based model and the concept-based model (Liu *et al.,* 2019: 1-3). The similarity-based model is premised on the perceptual similarities between two objects. For instance, if items B and C exhibit pre-existing similarities, it can be inferred that if item B possesses a certain characteristic X, it is probable that item C would also share this characteristic X (Liu *et al.*, 2019: 1-3). The concept-based model is premised on conceptual commonality rather than perceptual similarity. This means that logic is derived from existing knowledge about a concept or phenomena. Thus, it requires some degree of previously acquired knowledge for successful use in research (Sanchez *et al.*, 2023: 2-3). The study employed the concept-based model.

### 3.3.4. Data collection method

This refers to the techniques employed by researchers to gather information regarding a specific research topic. This allows the research questions to be addressed. The chosen data collection method plays a central role in determining whether the study will solve its research problem (Mwita, 2022: 532-538). In qualitative research, data can be collected either through primary data or through secondary data. In this study, data were collected through secondary sources. Secondary data is data that has been gathered by other researchers in their respective studies (Abu-Taieh, El Mouatasim & Al Hadid, 2020: 29). Since this study is a desktop study, the positions taken, and the subsequent findings were bolstered by secondary data. The study used a systematic literature review to gather relevant information from journals, books, government publications, and websites. Articles pertaining to water governance, good governance, the water-energy nexus, and IWRM were searched from Google scholar, (ii) Elsevier, Science Direct, and JSTOR. The search range for the articles spanned from 2013 to 2023 to ensure academic and scholarly relevance. The systematic literature review was done using document analysis. Document analysis in this study took the READ approach, translating into ready your research material (R), extract data (E), analyse data (A) and explain the findings (Dalglish, Khalid, & McMahon, 2020: 1424-1431). Document analysis was beneficial to the study because it allowed the extraction of context, formulation of questions, showcasing scientific progression, and allowing existing data or knowledge to be corroborated (Dalglish, Khalid, & McMahon, 2020: 1424-1431).

### 3.3.5. Data analysis

This study employed thematic data analysis. It is a qualitative research method that allows the researcher to sort and analyse large data sets (Kiger & Varpio, 2020: 846-854). This is done through identifying interpretive themes. The theoretical flexibility of thematic data analysis allows researchers to pinpoint overarching data patterns within a data set (Dawadi, 2020: 62-71). Thematic data analysis employed the bottom-up approach by using inductive reasoning. This means that the themes derived for thematic analysis were organically produced, emerging out of the associated data sets and not a pre-existing coding framework (Dawadi, 2020: 62-71). Table 1 outlines the themes that were produced and the accompanying codes relevant to each theme.

| **Themes** | **Codes** |
|---|---|
| Good governance and development | Importance of Good Governance; Dimensions of Good Governance; Principles of Good Governance; Relationship between Good Governance and Integrity; Characteristics of Good Governance; |
| Relationship between water and energy | Water-energy nexus; Energy Consumption in Water Sector; Importance of Pumping Station Efficiency; Water Distribution Systems, Measuring Water Quality; Sustainable Development Goal 6 |
| Infrastructure and Maintenance | Infrastructure failure; Inadequacy of Infrastructure; Stressed Water Treatment Plants; Impact of Load-Shedding on Water Supply |
| Integrated Water Resource Management | Natural Water Cycle; Urban Water Cycle; IWRM Approach; Central Components of |

| | |
|---|---|
| | IWRM; IWRM and Planning; Dublin Principles; Principles of IWRM; IWRM capacity building; IWRM framework; IWRM implementation |
| Water Management and Governance | Water management; Asset management; Water inequality; Informed water governance; Water scarcity; Public participation; Sustainability; Collaborative governance; Spatial fit; Water shortage, use, and governance; Community Awareness; Water Conservation |
| Energy insecurity | Impact of unreliable electricity; Loadshedding; Thermoelectric power generation; Water shedding |

Table 1: Themes and codes
(Source, Researchers' own, 2023).

The study used the six-step process of thematic analysis. The six-step process is as follows:

Step 1: Familiarisation
This phase entailed becoming acquainted with the data and reviewing it multiple times. Throughout this stage, the researchers documented the primary concepts that surfaced from the data (Aghdam *et al.*, 2020: 4).

Step 2: Coding
After establishing the themes, the researchers assigned codes corresponding to these themes, laying the groundwork for a holistic exploration of the data. All data was coded by pinpointing the pertinent information requiring categorization (Dawadi, 2020: 62-71). Table 1, above, showcases the codes that were developed.

Step 3: Searching for themes
This step encompassed conducting thematic analysis. Data pertinent to the objectives were structured according to relevance and alignment. The researchers categorized the data into various themes and sub-themes (Aghdam *et al.*, 2020: 4).

Step 4: Reviewing themes

After identifying themes, the researchers conduct a thorough examination, considering whether to merge, enhance, segregate, or eliminate initial themes. It is essential for data within each theme to connect logically, while maintaining distinct boundaries between themes (Dawadi, 2020: 62-71).

Step 5: Refining and naming themes

It entails "fine-tuning and specifying" the themes and possible sub-themes found in the data. Continual analysis was carried out to enrich the established themes. The researchers crafted names for these identified themes and precise definitions that succinctly encapsulate the core of each theme (Aghdam *et al.*, 2020: 4).

Step 6: Producing the report

Ultimately, the researchers translated the analysis into an understandable written piece by incorporating vivid and compelling examples extracted from the data that directly tie to the themes, research questions, and existing literature. This approach surpasses a simple portrayal of themes; it presents an analysis substantiated by factual evidence that tackles the research question and objectives. It is crucial to articulate this within the context of the outlined theoretical framework and underlying assumptions (Aghdam *et al.*, 2020: 4).

### 3.3.5.1. Thematic map

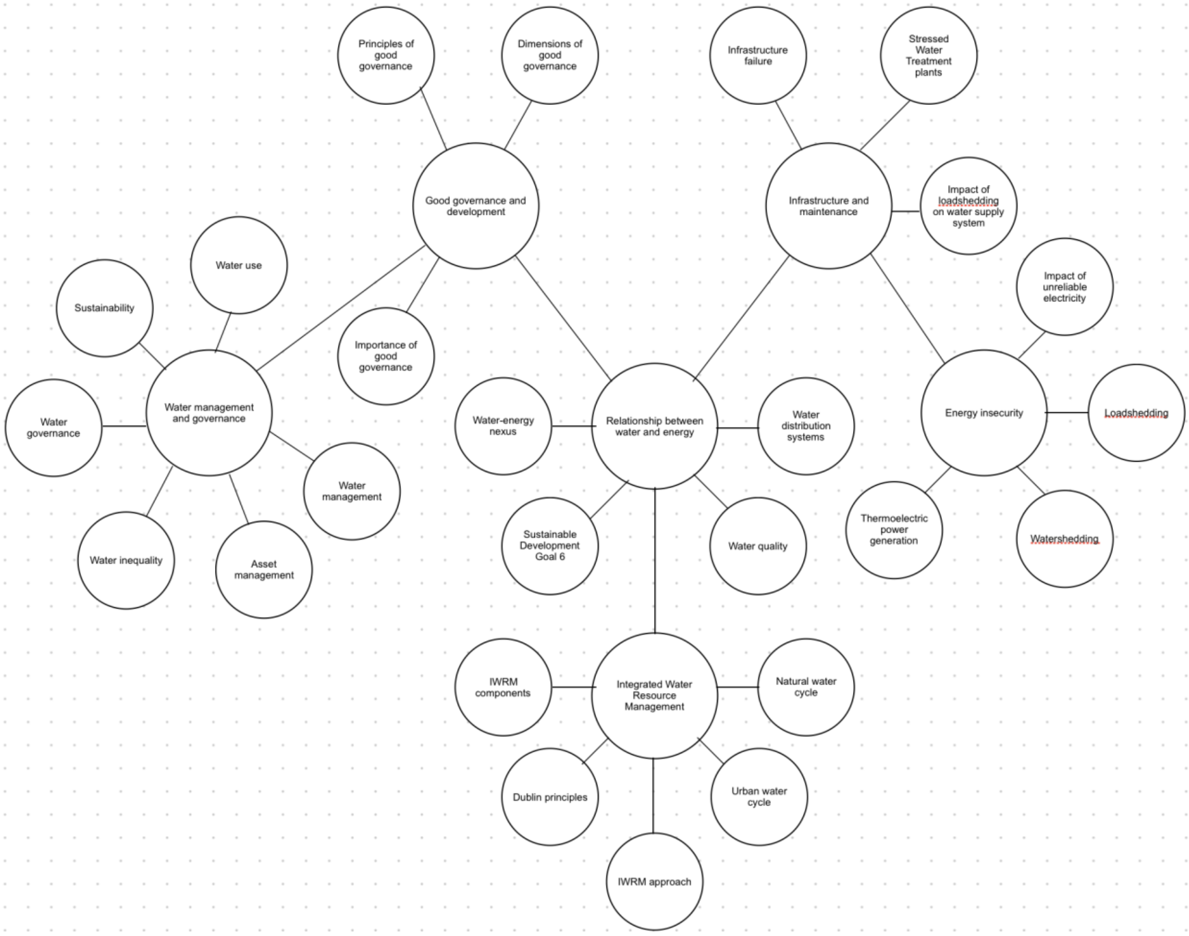


Figure 6: Thematic map
(Source, Researchers' own, 2023).

### 3.3.6. Trustworthiness and credibility of qualitative data

In using qualitative document analysis in this study, the trustworthiness of the study was determined using the following criteria: (i) Dependability, (ii) Confirmability, (iii) Credibility and (iv) Transferability (Nowell et al., 2017: 1-13).

The dependability of the study pertains to the consistency of its results or findings when applied to a comparable scenario. This emphasizes the research's reliability and uniformity. Thus, it focuses on the consistency of the research. The study is dependable if it clearly showcases the research processes used by researchers. The study used bracketing to separate the collected data into observations and interpretations. Thus, the study used the researchers existing biases to interpret data sets. However, the level of bias was moderated using reflexive auditing. Reflexive auditing refers to the process where the researcher's values influence the research, but the researcher can communicate the entanglement that arises (Stahl & King, 2020: 26-28), thus creating trust in the research. Confirmability in research refers to the extent to which data can be employed to support the research findings. The confirmability of the study is ascertained by evaluating its dependability, credibility, and transferability. It specifically centres on the researcher's interpretive process concerning the analysis of data. The credibility of the study refers to whether the research evokes a shared experience in the work of other researchers (Korstjens & Moser, 2018: 120-124).

Triangulation is a common method used to showcase credibility (Stahl & King, 2020: 26-28). Thus, the study used triangulation to ensure credibility. In addition, peer debriefing, in the form of institutional check-ups on the research by the research supervisor, took place. Transferability refers to how generalisable the findings of the research are (Stahl & King, 2020: 26-28). In other words, can the knowledge produced by the findings be applied to other research cases. Transferability was thus achieved when researchers not only provided thick descriptions of not only the water governance challenges within MMM, but also provided the context of the research's transferability to other municipalities.

### 3.3.7. Scope and delimitation

The study was based on the Mangaung Metropolitan Municipality (MMM); thus, the scope of the study was restricted to the geographical location of MMM. Geographically, the study covered the following cities and towns: Wepener, Van Stadensrus, Soutpan, Dewetsdorp, Thaba Nchu, Botshabelo, and Bloemfontein.

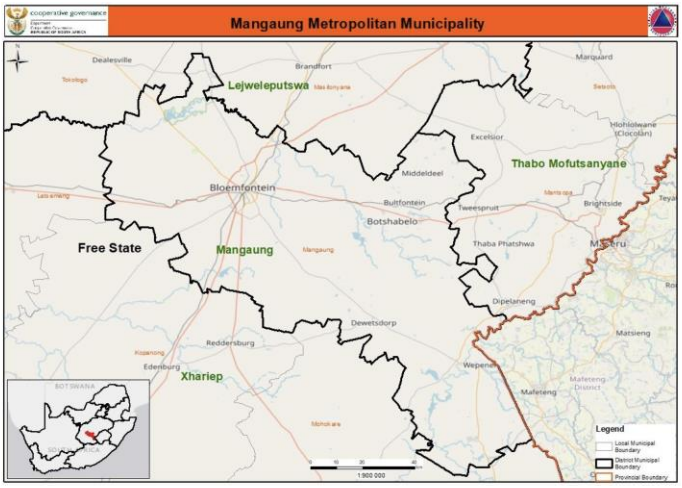



Figure 7: Mangaung municipal boundary
(Department of Cooperative Governance and Traditional Affairs, 2020).
Figure 8: The towns of Mangaung
(Municipalities of South Africa, 2023).

Figure seven is a map that outlines the municipal boundaries of Mangaung Metropolitan Municipality. The figure showcases the geographical position of MMM in the Free State province and it highlights the municipalities neighbouring to MMM. In addition, figure eight showcases MMM in isolation from other municipalities in the Free State. It displays the different towns encompassing MMM.

Since the study is a desktop study, no sampling strategy was employed because it used secondary data. The length of the research spanned 11 months, starting in January and concluding in November 2023. The researchers did not face any financial barriers in conducting the research, owing to all three researchers being funded by the National Research Foundation (NRF). Participation was not a concern in this study because it was a desktop study making use of secondary data sources with no human participants involved.

#### 3.3.8. Ethical considerations

This study is a desktop study making use of secondary data; thus, no participants were involved in data collection. Given the utilization of secondary data in this study, the concept of a sample size was rendered unnecessary. Employing inductive reasoning, the research homed in on a specific problem and progressed towards a conclusion or solution, drawing from dependable and credible secondary data. Significantly, this study was classified as a low-risk investigation since it did not involve human participants in primary data collection. The ethicality of the study was scrutinised by the University of the Free State's General Human Research Ethics Committee (GHREC). Having satisfied the necessary criteria, the study was granted ethical clearance on the 17th of July 2023. The ethical clearance number of the study is UFS-HSD2023/1059.

### 3.4. CONCLUSION

In conclusion, this chapter provided an overview of the research methodology employed in the study. The research objectives were delineated, focusing on understanding the influence that loadshedding has on water governance in MMM, assessing the impact on infrastructural capabilities, and recommending strategies to enhance the relationship between loadshedding and water governance. Hence, to address these objectives, a qualitative research methodology was chosen, specifically an exploratory research design, which allowed for an exploration of the research problem. The interpretivist research philosophy, aligned with the inductive reasoning approach, offered an apt framework for interpreting and comprehending the relationship between load shedding and water governance. Data collection was conducted through a systematic literature review, utilising document analysis to source relevant secondary data. The data analysis process followed the six-step thematic analysis approach, which ensured the identification and refinement of themes out of the data. The scope of the study encompassed the entire MMM, ensuring a comprehensive assessment of the influence that loadshedding has on water governance. Furthermore, the chapter acknowledged the importance of trustworthiness and confirmability of qualitative data, ensuring transparency and credibility in the research process. Ethical considerations were also discussed, with the study being categorised as a low-risk desktop study owing to its reliance on secondary data sources.

# 4. CHAPTER FOUR: ANALYSIS

## 4.1. INTRODUCTION

This section consists of an analysis of the secondary data that were collected. The data analysis method that used is thematic analysis. This chapter examines the secondary data collected. Furthermore, the analysis is complimented by grouping the identified themes under corresponding research objectives; thus, allowing the research questions of the study to be answered.

## 4.2. ALIGNMENT BETWEEN RESEARCH OBJECTIVES AND THEMES

| Research objectives | Themes |
|---|---|
| Establish the influence of loadshedding on water governance in MMM. | Relationship between water and energy |
| | Integrated Water Resource Management |
| | Energy insecurity |
| To determine how loadshedding has influenced the infrastructural ability of MMM to have good water governance | Relationship between water and energy |
| | Energy insecurity |
| | Water Management and Governance |
| | Infrastructure and Maintenance |
| Recommend implementable strategies to improve the relationship between loadshedding and water governance | Relationship between water and energy |
| | Infrastructure and Maintenance |
| | Good governance and development |

Table 2: Alignment between research objectives and themes
(Source, Researchers' own, 2023).

## 4.3. PRESENTATION AND DATA ANALYSIS

This section addresses the research questions of the study by using table 2 as a guiding framework, enabling the interpretation of the secondary data collected in the literature review. Important to note, is that in the literature review, the study could not find any primary studies to affirm the influence of loadshedding on water governance in the MMM. Due to this knowledge gap, the study included the experiences of other municipalities like Langeberg municipality and the City of Tshwane. Hence, their experiences are included in the discussion of findings below.

Objective 1- To establish the influence of loadshedding on water governance in MMM

Theme- Relationship between water and energy

Loadshedding negatively influences water governance in MMM because there is a water-energy nexus. Mathetsa (*et al.*, 2019: 12-13) states that: "…South Africa, where water availability and supply drives both electricity generation and food production, while energy is one of the most critical drivers of water treatment and distribution." Hence, electricity plays a central role in pumping water to and from wastewater treatment plants and into reservoirs from which purified water is transported through the WSS to households. Thus, it can be deduced that without electricity, grey water cannot be pumped to wastewater treatment plants and the wastewater treatment plants would not be able to purify the grey water. Therefore, MMM would not receive a stable supply of potable water and wastewater would start to build-up because there is no electricity to pump the water away from households. Thus, it can be deduced that loadshedding has a negative influence on water governance in MMM.

Theme- Integrated Water Resource Management

The disruptive influence that loadshedding has on water governance in MMM means that IWRM cannot be effectively implemented. This is because IWRM is composed of the natural water cycle, the urban water cycle, and its composite systems, namely water supply, wastewater treatment, and storm water control. For IWRM to be effective, there should be a holistic integration between supply and demand management in both the natural and urban water cycles. However, since loadshedding disrupts the flow of water in the urban cycle, it can be deduced that this negatively impacts supply and demand management in the natural water cycle thereby negatively affecting water governance in MMM.

Theme- Energy insecurity

Loadshedding is a result of poor government planning. The White paper on the Energy Policy of the Republic of South Africa (1998) warned that the country would exceed its available supply of energy by 2007. Despite this warning, the construction of the Medupi and Kusile power stations only started in 2007 and 2008 respectively. Thus, government has induced energy insecurity and because of this, government has induced water scarcity. This is because electricity is needed to keep the pressure in the WSS uniform. Since pump stations cannot pump water to higher-lying areas, this induces water scarcity in these areas thereby decreasing the quality and equity of water governance in MMM.

Objective 2- To determine how loadshedding has influenced the infrastructural ability of MMM to have good water governance.

Themes- Energy insecurity and the relationship between water and energy

The urban water cycle consists of three systems namely: (i) water supply system, (ii) wastewater system and (iii) stormwater system. These systems are dependent on electricity for their optimum functioning. Hence, the introduction of higher stages of loadshedding has resulted in municipalities being without electricity for up to nine hours per day. This is problematic because there is a nexus between water and energy. Sharif *et al.* (2019: 520-521) states that: "In a water supply system, energy is consumed for source water extraction, transmission, treatment, and distribution". Therefore, it can be deduced that loadshedding temporarily halts the purification and pumping of water in MMM. It does this by preventing water treatment plants, water supply systems and booster pumps from functioning. This is supported by appendix G that warns residents of MMM of a water supply interruption caused by: "…Eskom poles that were damaged during a veld fire. The affected poles supply electricity to Welbedacht water treatment plant…", thereby highlighting the centrality of electricity to water governance.

Theme- Infrastructure and maintenance

The Welbedacht pipeline provides MMM with 70 percent of its supply of potable water (Department of Water and Sanitation, 2023). The pipeline is gravity-fed, meaning that it does not use pump stations that are reliant on electricity for their functioning. However, the pipeline flows into the Brandkop reservoir which is reliant on pump stations for the distribution of water through MMM's water supply system. This hinders the ability of MMM to effectively pump water from the Brandkop reservoir during loadshedding. SALGA (2022) states that "…electricity disruptions have severe consequences for the continuous treatment and supply of water services."

The issue of pump station inefficiency affects residents in high-lying areas the most. This issue is experienced by Langeberg municipality (2022): "…Interrupted electricity supply strains the ability for water to be pumped to reservoirs. This can result in low to no water pressure". The City of Tshwane (2022) faces the same issue, stating that: "…reservoirs that are under significant pressure, such as high-lying reservoirs, may slowly have their water level lowered until they threaten to run dry". Therefore, based on the shared experiences of the two municipalities, it can be deduced that MMM faces similar issues because its WSS is reliant on Eskom electricity.

The risk that loadshedding poses to water infrastructure is not lost on water services providers. Rand water (2022: 19) states that: "…the potential failure of the organisation's critical infrastructure such as pumping stations…" represents a risk to its operations. This is because outages at pump stations causes pressure within the WSS to decrease. Causing water inequality between high-lying areas and low-lying areas. Thus, the Department of Water and Sanitation (2023) has mulled the introduction of water-shifting because "…the main cause of lack of water is intermittent power cuts…". Therefore, it can be deduced that the water infrastructure in MMM cannot operate sustainably based on the consideration of emergency water management strategies such as water-shedding and water-shifting.

Theme- Water management and governance

The country's failing water infrastructure points to the lack of good water governance. This is substantiated by Gumede (2022) who states that, "Out of the 824 water treatment plants across the country, only 60 release clean water". The South African Institution of Civil Engineering (2022: 24-28) states that "Only 40 percent of water supply systems achieved microbiological water quality compliance…". Cross-referencing this with the 2022 South African Institution of Civil Engineering infrastructure report card proves a lack of good water governance in South Africa. In the context of MMM, figure five points out that it is a water service authority with poor performance and in need of critical intervention. Thus, it can be deduced that poor water governance is already present in MMM and that loadshedding has merely exacerbated the existing issues.

Objective 3- Recommend implementable strategies to improve the relationship between loadshedding and water governance.

Theme- Relationship between water and energy

It has been established that loadshedding is the independent variable that has an influence on water governance. Hence, the crux of the issue is the lack of electricity to power water treatment facilities and pump stations. To this effect, the issue can be ameliorated by learning from the international experience and solutions highlighted in the literature review chapter. One such is Nepal, where the government introduced strategies to diversify energy sources by investing in renewable energy infrastructure projects and battery energy storage solutions. Mishra *et al*. (2023: 1479-1488) states that: "…the demand of the drinking water to be lifted within sunshine hours". Meaning that, solar panels attached to the WSS can meet the energy demands of the WSS on sunshine days. However, Mishra *et al*. (2023: 1479-1488) states that "...the battery storage option is available". Highlighting that a battery storage solution must be implemented in conjunction with solar panels to account for days on which the intensity of solar irradiation is low. In addition, the Nepali government has installed solar panels at pump stations to ensure the continuous flow of water through the WSS. Mishra *et al*. (2023: 1479-1488) states that "The economy and reliability of solar power made it an excellent choice for water pumping". Thus, it can be deduced that the relationship between loadshedding and water governance can be improved by making use of renewable energy sources.

Theme- Infrastructure and maintenance

The lack of infrastructure maintenance has compromised the ability of MMM to practise good water governance. Allegrante and Sleet (2021) highlight that infrastructure maintenance is imperative for good water governance. To achieve this, municipalities must collaborate closely with water utilities, focusing on urgent repairs, improving maintenance protocols, and integrating resilient technologies to protect water distribution networks. These strategic initiatives are essential for mitigating the adverse effect of loadshedding on water governance. Thus, it can be deduced that an increase in maintenance on the water infrastructure of MMM will improve the relationship between loadshedding and water governance.

## 4.4. CONCLUSION

This chapter presented the secondary data that was collected under the topic of "Exploring the influence of loadshedding on water governance in MMM". The qualitative, secondary data from journals, books, government publications and websites were analysed through thematic analysis. The purpose of this chapter was to organize and present the data in alignment with the study's objectives and the pertinent themes identified. Facilitating a comprehensible analysis of the information. Consequently, the subsequent chapter will delve into the conclusions drawn from the study and offer recommendations based on the findings.

# 5. CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

## 5.1. INTRODUCTION

This chapter draws conclusions on the outcome of the study. The conclusions are drawn from the results of the data analysis chapter. The chapter also provides recommendations on how the findings can be improved. Therefore, this chapter outlines recommendations to improve the influence that loadshedding has on water governance in MMM and proposes further areas of research based on the findings of the study.

## 5.2. CONCLUSIONS

The study set out to explore the influence of loadshedding on water governance in MMM. To do this, the study was guided by the following research questions:

- What is the influence of water governance on loadshedding in MMM?
- How has loadshedding influenced the infrastructural ability of MMM to provide good water governance?
- What strategies can be implemented to improve the relationship between loadshedding and water governance?

Therefore, the study's aim was to discern whether loadshedding compromises the ability of MMM to have good water governance. Hence, the study made use of the qualitative research method. It was complimented by the interpretivist approach that used inductive reasoning. Since the study was a desktop study, it used secondary data sources from (i) journals, (ii) books, (iii) government publications and (iv) websites. Secondary data sources were thematically analysed using the six steps of thematic analysis.

The study revealed that loadshedding has a negative influence on water governance in MMM. This is because loadshedding prevents water infrastructure from operating effectively. First, loadshedding causes primary water pump stations to stop functioning. As consumers use the existing supply of water within the system, the internal pressure of the WSS decreases. Secondly, loadshedding is instituted city wide and not limited to a specific neighbourhood, causing booster pumps to sporadically go offline. The booster pumps are vital to the functioning of the gravity fed WSS. As they fail, consumers in high-lying areas are left without water because functionally speaking, it is impossible for the existing supply of water in the WSS to reach them thereby inducing water-shedding. However, low-lying areas still receive water flowing from reservoirs into the WSS via gravity. However, to protect the remaining water supply, water-shedding is implemented as a preventative measure thereby ensuring that the reservoirs do not reach critically low levels.

## 5.3. RECOMMENDATIONS

The analysis of the secondary data in chapter four revealed that loadshedding has an influence on water governance in MMM. Therefore, the study recommends the following:

- MMM should use renewable energy sources such as solar and wind power to decrease its reliance on the national power grid. It can immediately add a few kilowatts of energy to the municipal grid by enacting by-laws that would enable households with solar panels to feed electricity into the grid. This has the potential to enhance the reliability of electricity supply to critical water infrastructure.
- MMM should complement the roll out of renewable energy sources with energy storage technology like batteries. This will allow MMM to store surplus energy during times when loadshedding is not occurring. This reserve of energy can be used to operate water infrastructure during loadshedding, guaranteeing an uninterrupted water supply.
- To ensure that the supply of renewable energy is used efficiently, MMM should integrate energy-efficient technologies into its WSS. This would enhance the energy efficiency of the WSS, which would improve the resilience of water infrastructure against loadshedding.
- To that effect, Bloemwater should roll out solar farms at its wastewater treatment facilities. The implication is that the entire water infrastructure system within MMM would be isolated from loadshedding end-to-end.
- However, if this is not cost-effective, Bloemwater should acquire diesel generators to intermittently power its wastewater treatment facilities to prevent the quality of water in MMM from being compromised.
- MMM should take a crisis-management approach to the current water situation. It should prioritise fixing water leaks in the WSS and must regularly carry out maintenance of the existing water infrastructure.
- MMM should advocate for more prudent water use by consumers. Especially during stages five and six of loadshedding. Hence, MMM should initiate public awareness campaigns to educate citizens of the effect that loadshedding has on water governance.

## 5.4. FUTURE AREAS FOR RESEARCH

As a desktop study, the transferability of the research findings was limited to the MMM. In addition, the study did not fully explore possible solutions to improve the relationship between loadshedding and water governance. Hence, the following areas could be further explored:

- The feasibility of using renewable energy provided by households that have solar panels. This area should be further explored as a possible solution to the current water issues that MMM faces. It is vital to ascertain how much renewable energy households in MMM produce and how much of this supply can be realistically fed into the electricity grid. Hence, calculations would have to be done with the help of an electrical engineer to determine whether this supply of renewable energy can power the WSS of MMM.

- This study set out to explore the influence of loadshedding on water governance in MMM by determining whether loadshedding has compromised the infrastructural ability of MMM to have good water governance. Therefore, a future study could explore the influence of loadshedding on the quality of potable water.
- The literature review could not yield any significant results regarding the influence of loadshedding on water governance in the Mangaung Metropolitan Municipality. This is because there is no primary study done on the subject. Hence, as a desktop study, the study had to draw on primary studies conducted in other municipalities like the City of Tshwane. Therefore, the study lacks the transferability and credibility of a primary study. Hence, a future empirical study should be conducted on the influence of loadshedding on water governance in the Mangaung Metropolitan Municipality.

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## APPENDICES

APPENDIX A: Bloemwater maintenance notice 2022

MANGAUNG
METRO MUNICIPALITY
METRO MUNISIPALITEIT
LEKGOTLA LA MOTSE
DIRECTORATE
OFFICE OF THE
CITY MANAGER
***Communications***

**31 MAY 2022**

PUBLIC NOTICE

**RE: POSSIBLE WATER SUPPLY INTERRUPTIONS IN VARIOUS PARTS OF MMM_BLOEMWATER MAINTENANCE**

**Residents of Mangaung Metro are hereby informed that Bloem Water will embark on a scheduled Winter maintenance programme at Welbedacht Plant on Wednesday, 01 June 2022, for a period of 36 hours.** This is for the cleaning of sediment dams and general maintenance of the unit process at Welbedacht water treatment plant. **There will be no supply to all reservoirs within the Welbedacht system, which may result in water supply interruptions.**

**The following areas will be affected:**

| AFFECTED AREAS | | |
|---|---|---|
| • Pellessier<br>• Lourierpark<br>• Fauna<br>• Wilgehof<br>• Part of universitas<br>• Gardenia Park<br>• Dewetsdorp<br>• Dewet park | • Vista Park<br>• Heidedal<br>• Rocklands<br>• Phelindaba<br>• Bloemdal<br>• Bloemanda<br>• Phase 2,3,4,5,6, etc<br>• Freedom Square | • Bergman Square<br>• Grassland<br>• Phahameng<br>• Bochabela<br>• Phelindaba<br>• Bainsvlei<br>• Langenhoven park<br>• Spitskop N1 near Heuwelsig area |

All residents, businesses and consumers in the affected areas are kindly requested to make the necessary arrangements for gathering water for cooking, washing, cleaning, etc for that period.

**Mangaung Metro would like to apologise in advance for any inconvenience caused.**

***Ends.***

***Issued by MMM Communications***
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***For enquiries contact:***
*Qondile Khedama*
*GM: Communications*

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**25 JULY 2022**

PUBLIC NOTICE

**RE: POSSIBLE WATER SUPPLY INTERRUPTIONS DUE TO MAINTENANCE OF WELBEDACHT SYSTEM**

Residents of Mangaung Metro are hereby informed that Bloem Water will undertake **maintenance of the Welbedacht system on Wednesday, 27 July 2022, for a period of 36 hours.** The scope of work includes replacement of the outlet valve at Brandkop reservoir guesthouse, cleaning and inspection of the dam by Department of Water & Sanitation, repair of MMM 600mm pipeline, and servicing of switch gears and transformers at the Welbedacht Plant. The repair of the 600mm pipeline requires total cut-off of water supply, which may result in water supply interruptions.

**The following areas will be affected:**

| AFFECTED AREAS | | |
|---|---|---|
| • Bainsvlei<br>• Bergman Square<br>• Bloemdal<br>• Bloemanda<br>• Bochabela<br>• Dewetsdorp<br>• Dewet park<br>• Fauna | • Freedom Square<br>• Gardenia Park<br>• Grassland<br>• Heidedal<br>• Langenhoven Park<br>• Lourierpark<br>• Part of universitas<br>• Pellessier | • Phahameng<br>• Phase 2,3,4,5,6, etc<br>• Phelindaba<br>• Rocklands<br>• Spitskop N1 near Heuwelsig area<br>• Vista Park<br>• Wepener<br>• Wilgehof |

All residents, schools, businesses and consumers in the affected areas are kindly requested to make the necessary arrangements for gathering water for cooking, washing, cleaning, etc for that period.

Jojo tanks will be placed at strategic points during the shutdown.

**Mangaung Metro would like to apologise in advance for any inconvenience caused.**

***Ends.***

***Issued by MMM Communications***
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APPENDIX C: Harvard substation power failure

20 March 2023

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CENTLEC

30 Rhodes Avenue
Oranjesig
Bloemfontein
9301
www.centlec.co.za
@Centlec @centlecutility

**OFFICE OF THE CEO**

***Communications and Marketing***

| | |
|---|---|
| **Contact Person: L. Mamatu** | **Date:** 20 March 2023 |
| **E-mail:** lele.mamatu@centlec.co.za | **Tel:** 051 409 2718<br>**Fax:** 051 xxxxxxx |
| **Our Ref.:** | **Your Ref.:** |

**TO ALL MEMBERS OF THE COMMUNITY**

**POWER FAILURE AT HAVARD SUBSTATION**

During the 19H00 this evening, we had experienced a power outage at Harvard Substation which left the whole City of Bloemfontein without power.

Upon investigation, our personnel discovered that the outage occurred due to equipment failure caused by the system fault.

However, our personnel are currently on site working to clear the fault and reconnect electricity in all areas. The process of switching has already begun and due to the amount of work involved, we are hopeful that most of the areas will be reconnected as soon as possible.

We would like to apologize to the community of Mangaung for the inconvenience caused as a result of this outage.

Lele Mamatu
Spokesperson
CENTLEC (SOC) Ltd
051 412 2718 / lele.mamatu@centlec.co.za

MS Sekoboto (CEO), T Malgas (Company Secretary)

APPENDIX D: Reservoir maintenance notice 2023

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**03 MAY 2023**

PUBLIC NOTICE

**RE: MANGAUNG EMBARKS ON RESERVOIR MAINTENANCE PROGRAMME**

Residents of Mangaung Metro are hereby notified that the City is embarking on the cleaning and maintenance of reservoirs across all regions. This is an operational programme with the purpose of ensuring that water supplied to the Mangaung community is of high quality and complies with drinking water quality standards for human consumption. During this operation, there could be shutdowns and restricted water supply to communities.

**The first phase of maintenance is scheduled as follows:**

| Date and Duration | Trajectory | Task | Affected areas |
|---|---|---|---|
| 03 May – 05 May 2023 (36 hours) | De Hoek to Uitkyk Trajectory<br><br>Balancing Dan and Manifold.<br><br>Domestic pipeline | • Remove & Replace LCV no6.<br>• Remove and replace TAV no3 and no7 Gate valves.<br>• 2 x Farmers take offs leakages to be Blanked.<br>• Cleaning and inspections of reservoir<br>• Replace Domestic Valves | Dewetsdorp, Wepener, Pellesier, De Wet, Fauna, Bainsvlei, Groenvlei, Universitas, Langenhoven park, Gardenia Park, Wilgehof, Rose Park and adjacent areas, Fleurdal, Louriepark, Vista Park, Ehrlich Park,chicken factory N8 |

All residents, businesses and consumers in the affected areas are kindly requested to make the necessary arrangements for gathering water for cooking, washing, cleaning, etc for that period.

**Mangaung Metro would like to apologise in advance for any inconvenience caused.**

***Ends.***

***Issued by MMM Communications***
*Call Centre: 0800 111 3000*

***For enquiries contact:***
*Qondile Khedama*
*GM: Communications*

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APPENDIX E: De Hoek and Uitkyk reservoir maintenance

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**24 JULY 2023**

PUBLIC NOTICE

**RE: MMM RESERVOIR MAINTENANCE PROGRAMME: 25 – 27 JULY 2023 SCHEDULE**

Residents of Mangaung Metro are hereby notified that the City will embark on the annual cleaning and inspection of De Hoek and Uitkyk reservoirs. This is an operational programme with the purpose of ensuring that water supplied to the Mangaung community is of high quality and complies with drinking water quality standards for human consumption. During this operation, there could be water shutdowns and/or restricted water supply to communities. **The next phase of maintenance is scheduled as follows:**

| Date and Duration | Trajectory | Task |
|---|---|---|
| **25 – 27 July 2023**<br>**00H00 – 12H00 (36 hrs)** | Uitkyk and De Hoek reservoirs | • Mainline leakage repairs and Internal mechanical seals installation<br>• LCV no. 8 removal and replacement<br>• Bainsvlei meter no1 and take off isolating valve |

| THE FOLLOWING AREAS MAY BE AFFECTED BY THE SHUTDOWN: | | |
|---|---|---|
| • Pellessier<br>• Lourierpark<br>• Fauna<br>• Wilgehof<br>• Part of universitas<br>• Gardenia Park<br>• Dewetsdorp<br>• Dewet park | • Vista Park<br>• Heidedal<br>• Rocklands<br>• Phelindaba<br>• Bloemdal<br>• Bloemanda<br>• Phase 2,3,4,5,6, etc<br>• Freedom Square | • Bergman Square<br>• Grassland<br>• Phahameng<br>• Bochabela<br>• Phelindaba<br>• Bainsvlei<br>• Langenhoven park<br>• Spitskop N1 near Heuwelsig area |

All residents, businesses and consumers in the affected areas are kindly requested to make the necessary arrangements for gathering water for cooking, washing, cleaning, etc for that period.

**Mangaung Metro would like to apologise in advance for any inconvenience caused.**

***Ends.***

***Issued by MMM Communications***
*Call Centre: 0800 111 3000*

***For enquiries contact:***
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*GM: Communications*

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APPENDIX F: Water supply interruption notice

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**09 OCTOBER 2023**

PUBLIC NOTICE

**RE: WATER SUPPLY INTERRUPTIONS IN VARIOUS PARTS OF MANGAUNG DUE TO PIPE BURST**

Residents of Mangaung Metro are hereby informed of a pipe burst on the Bloemwater pipeline between Dehoek and Uitkyk reservoir. This is on the main line that supplies water to Bloemfontein. Technicians are already on site and repair work is projected to take 36 hours.

**The following areas may be affected:**

| AFFECTED AREAS | | |
|---|---|---|
| • Pellessier<br>• Lourierpark<br>• Fauna<br>• Wilgehof<br>• Part of universitas<br>• Gardenia Park<br>• Dewetsdorp<br>• Dewet park | • Vista Park<br>• Heidedal<br>• Rocklands<br>• Phelindaba<br>• Bloemdal<br>• Bloemanda<br>• Phase 2,3,4,5,6, etc<br>• Freedom Square | • Bergman Square<br>• Grassland<br>• Phahameng<br>• Bochabela<br>• Phelindaba<br>• Bainsvlei<br>• Langenhoven park<br>• Spitskop N1 near Heuwelsig area |

**Water tankers will be dispatched to areas that will be affected by interruptions.**

**We will regularly update residents on the progress of water restoration. Mangaung Metro apologises for the inconvenience this may cause.**

***Ends.***

***Issued by MMM Communications***
*Call Centre: 0800 111 3000*

***For enquiries contact:***
*Qondile Khedama*
*GM: Communications*

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**14 OCTOBER 2023**

PUBLIC NOTICE

**RE: POSSIBLE WATER SUPPLY INTERRUPTION DUE TO DAMAGE CAUSED BY VELD FIRE**

Residents of Mangaung Metro are hereby **alerted** of a possible water supply interruption on the Bloemwater (Vaal Central Water Board) mainline. Water supply may be interrupted due to ESKOM poles that were damaged during a veld fire. The affected poles supply electricity to Welbedacht water treatment plant and adjacent areas.

The estimated restoration time is 19 hours. ESKOM has assured the City that it is working around the clock to resolve the challenge at the plant.

**The following areas may be affected:**

| AFFECTED AREAS | | |
|---|---|---|
| • Pellessier | • Vista Park | • Bergman Square |
| • Lourierpark | • Heidedal | • Grassland |
| • Fauna | • Rocklands | • Phahameng |
| • Wilgehof | • Phelindaba | • Bochabela |
| • Part of Universitas | • Bloemdal | • Phelindaba |
| • Gardenia Park | • Bloemanda | • Bainsvlei |
| • Dewetsdorp | • Phase 2,3,4,5,6, etc | • Langenhoven park |
| • Dewet park | • Freedom Square | • Spitskop N1 near Heuwelsig area |

**We will regularly update residents on the progress of water restoration. Mangaung Metro apologises for the inconvenience this may cause.**

***Ends.***

***Issued by MMM Communications***
*Call Centre: 0800 111 3000*

***For enquiries contact:***
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APPENDIX H: Ethical clearance

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UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

**GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)**

17-Jul-2023

Dear Dr Tafadzwa Maramura

**Application Approved**

Research Project Title:
**Exploring the influence of loadshedding on water governance in the Mangaung Metropolitan Municipality**

Ethical Clearance number:
**UFS-HSD2023/1059**

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

**Dr Adri Du Plessis**
**Chairperson: General/Human Research Ethics Committee**

Adri Du Plessis Digitally signed by Adri Du Plessis Date: 2023.07.19 12:36:31 +02'00'

205 Nelson Mandela Drive
Park West
Bloemfontein 9301
South Africa

P.O. Box 339
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APPENDIX I: Turnitin report

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**AUTHORS: BADE NAMEERA, TSHABALALA THATO, & STRYDOM CHRISTOPHER**

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