



# Urban Water Security and Water Management

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A CASE OF THE JOHANNESBURG METROPOLITAN AREA.

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**Abstract**

The drought experienced in recent years changed the narrative around water in South Africa, it catalysed a national conversation and brought about concerns over water security. Urban areas are anticipated to accommodate over 60 percent of the population, this additional stress makes urban water security an important issue to address. Johannesburg is the heart of South Africa's economy the prosperity of the city is of utmost importance. Safeguarding urban water resources is imperative. Integrated urban water management has been developed and used around the world to transform urban water practices to more sustainable and holistic approaches. This concept has largely been criticised as a global north paradigm as it apparently does not suit all contexts. However, all water problems across the globe are unique and there is no one solution designed to solve them all. Governance does not only concern the structures and institutions including the procedures voiced in law and policy, but also social norms. Water resource management frameworks in South Africa provide a theoretical foundation of how knowledge is generated for effectively managing water. How these foundations translate in practice, reveals the strength and capacity of administrative regimes to ensure urban resilience among other things, to water scarcity.

Keywords: water security, water scarcity, urban water management, urban resilience, water governance, integrated urban water management (IUWM).

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**List of Abbreviations**

<b>CMA</b>	Catchment Management Areas
<b>DWA</b>	Department of Water Affairs
<b>DWS</b>	Department of Water and Sanitation
<b>IUWM</b>	Integrated Urban Water Management
<b>IWRM</b>	Integrated Water Resource Management
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>NWRS</b>	National Water Resource Strategy
<b>NWRS2</b>	<b>National Water Resource Strategy</b>
<b>WUA</b>	Water Users Association
<b>UN</b>	United Nations



# 1. Introduction

## 1.1 Background

Historically the patterns of access to water and other key sectors of public service delivery in South Africa have been undoubtedly skewed (Goldin, 2010). Following the political changes in the early 1990's the newly elected democratic government of South Africa was tasked with rectifying the then growing service and backlogs with respect to access to water supply and sanitation (Cairncross & Valdmanis, 2006). The backlogs in water supply and sanitation were a result of the apartheid governments spatial planning mechanisms. This system largely excluded townships and rural areas which were, and still are, commonly inhabited by black South Africans. About a decade ago, the Department of Water and Sanitation (DWS) faced complications in providing basic services. Attributed to poor service delivery were unmaintained aging infrastructure, with pipes either bursting or leaking severely. Both the quantity and quality of available water supply were and still are in decline. Compounding this issue is a departure of capacity and skills from the DWS which further affected the security of supply. Only 39% of the 250 engineer positions, and six out of 45 lower management roles, were filled. These gaps were leading to poor monitoring and governance of water resources, exposing the water systems to illegal activities which worsened the situation. Since then, the country has made major strides in improving access to water supply. The efforts of the new government resulted in an increased number of households with access to piped water from 6.6 million in 1994 to 11 million in 2005. All things being equal, this means that 4 million additional connections were delivered over the 11-year period (Nnadozie, 2011). The government introduced a comprehensive reform process for the water sector with the goal of achieving an enhanced and more equitable water management system (Walter *et al.* 2011). According to current usage trends, it is estimated that water demand will exceed availability by 2025. The ongoing tendency towards industrialization and urbanization of the population is expected to place further pressure on the country's sources of water supply unless appropriate remedial measures are put in place. Another issue that the government is grappling with is providing informal settlements with adequate infrastructure. Together with municipalities and other related agencies, efforts by government are directed towards the provision of storm water management and drainage systems, as part of an overall infrastructural intervention in low-income urban communities. These efforts are, however, not making the desired, far-reaching impacts for various reasons (beyond the scope of this research) (Armitage, 2011). Water-related infrastructure in informal settlements is often entangled in power relations at the municipal administrative level, such that servicing the poor is given low priority (Fourie, 2008)

The drought experienced during the 2014-2016 period changed the narrative around water in South Africa, it catalysed a national conversation and brought about concerns over water security. Drought is an extreme physical process and is often characterized as "a slow-onset natural hazard whose

impacts are complex and reverberate through many sectors of the economy such as water resources, agriculture, and natural ecosystems” (Vetter, 2009 p.29). Drought is a persistent feature of the South African climate. It is a regular occurrence in South Africa in all climatic regions at varying times of the year with fluctuating intensity, spatial extension and duration (Rouault & Richard, 2003). Various periods have been recorded where droughts crippled the national water supply as in the periods from 1964 to 1970, 1991 to 1995 and again from 2002 to 2005, 2014 to 2016 (South African Weather Service, 2018). The Minister of Water and Sanitation’s recent announcement of water restrictions brought home the criticality of South Africa’s water scarcity - prolonged drought conditions have meant many of the country’s major dams are emptying faster than they can be replenished. This has major implications for the country at large, more specifically urban areas.

In addition to the challenges of water availability and quality being experienced globally, South African cities are also under pressure to respond to issues of economic transformation and social division (Carden & Armitage, 2013). Despite accelerated basic service delivery, many local authorities are battling to keep pace with urbanisation, intensifying competition for scarce resources and raising social tensions. Water crises have emerged in different forms and contexts in many nations around the world. The nature and significance of these problems have different meanings for different people and sectors of society (Quinn, 2012). This brings into question the notion of resilience, especially when assessing urban environments in South Africa. Who will be able to withstand water crises in Johannesburg and, how will this be done? In the context of Johannesburg for example, where the poor living in urban areas are often at the centre of such dilemmas, where they do not have proper access to adequate water and related infrastructure for everyday use. Figure 1 below helps put this into perspective. In 2001, 17% of City of Johannesburg households in informal settlement had piped water in their homes or on their yard. A further 40% could obtain piped water within 200 metres of their homes. 30% had access to piped water more than 200 metres from their dwellings (there is no clear indication of how far away the water source is) while 14% had no access at all. 20% of households in informal settlement used flush toilets, 28% used bucket latrines, 27% used pit latrines and 11% made use of chemical toilets; the remaining 14% had no access to toilet facilities (Housing Development Agency, 2012).

**Informal settlement households in Johannesburg with access to basic water and sanitation services, 2001 & 2007.**

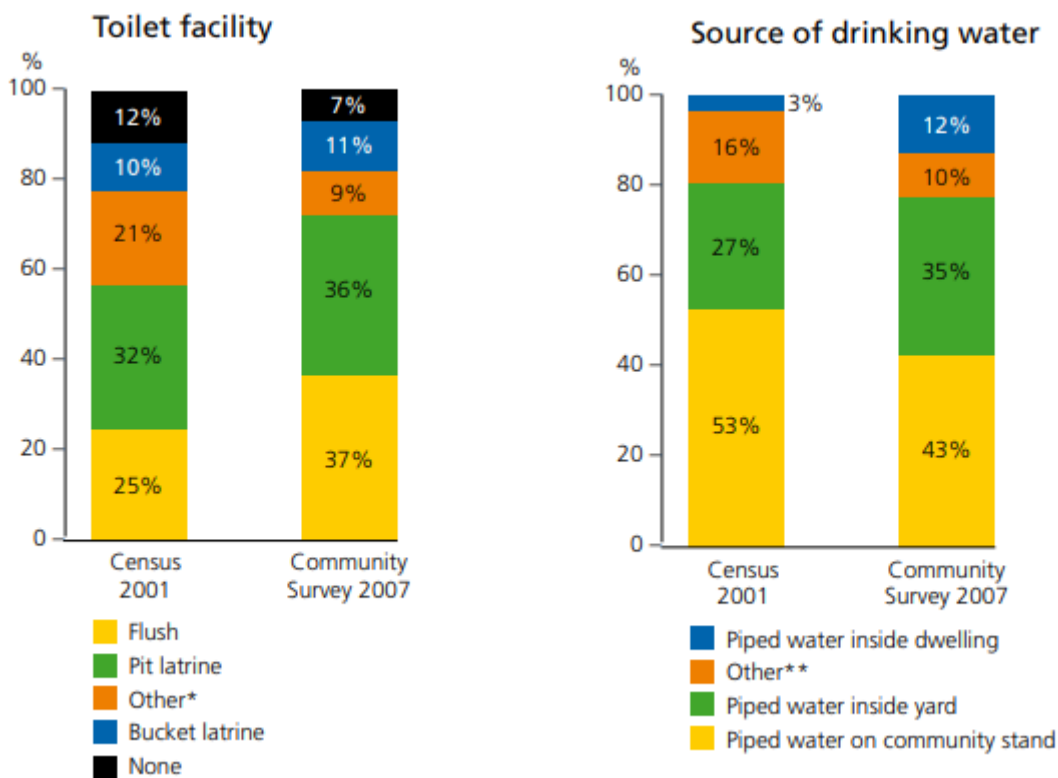


Figure 1: Access to services for informal settlement households in Johannesburg (Housing Development Agency, 2012).

Crises in this instance, can provide triggers for rethinking the nature of the problems and how to tackle them. Sometimes the key issue is the sufficiency of supply, in other words, water security for a large and diverse population, but the form in which this problem is presented is often times different for rich and poor, industry and household sectors, and for those in the central city, the urban fringe, and the water catchment areas (Olsson & Head, 2015). The principal coordinating mechanism for achieving water security is the National Water Resource Strategy (NWRS), first published in September 2004 (DWA 2004). This NWRS provided an overview of South Africa's water situation, strategies for water resource management, arrangements for cooperative governance, and a strategic perspective for each of the 19 water management areas (Quinn, 2012).

## 1.2. The Johannesburg Metropolitan Area

The discovery of gold in 1886 was pivotal in the growth of Johannesburg from a humble mining town to a major urban conurbation. Johannesburg is located in the Gauteng province of South Africa. Johannesburg sustains a quarter of the gross population of South Africa, accounting for 10% of the economic activity on the entire African continent (Turton *et al.* 2006). Johannesburg, Jozi, or 'Joburg', as it is affectionately known, is the largest city in South Africa with a population density of 2,900 people per square kilometre. It is also one of the 50 largest urban agglomerations in the world (UN World Urbanisation Prospects, 2018). In 2016, Johannesburg had an estimated population of 4.4 million people (Statistics SA, 2018). The greater metropolitan area pictured in figure 1 below, the focus of this research, has an estimated 8 million inhabitants and growing (Joburg Tourism, 2018). Johannesburg's 2018 population is now estimated at 10,016,000. In 1950, the population of Johannesburg was 1,653,000. Johannesburg has grown by 617,000 since 2015, which represents a 2.14% annual change (World Population review, 2018). Up to this day, the growth of the city has been contingent upon the availability of water. Johannesburg is somewhat unconventional as it has an unusual location for a major urban centre as it is situated on a continental divide some distance from any sizeable water source (Turton *et al.* 2006). Consequently, inhabitants have always been in a precarious position regarding water acquisition.

The dawn of the democratic dispensation in 1994 steered vast changes across the country. For a city such as Johannesburg, this meant substantial administrative reorganisation, where multiple municipalities were combined into new ones, thus incorporating townships into the new structure as well. The spatial planning regime of the apartheid era was one of racial and social segregation where white and black people for the most part, were institutionally separated (Förster *et al.* 2017). This amalgamation resulted in the new greater metropolitan area of Johannesburg with multiple departments involved in water and sanitation services, all operating with no cohesion. As a result, the fragmentation of responsibilities within the municipality perpetuated a culture with little accountability for results. According to the City of Johannesburg (2018), the city needs to plan for a population growth of about 66% in the coming 30 years, which includes plans to improve access to clean water, energy and the management of waste and sanitation.

In this thesis, the empirical research context is set in South Africa, more specifically the Johannesburg Metropolitan Area. It is important to consider how the imminent threat of water scarcity will affect the metropolitan, as the hub of the South African economy is nested in Johannesburg (Turton *et al.* 2007). The focus of this thesis is to examine the shortfalls in governance pertaining to urban water management, and to understand how these shortfalls can be remedied to promote water security and a resilient urban environment. South Africa has already developed extensive physical infrastructure which transcends the natural boundaries of water resources and must now coordinate water management across both physical and political boundaries (Turton *et al.* 2006).

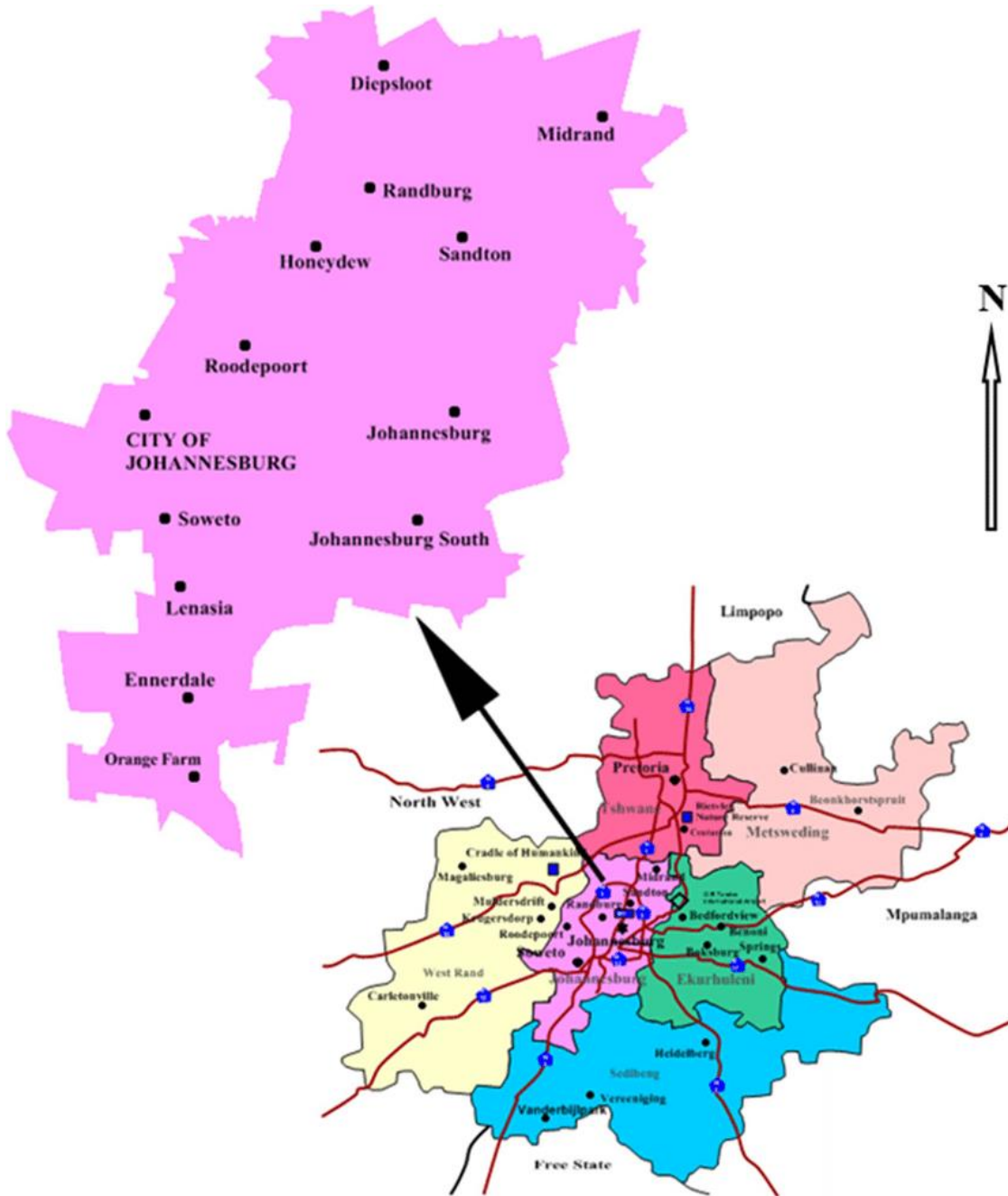


Figure 2. Johannesburg Metropolitan Area within the greater Gauteng Province (Sibanda et al. 2017).

### 1.3. Problem Statement

South Africa is a semi-arid country facing severe water constraints, according to Herrfahrtdt-Pähle (2010), therefore it comes as no surprise that it experiences such challenges. Partnered with the understanding that water resources need to be managed in an integrated and systematic manner to ensure the sustainability of these resources, it begs the question how well equipped the Johannesburg Metropolitan Area is to face water related challenges? (Turton *et al.* 2007). Governance structures and institutions may no longer be adequate in effectively managing these resources. This research takes a closer understanding on urban water security and the implications of ongoing user trends on future urban water supply.

This research will contribute to bridging the knowledge gap between theory and practice, as it has been previously mentioned., South Africa has one of the best legal frameworks pertaining to water and the management thereof but there seems to be a discrepancy in translating that into practice (Herrfahrtdt-Pähle, 2014; Siyanbola & Olamade, 2016). While keeping previous research and identified implementation barriers in mind, further research gaps in this area exist because IUWM projects are still relatively new and involve increased complexity. There are wide knowledge gaps in the planning, design, implementation, operation and management of IUWM, which impedes the uptake (Sharma, *et al.* 2010). This is discussed in detail in section 2.5. In terms of management, the South African National Water Act (No. 36 of 1998) is seen as one of the most progressive legislative and policy frameworks for water management in the world (Tissington *et al.* 2008; Carden & Armitage, 2013; Herrfahrtdt-Pähle, 2014). Wherein lies the problem then? Could more have been done to avert the dramatic effects of the 2014-2016 drought? These are pertinent questions which this research aims to answer.

### 1.4. Relevance of the Research

Particularly in context of further population growth, urbanization and natural resource constraints in the future, it seems to be crucial to find sustainable solutions for urban water security. This research contributes to this aim by analyzing governance of urban water management in Johannesburg. For this research, an integrated management regime that is studied is IUWM as it primarily focuses on the urban setting. The provisions thereof have been studied and applied in various urban environments around the world. This research will contribute to the body of knowledge on the provisions and governance of IUWM and examine whether IUWM is suitable for the urban environment that is the Johannesburg Metropolitan Area.

With the aid of the research questions, the prospects of IUWM and the benefits for society are addressed alongside the status of urban water management in South Africa. Mackay & Last (2010) indicate that climate shifts, environmental degradation, aging infrastructure, energy adaptation and

population growth are some of the challenges that the current and future generations will be faced with.

Connections between water management and spatial planning occur in various ways. It has been observed that urban water management is becoming integrated with components of spatial planning such as land use policy, building construction, economics, legislation, education and social acceptance, and community involvement (Mitchell, 2006; Woltjer & Al, 2007). IUWM is nested within the spatial planning arena and coordination of the two aspects will be conducive to sustainable and liveable environments. However, Woltjer & Al (2007, p.212) state that “The majority of decisions with regard to water management are made without reference to spatial planning issues related to urbanization and population growth, and conversely development and land-use decisions are also made with little consideration of their effects on water systems”. Because of the interconnected nature of IUWM and spatial planning, it is necessary to intervene and engage with the transition from the current state to one that enables increasingly secure and sustainable water systems and the necessary governance structure to follow through on this.

## 1.5. Research Questions

Effective water governance and management often have complex arrangements, which are context dependent and not open to prescribed generic norms (OECD, 2015). These governance arrangements must be flexible enough to allow water managers to reach their goals in changing social, economic and environmental contexts.

To fulfil the requirements of this thesis, the following question is pertinent to address:

To what extent are the current water management structures of government enough to sustain present and future water needs of the Johannesburg Metropolitan Area?

The below listed sub-questions will assist in addressing the main question:

- To what extent can the events leading up to the current water crisis in South Africa, and further Johannesburg be attributed to lacklustre governance and institutional administration?
- What are the implications of water scarcity on the growing population of Johannesburg?
- What is the concept-of-fit of urban water management paradigms such as IUWM in Johannesburg?
- What needs to be done for Johannesburg to realise the full benefits of the world class water policies in South Africa?

## 2. Theories Underpinning the Research

### 2.1. Urban water security

The concept of water security was popularised in the 1990s and has evolved significantly since then. Multiple definitions of the concept of water security exist. The United Nations Water (2013) has defined water security as “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability”. Reddy (2002) defines it as people and communities that have reliable and adequate access to water to meet their different needs at present and in the future, are able to take advantage of the different opportunities that water resources present, are protected from water-related hazards and have fair alternative where conflicts over water arise. Allan et al. (2013 p.625) further describes water security as “adequate protection from water-related disasters and diseases and access to sufficient quantity and quality of water, at affordable cost, to meet the basic food, energy and other needs essential for leading a healthy and productive life without compromising the sustainability of vital ecosystems and (...) an acceptable level of water-related risks to humans and ecosystems, coupled with the availability of water of sufficient quantity and quality to support livelihoods, national security, human health, and ecosystem services”.

Internationally the key words defining water security are reliable, available and acceptable quantities and quality of water necessary for health, livelihoods, ecosystems and production (Muller, 2013). It is necessary to make sure that the way water is provided comes at an acceptable level of risk. These risks include flooding and droughts. In addition, we have to worry about risks to the environment and to the economy. Looming water-related threats to human beings have birthed various debates in the scientific and governance arenas (Grey & Sadoff, 2007). These debates are centred around establishing possible means for achieving acceptable quality and quantity of water not only for human health and livelihood, but for ecosystems and production as well, together with acceptable levels of water-related risks to humans’ environments and economies (Grey & Sadoff, 2007). Notwithstanding, it is also acknowledged that water scarcity originates not only from quantitative or qualitative scarcity, but also from inefficient use and lacklustre management (Walter *et al.* 2011).

According to Brears (2016), there exist two kinds of challenges to achieving urban water security, namely climatic and non-climatic challenges. The non-climatic challenges are: demographic changes, rapid urbanisation, rapid economic growth and rising income levels and increased demand for energy. The climatic challenges comprise: impacts of climate change on water quality and quantity and the socioeconomic risks of climate change (Brears, 2016). Nonetheless, water security is not a single fixed goal, water security it is an ever- changing continuum that evolves according to



various challenges posed, both non-climatic and climatic elements. Figure 3 below summarizes the key elements of water security.

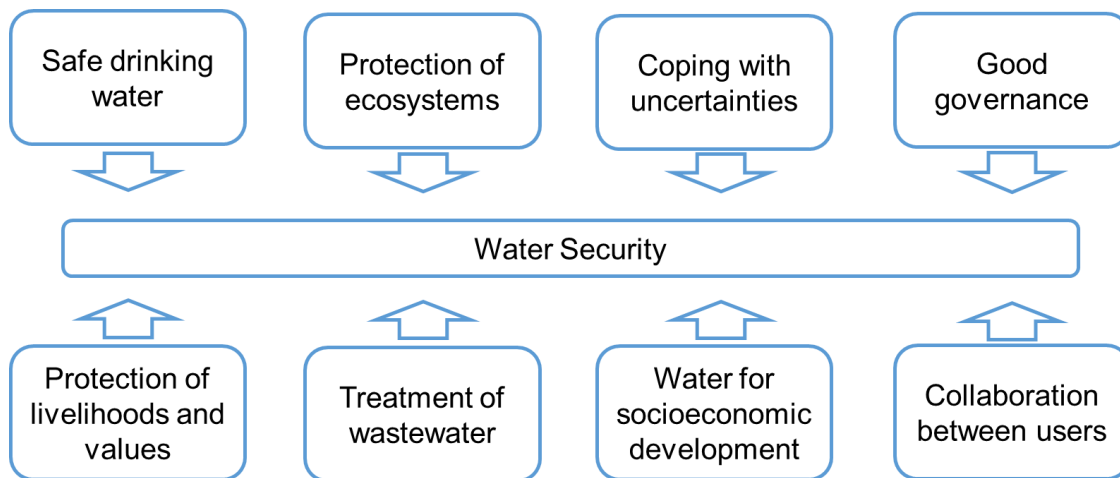


Figure 3. Key elements for achieving water security after Brears (2016).

Future water security depends not only on meeting increased demand but also on how effectively humans can use limited water resources to meet their needs (Brears, 2016 & Rockström *et al.* 2014). The future of global water resources is under stress, this calls for suitable governance mechanisms to work proactively towards protecting the precious resource that is water. In South Africa particularly, provisions are made in the National Water Act for addressing water governance. The trouble however, lies in the lack of adequate implementation of one of the most powerful water acts on the African continent and possibly the world (Muller, 2008). Consequently,

Urban water security differs from general water security by way of application as it speaks to a specific area, an urban agglomeration and the sectors therein (Hoekstra *et al.* 2018). The Johannesburg metropolitan can be considered one such agglomeration as it comprises numerous urban territories (Stern, 2006). In so doing, this delineates components that are characteristic of urban water security, such as high population density for one. What makes the case of Johannesburg unique is the fact that it is situated on a watershed (Vincer, 2015), the nearest water reservoir being in access of 70km. This means that water is transported over long distances by way of intricate water transfer schemes to service the many functions of the metropolitan (Muller, 2002). The phenomenon has been described by McDonald *et al.* (2014) as “the reach of urban water infrastructure”. The nature of cities is such that they cluster the water demands of the urban population in a small area, which further stresses the availability of freshwater resources. However, cities also represent a concentration of economic and political power, which stands true of Johannesburg as it houses 45 percent of South Africa’s economy (McDonald *et al.* 2014; Turton *et al.* 2007). This concentration of economic and political power also enables cities to build urban water infrastructure to satisfy their demand, just as was accomplished in Johannesburg since the discovery of gold in the 19<sup>th</sup> century.

The current discourse on water security can be viewed as a progression of relevant topics throughout successive stages. Figure 4 below depicts the development of water management concepts. This discourse is traced back to the 1980's where the concern at the time was managing water resources in an integral manner (figure 2). During this time, it was acknowledged that water systems fulfil various functions to be considered in an integrated manner (Schoeman *et al.* 2014; Hoekstra *et al.* 2018). During the 1990s, especially after the publication of the Brundtland report, the discourse shifted to one of sustainability and the focus was thus on the sustainable management of water resources (Hoekstra *et al.* 2018). As climate change and the consequences thereof gained importance, the main theme from approximately a decade ago was centred around adapting climate change and adaptive water management still is a highly relevant topic today (Restemeyer *et al.* 2015). Water security being the focus of this research, gained traction in the early 2000's and was popularised by publications from the World Water Council and the Global Water Partnership on concerns of global water security.

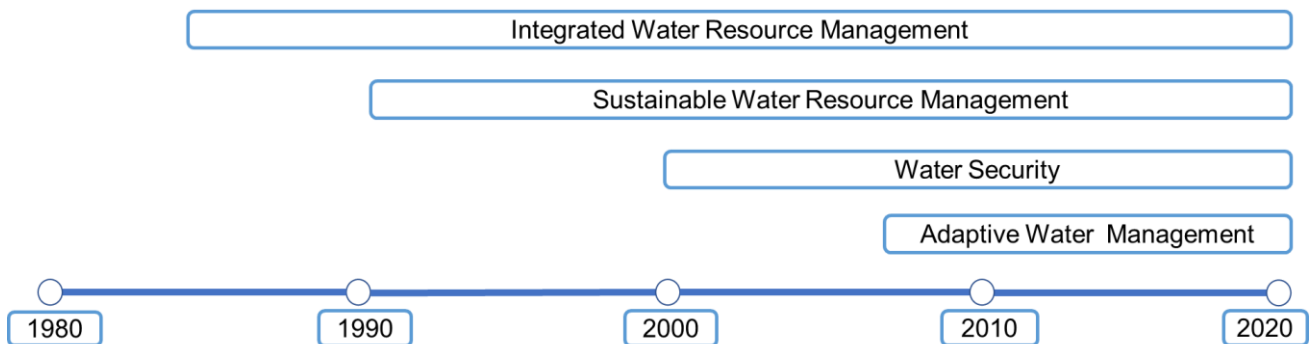


Figure 4. Emergence of new water management concepts over time. Adapted from Hoekstra *et al.* 2018.

Scientists from different disciplinary backgrounds appear to give different interpretations to the term water security. Cook and Bakker (2012) discuss framings of water security across the physical and social sciences. They find that in the engineering domain, water security studies generally focus on protection against water related hazards (floods, droughts, contamination, and terrorism) and water supply security (percentage of demand satisfied). According to Grey & Sadoff (2007), the term “water security” is used, often without concise definition. Looking at the water-food-energy nexus, the food- and energy security refer to consistent of food or energy to support livelihoods and production. Grey & Sadoff (2007) add that “water security” has been used in literature with a tantamount meaning, the major difference being that the both the absence and presence of water is hazardous (Rodda *et al.* 2016).

Water security can be envisioned as a point on the horizon, something to work towards instead of a single fixed goal. To ensure urban water security, there is an increasing common understanding that an integrated approach offers a better understanding of how water supply, sanitation, wastewater, storm water and solid waste interact (Brikké & Vairavamoorthy, 2016). Such an approach is based on numerous key concepts of urban water management such as the resilience of urban water

systems to global change; interventions over the entire urban water cycle; reshaping the manner in which water is used and reused; and the governance and financial management structures encompassing the entire urban water cycle.

## 2.2. Understanding cities as complex systems

A systems approach can be helpful to comprehend the complexity of the urban system (Mc Loughlin, 1969). It is useful to point out that the system itself may not be complex, but rather the way the components of the system interact, on various levels, across spatial and temporal scales. “In general usage, a system is understood as a ‘complex whole’, a set of connected things and as a group of objects related or interacting so as to form a unity” (McLoughlin, 1969 p.75). “Complexity thus represents dynamic realities and non-linear behaviour” (De Roo & Silva, 2016), it is therefore useful to view cities as complex systems because of the dynamic interacting components contained within cities. Constantly evolving through space and time across multiple scales. This understanding opens us up to the reality of the multiplicity of urban water security.

## 2.3. Governance Theory

The focus and situation of water governance in South Africa shifts in accordance with changing contexts, and as new sets of problems become apparent (Woodhouse & Muller, 2017). Governance is defined as ‘steering human behaviour through combinations of people, state and market incentives in order to achieve strategic objectives’ (Jones *et al.* 2011). The Global Water Partnership defines water governance as “the range of political, social, economic and administrative systems that are in place to regulate development and management of water resources and provisions of water services at different levels of society” (Furlong *et al.* 2016). Fukuyama (2013 p.350) describes governance as “a government’s ability to make and enforce rules, and to deliver services, regardless of whether that government is democratic or not”. From the above stated definitions, they all have in common either the notion of resource allocation and or the exertion of some form of control. Herein lies the essence and probable cause of the status quo in Johannesburg, the governance and sufficient management of urban water resources to ensure water security for the city and all its components in their various interactions. In support of this statement, the Organisation for Economic Co-operation and Development (OECD, 2015) acknowledge that water crises are primarily governance crises. Regrettably, much of the vision intended by the South African water reform process has not materialized. This is particularly the case for water governance, where the rate of establishment of institutions across all levels has been especially slow (Quinn, 2015). The context in which people and their societies interact with water frames the way that the relationship is described. This inroefs turn determines the rules and procedures that constitute water governance and explains why water governance discourses are so often discordant (Woodhouse & Muller, 2017).

The OECD has defined water governance as “the range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision-makers are held accountable for water management” (OECD, 2015 p.5). Figure 5 below illustrates the OECD Principles on Water Governance, which are anticipated to contribute to improving the “Water Governance Cycle” from policy design to implementation, this may be a useful application when considering the gap between policy and implantation in Johannesburg.

### Overview of OECD Principles on Water Governance

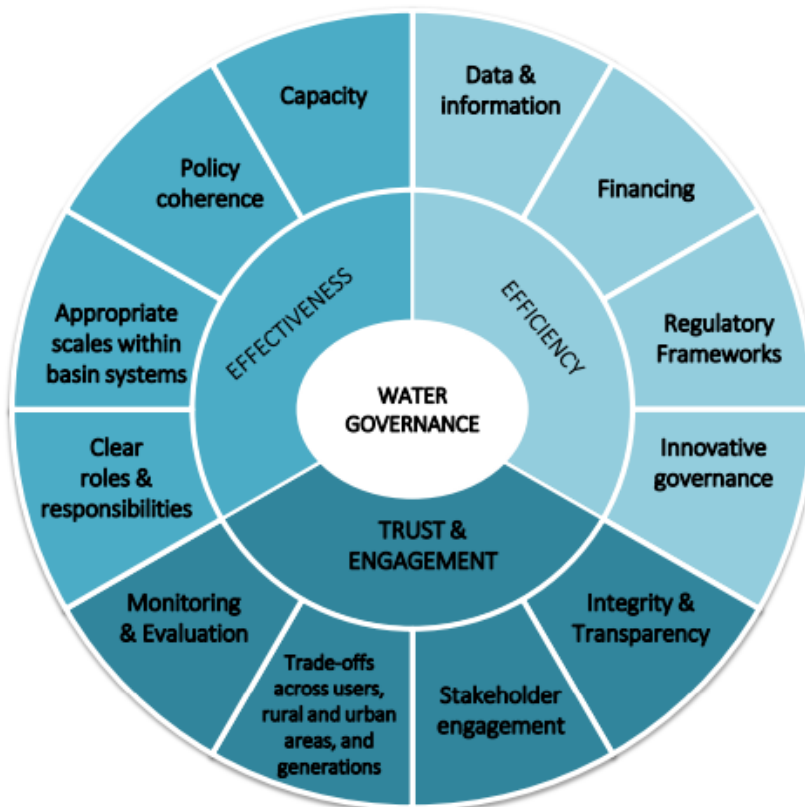


Figure 5. Principles on water governance. After OECD (2015).

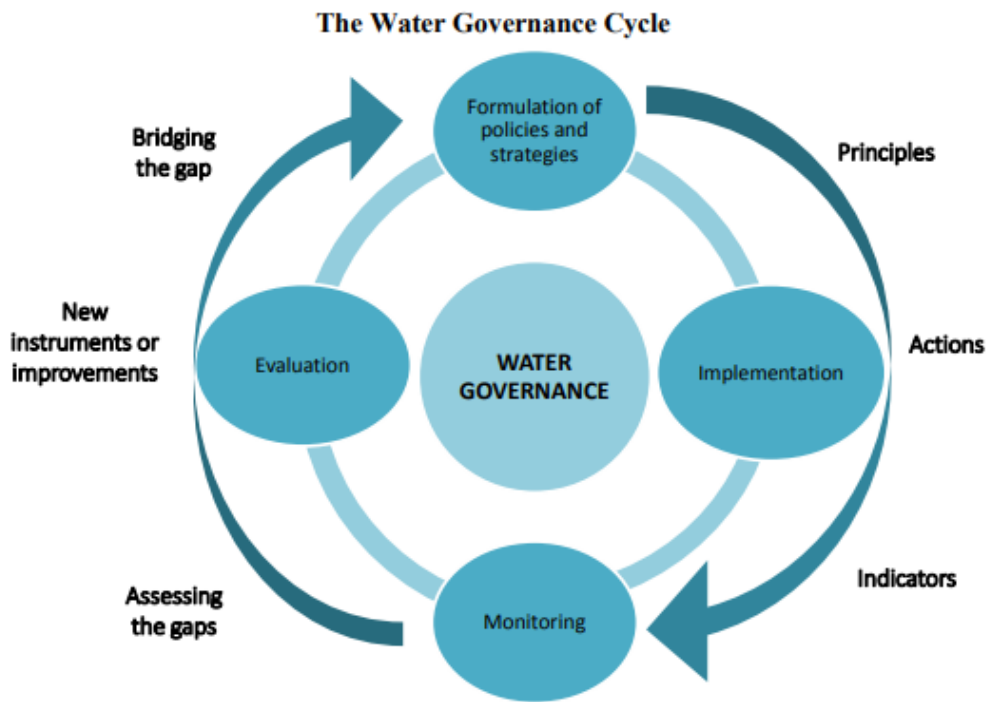


Figure 6. Water governance cycle. OECD (2015).

However, it is imperative to point out that there is no one-size-fits-all solution to global water challenges, but rather a large diversity of situations within and across countries which require solutions adapted to fit the context. Governance responses should therefore be adapted to territorial constraints, all the while recognising that governance is considerably context-dependent and important to fit water policies to places (OECD, 2015). This brings into question, the adoption of generally global north paradigms of water management in South Africa, paradigms such as IUWM.

At this point it is useful to delineate water governance from “water resource management” as water resource management it is assumed to include water governance. Rather, management can be considered to focus on the operational activities of monitoring and regulating water resources and the use thereof including planning, building and operating water infrastructure. Drawing from previous definitions, water governance is thus the overarching framework which sets objectives and guides the strategies for achieving these objectives and monitoring the outcomes (Woodhouse & Muller, 2018). As such, Siyanbola & Olamide (2016) write that South Africa is one of the few countries in the world where the basic right to sufficient water is a constitutional cornerstone. They further go on to state that government is reactive rather than proactive, in the sense that the government is in denial and refuses to acknowledge that there is a water problem in South Africa. Förster *et al.* (2017) add that the formal structure of policy and law, along with the idea of collaborative water governance in newly established institutions may be declared on paper, however the existing agential capabilities, or lack thereof, on all levels of South African water governance in practice are not suitable for the successful implementation of such policy. South Africa has a history of centralized, authoritarian, and hierarchical water management along administrative boundaries (Herrfahrdt-Pähle, 2014 and Brikké & Vairavamoorthy, 2016).

## 2.4. General Water Management

Water is a fleeting, unequally distributed and highly variable yet renewable natural resource. It is intrinsically part of the natural environment while remaining essential in all social and economic activity (Woodhouse & Muller, 2017). Climate change affects the function and operation of existing water infrastructure, typically comprised of hydropower, structural flood defences, drainage and irrigation systems, as well as water management practices (Abott & Cohen, 2010). These very same functions and operations are the fibre that hold South Africa together and when under severe pressure, it becomes a national threat and politicians continue to be misled by the apparent simplicity of water (Muller, 2012). In recent years, the effects of climate change have become more prevalent in the form of longer lasting droughts across South Africa (Matuszewska, 2010; Jacobsen *et al.* 2012).

In contextualising urban water management, it is important to take a step back and peak into the way water resources are generally managed in South Africa. The New Water Policy requires that water management initiatives be divided into Catchment Management Areas (CMAs) which are geographically defined by watersheds (Department of Water Affairs and Forestry, 1997). This has implications for urban water management as cities fall within an individual catchment and therefore the management of water resources in these areas is governed at the regional scale by a Catchment Management Agency (CMAg) (DWA, 1997). There are 9 Water Management Areas (WMAs) pictured in figure 5, with the associated dam water levels in each area. This depicts how critical the situation is for some regions, with a tendency to water scarcity. The National Water Act (36 of 1998), under the authority of national government, provides for the establishment of Catchment Management Areas (CMAs) within these water management areas (figure 7). Catchment Management Agencies have the responsibility of managing water resources at a catchment level (Department of Water Affairs, 2018).



Figure 7. Map of water management areas in South Africa (Department of Water Affairs, 2018).

The CM Agency is established indicating the area, important water resources and use and protection measures amongst others. The CMAs are important as they ensure the decentralization of power to catchment level. In turn, this allows for integration, cooperation and public participation for long-term sustainability of water resources. The CMA is the driving force behind the potential success of water resource management (Department of Water Affairs, 2012). The full consumption of South Africa's water resources is imminent, even though this will be reached at different time intervals for the respective water catchment management areas (Grant, 2011), pictured in figure 8 below.

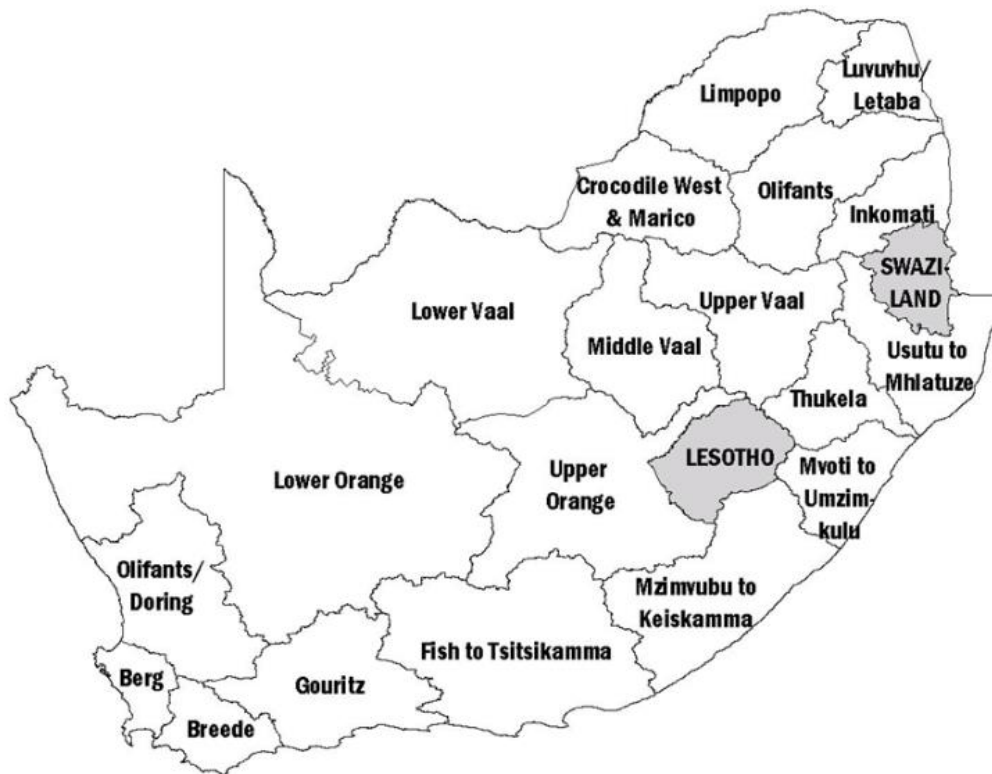


Figure 8. CMAs established within the water management areas (Bohensky, 2014).

One immediate challenge is that water resource management involves a diversity of functions, undertaken at a wide range of scales. Functions may be allocated to geographies that are administratively defined by constitutional arrangements or undertaken in environmentally determined geographies such as river basins or water-sheds (Muller, 2018).

Despite the commendable achievements in water and sanitation provision over almost two decades of democratic transition, several challenges persist. These challenges are summarised in Table 1. The challenges are classified into three broad categories of governance, institutional, and water resources and are discussed below.



Category	Nature of Challenge
Governance/policy	No strict enforcement of regulations Inadequate by-laws/regulations No will to control sprawling of slum settlements Unsustainable policy
Institutional	Lack of human capacity Conditions and age of infrastructure Lack of maintenance Badly designed infrastructure High levels of leakage Corruption
Water Resources	Insufficient water supply Drought impact Pollution and deterioration of water quality Threat of waterborne diseases

Table 1. Main challenges affecting water provision in urban areas of South Africa. Adapted from Makaudze & Gelles (2015).

### Governance/Policy

Many municipalities have demonstrated lack of political will to deal with the enforcement of bylaws and regulations to govern spatial arrangements in informal settlements. (Makaudze & Gelles, 2015). This produces further issues for municipalities in several ways. First informal settlements grow indiscriminately, this is problematic as these settlements encroach preserved land often not suitable for human settlement such as flood-prone areas (UN Habitat, 2015). Second, orchestrating water and sanitation services under such conditions is difficult to implement, monitor, and enforce. Third, it is difficult for municipalities to plan and budget for water related services and provision with a high influx of internal and external migrants moving into cities each year. Most skilled labourers in the water sector are nearing or of retirement age. This poses significant challenges for the water sector as there is a large gap to be filled in terms of engineers, scientists and researchers for example (Wall & Rust, 2017). Not many water services authorities have been able to maintain proper management of water service infrastructure. Accordingly, many municipalities are experiencing frequent water service failures resulting from non-functionality of their regulatory plans, coupled with jurisdictional issues (Makaudze & Gelles, 2015).

## 2.5. Provisions for IUWM

South Africa has comprehensive water resource management policies and framework which make provisions for IUWM. How the efforts of implementing IUWM translate into practice is highly questionable as experience around the world is that, more often than not, water laws are not the problem, these laws are simply not implemented accordingly (Muller, 2007). To tackle water challenges facing Johannesburg, Ferguson *et al.* (2013) emphasize that finding solutions requires arrangements that recognise cities as complex, dynamic, and adaptive systems that depend upon interrelated ecosystem services at local, regional, and global regimes. It has become well established that traditional water management approaches are not enough to deal with emerging water challenges (Furlong *et al.* 2016). The IUWM approach advocates for the integration of many aspects pertaining to water security which are usually dealt with in silos (Global Water Partnership, 2012). An IUWM approach views water supply, drainage and sanitation as components of an integrated physical system (the urban water cycle), all the while recognising that the system is embedded within an organisational framework as well as in the larger natural landscape (Mitchell, 2006). The Global Water Partnership describes IUWM in the following way (Global Water Partnership, 2012): IUWM puts forward a series of principles that support better coordinated, responsive, and sustainable resource management practice. It is an approach that integrates water sources, water use sectors, water services, and water management scales. Working across vertical and horizontal administrative boundaries to overcome the traditional fragmentation of the Urban Water Cycle and integrate interdependent sectors is important for future water security. Folke *et al.* (2005) further state that urban water reforms should result in resilient water resource management that explicitly considers complexity, uncertainty and immediate and long-term change. IUWM has been worked on and developed in other parts of the world. Accordingly, several strategies and guidelines have been developed to facilitate its uptake.

Even with the strategies proposed above, urban areas present inherent challenges to implementing IUWM. These challenges present themselves in the form of infrastructure, investment and institutional challenges (Closas *et al.* 2012).

- **Economic and Investment Challenges:** The economic evaluation and cost-benefit analysis of IUWM solutions must be extended and customised to fit each individual case. Reliable economic models and analyses is essential to test the feasibility of IUWM approaches in comparison with traditional technologies. Securing funds from the government is necessary, especially in cases where local governments lack the funds or capacity to influence capital investments.
- **Institutional Challenges:** Developing the institutions for IUWM is one, if not, the limiting factor for its correct implementation. Just as the IUWM approach provides adaptive solutions to urban challenges, city organisations and institutions responsible for urban water management must find means to accommodate these principles and adapt their structures

to the requirements of IUWM. The awareness and knowledge of stakeholders is essential.

However, aligning institutional goals and strategies within complex systems of local and national governance is vital to ensure the success of IUWM approaches. Dealing with different organisational structures, various jurisdictional levels within metropolitan areas, fragmented institutions, and in some cases, discordant interests are determining factors for the development of IUWM.

- Information Gaps: Climate change will affect river hydrology in the future and there is little information available about future climate at the city level. River basins are a relevant intermediate level on how urban water resources will be affected by climate change (Jacobsen *et al.* 2012; Closas *et al.* 2012).

Apart from the challenges in urban areas, the water management paradigm of IUWM has been criticised for being a global north paradigm, this is further addressed further on in the research.

What is the concept-of-fit of urban water management paradigms such as IUWM in Johannesburg? The social and institutional problems are a barrier to the development of more sustainable urban water management in Johannesburg. For South African cities, the following frameworks are in place to guide sustainable integrated development and the maintenance of service delivery:

- Integrated Development Plans (IDPs) - the goal of IDPs is to bring about prosperous cities that deliver services in an equitable and effective manner through well-governed administrations.
- Water Services Development Plans (WSDPs) – are plans which explain ways in which the city aims to provide equitable, sustainable, people-cantered, affordable and credible water services to all (DWAF, 2004).

Even though these frameworks are in place, they do not address the fundamental changes that need to take place to secure water resources and maintain a water secure status for the country.

## 2.6. Resilience

During times of change and uncertainty, the need for resilience should be high on urban agendas (Quigley *et al.* 2018). Resilience theory has the potential to improve practice by re-equating current discourses to better value the urban setting, where the integration of social and ecological systems, and the ability to enable adaptability and transformability, are essential (Quigley *et al.* 2018). The word resilience has its roots in Latin, from *resi-lire*, which translates to ‘spring back’ (Davoudi *et al.* 2012). It was in the 1960s that the resilience was incorporated into the field of ecology, subsequently the concept was further modified and evolved to encompass multiple definitions, where resilience is defined as “the magnitude of the disturbance that can be absorbed before the system changes its structure” (Davoudi *et al.* 2012, and Spaans & Waterhout, 2017 p.109). However, before doing so they explain that resilience is not only defined according to the time it takes for the system to recover after a shock, but also how much disturbance it can handle and remain within critical thresholds. Building resilience is understood as an interdisciplinary, cross-initiative objective and thus an integrative challenge (Davoudi *et al.* 2012). For the purpose of this research, resilience from a socio-ecological perspective, and consequently urban resilience are focused on. One key difference between traditional aspects of resilience such as engineering and ecological resilience is that social-ecological resilience recognises the ability of a system to change, adapt and transform (Quigley *et al.* 2018).

### 2.6.1. Socio-ecological Resilience

Conceiving cities as socio-ecological systems implies understanding them in a complex and holistic way. This concept acknowledges that cities are complex systems which are constantly changing in an often-unforeseeable manner (Sanchez *et al.* 2018). Because the research takes on a systems perspective on cities or urban areas, it is then necessary to address the notion of socio-ecological resilience in terms of water scarcity. In essence, resilience focusses on the ability of a system (in the research context local urban areas that are at risk of experiencing water insecurity) to withstand and recover from ‘disturbances’ that are impacting the system. Here the disturbance is water scarcity brought on by, amongst other causes, a series of droughts and the semi-arid nature of South Africa’s climate and the ability to resist or reduce consequences, the resilience. Socio-ecological resilience advocates that a system is in a constant state of movement and change (Davoudi *et al.* 2012). This is because socio-ecological resilience includes the interaction between human society and its environment, as the development of our society cannot be viewed separate from the environment in which it takes place (Folke *et al.*, 2016). In this perspective, socio-ecological resilience views the societal aspect of resilience as a complex adaptive system with unforeseeable uncertainties (Kim & Lim, 2016).

In this case, resilience is the ability of a system to reorganize, adapt, change and improve, both from the impact that extreme water scarcity and droughts have as well as other influences that can have an impact on the ability of an urban area to handle disturbances (Carpenter et al. 2005). In the same vein, it also includes the learning capacity inherent in the system which can lead to re-evaluation of the conditions in a system (Leach, 2008). Moreover, socio-ecological resilience recognises that if changes in the system are no longer able to resolve the stress that is pressuring the system, the current state of the system then becomes undesirable. To resolve this, instead of adaptation within the system, a transformation of the system is seen as a step to change the system in such a way that the stress can be resolved (Davoudi *et al.* 2012; Restemeyer et al. 2015). Perhaps the same can be said for urban water management practices in the Johannesburg Metropolitan, that adapting to climate change may not be enough if current water use trends persist, a complete overhaul of the system is necessary.

The notions of robustness, adaptation, as well as transformation are intrinsically embedded in the concept of socio-ecological resilience (Restemeyer *et al.* 2015). These notions are key in curtailing a water crisis in Johannesburg. Transformation in this case refers to the willingness of actors to participate and change their mind-set and approach in light of new information or insights (Restemeyer *et al.* 2015). These notions can be improved upon by way of spatial measures (green infrastructure) and policies to improve the resilience of Johannesburg Metropolitan. Water security in urban areas has multiple far-reaching impacts that require different approaches. As a corollary, resilience can focus on part of the impact brought on by water scarcity, on water security or cover other aspects regarding water security, which impact upon food-and energy security as well (Quigley *et al.* 2018).

### 2.6.2. Urban Resilience

From the understanding of cities as complex adaptive systems, the delineation of socio-ecological resilience can be taken a step further. Urban resilience is understood in this research, as an extension of socio-ecological resilience. Due to the nature of urban areas in South Africa, which can somewhat be described as dual manifestations, urban resilience is key when assessing the concept of resilience and the place it holds in the water security conversation. Urban resilience can thus be interpreted as boundary object. According to Meerow & Newell (2016), a boundary object refers to a concept that has shared meaning in different social worlds and inherently supports cross-disciplinary collaboration. “Urban resilience refers to the ability of an urban system—and all its constituent socioecological and socio-technical networks across temporal and spatial scales—to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity” (Meerow & Newell, 2016 p. 7). This definition offered by Meerow & Newell (2016) not only reconciles the inequalities faced in Johannesburg in a practical sense but also addresses crucial factors underlying the necessity of urban resilience theoretically, pertaining to water security. When analysing resilience, it is necessary

to explore it in an all-encompassing manner. There are five crucial questions to consider when talking resilience, just as (Restemeyer *et al.* 2015) distinguish resilience for who, to what, so is it essential to ask the same of urban resilience. In so doing, various trade-offs arise around the notion of resilience coupled with water security displayed in table 2 below. For example, whose resilience is prioritised, and who determines what is desirable for an urban area? (Meerow & Newell, 2016). These are pertinent questions for achieving urban resilience, and addressing urban inequalities is central to formulating water scarcity resilience strategies (Rodina & Harris, 2016).

Questions to Consider		
Who	T R A D E - O F F S	Who determines what is desirable for an urban system? Whose resilience is prioritized? Who is included (and excluded) from the urban system?
What		What perturbations should the urban system be resilient to? What networks and sectors are included in the urban system? Is the focus on generic or specific resilience?
When		Is the focus on rapid-onset disturbances or slow-onset changes? E Is the focus on short-term resilience or long-term resilience? O Is the focus on the resilience of present or future generations?
Where		Where are the spatial boundaries of the urban system? Is the resilience of some areas prioritized over others? Does building resilience in some areas affect resilience elsewhere?
Why		What is the goal of building urban resilience? What are the underlying motivations for building urban resilience? Is the focus on process or outcome?

Table 2. The five W's of urban resilience. After Meerow & Newell (2016).

## 2.7. Adaptation

An adaptive system is a system that changes in the face of disturbances to maintain a consistent state by changing its properties or modifying its environment. The ability of a system to anticipate and respond to various stressors, its adaptability, is considered a central tenet for aligning complex social and ecological systems in the face of uncertain futures (Bettini *et al.* 2015). It has been argued, with its mixed background from organizational theory, ecology, and anthropology that the concept of adaptive capacity can connect new disciplinary perspectives to better understand the complexity of sustainability problems (Bettini *et al.* 2015).

This research proffers that the degree of social adaptive capacity has a strong influence on the water security status. It is envisioned that if the present state of water scarcity prevails, the social adaptive capacity may deteriorate to a state of social instability, along with environmental deterioration in figure 9 below.

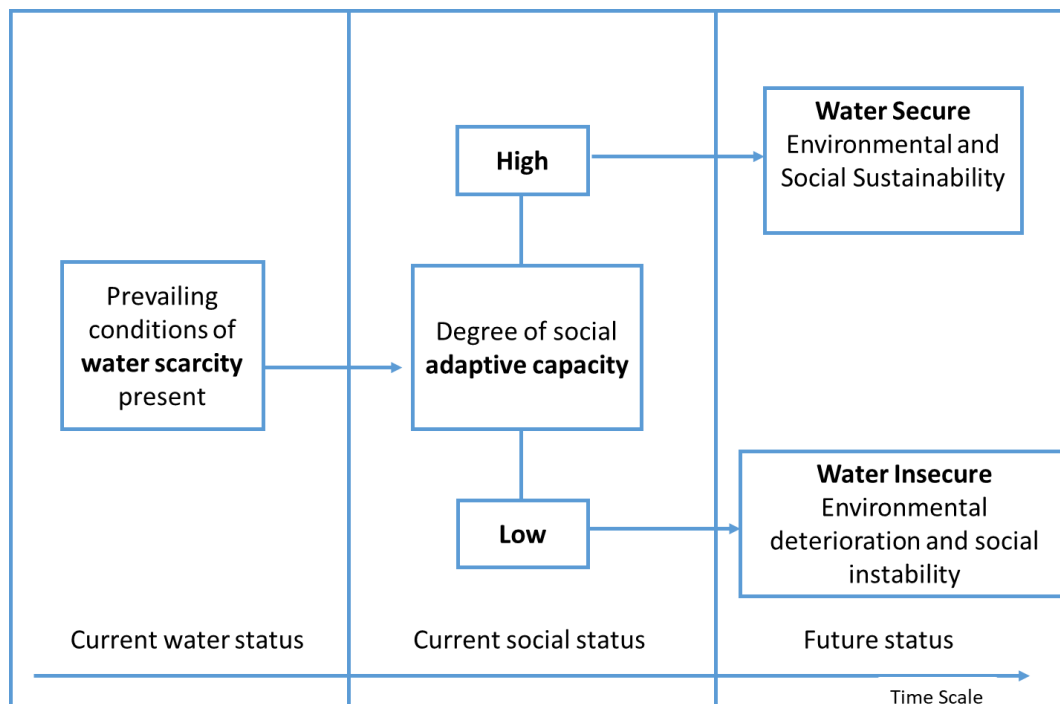


Figure 9. Schematic of the probable outcomes based on adaptive capacity Adapted from Turton, 2001.

The level of social adaptive capacity, loosely defined by Ohlsson (2000) as the ability of a society to adjust to the increasing levels of water scarcity, is the determining variable between water security or water insecurity (Turton, 2001). By using this, the research is able to determine how far along Johannesburg is in terms of the three stages of adaptation to water scarcity:

- The first level entails societies' attempts at supply-led management, which is essentially acquiring more water (Ohlsson & Turton 1999). This is achieved by dam building, pipelines, inter-regional water transfer schemes and the drilling of boreholes to abstract groundwater. At this stage, the main social resources required are large-scale engineering interventions

(Ohlsson & Turton, 1999). A contemporary example of this in South Africa is the Lesotho Highlands Water Project (the largest water transfer scheme in the world) designed to bring water to South Africa's industrial heartland, Johannesburg, from the Katse Dam in Lesotho. Rain water harvesting is a household level, low-tech, intervention practiced by some households and farmers.

- At the second level of (increased) adaptation, when continued supply-side management can no longer match the amounts of water required by continuing population and societal welfare increases. At this stage, societies are forced to make use of demand-led regulation, first by end-use efficiency measures, the objective of which, is to get more use out of every drop. Social resources utilized at this stage are institutional change, new regulatory frameworks and economic incentives for water saving. In the case of Johannesburg, this an example is tiered water pricing (Ohlsson & Turton, 1999; Institute for Security Studies, 2018).
- At the third level of (further increased) adaptation, societies are forced to abandon the traditional goal of food self-sufficiency and replace it by food security. This is the ability to produce sufficient economic value in industries and cities, or by non-renewable resource abstractions, to be able to import the required amount of food. This is the second stage of demand management, namely allocative efficiency (get more value out of every drop). The need for social resources at this stage are particularly acute, since allocative efficiency entails enforced and large-scale social restructuring. For example, people must now find jobs and livelihoods in cities and industries instead of in agriculture.

The goal of adaptation to water scarcity is to realise natural water resource reconstruction, that is, a level of water resource extraction which is below the natural resource sustainability level (Allan & Karshenas, 1996). This means that total water withdrawals must be less than the annually renewable amount of water. The challenge for water management is to accomplish this with available social resources, in a manner that does not hinder development expectations (Turton, 2001). The tools to accomplish this, however, differ vastly from the era of engineering. The most effective tools today are institutional change, economic incentives & disincentives, and the large-scale social structural change (Turton, 2001). This requires some degree of self-organisation as the system elements are diverse in both form and capability, they adapt by changing their rules of interaction and hence behaviour, as and when they gain experience (Pahl-Wostl, 2015).



## 2.8. Spatial Planning

Spatial planning can be broadly defined as “*the practices that influence the distribution of activities in space*” (Woltjer and Al, 2007: 1). Spatial planning is a tool used to involve multiple policy agendas implemented in a specific place that result in conflicts in space and time. The outcome of spatial planning is therefore to mediate how land is used which is integral to the promotion of environmental sustainability (Owens & Cowell, 2005). Campbell (1996) highlights the conflicts that exist between the various spatial planning goals of social, economic and environmental sustainability. Traditionally, the growth of cities has been characterised by the destruction of the natural environment, however, environmental considerations in planning have not always been overlooked as the current urgency surrounding environmental protection suggests (Campbell, 1996). Further implications for spatial planning are the decoupling of economic growth and environmental degradation. Figure 10 below illustrates the conflicts between the three priority areas of spatial planning. Rana (2009) notes that a major conflict exists between the need for environmental justice, the equitable distribution of resources and the notion of a sustainable city.

National Planning Commission of South Africa has recently stated that ‘providing high-quality public services is the single most important thing that can be done to overcome the inequalities of apartheid (Republic of South Africa, 2011). Their vision is one of transforming the public service and improving state performance through enhancing institutional capacity by way of a polycentric governance model. A model in which local government will retain responsibility for ensuring adequate service provision in its areas, and regional authorities (assumed to have higher levels of competencies) will provide services in cases where municipalities have inadequate technical and financial capabilities (Republic of South Africa, 2011).

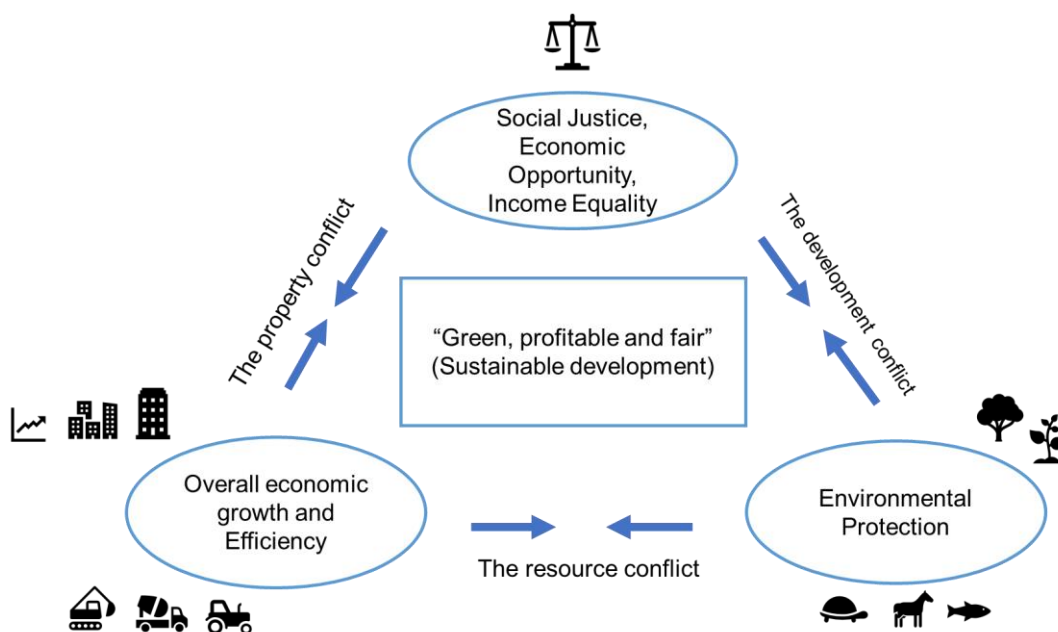


Figure 10. Conflicts between the three priority areas of spatial planning. Adapted from (Rana, 2009).

It is argued that the redistribution of environmental resources away from the urban elite to the urban poor cannot be achieved under the current neoliberal market economy in which all are unable to participate in an equitable manner (Rana, 2009). This is intensified in cities of the global south given the large gap that exists between the urban rich and the urban poor. In South Africa, and even Johannesburg particularly, this was exemplified by spatial planning regimes and the separation of white and black residential areas. These concerns must be taken into consideration by spatial planning initiatives and ways in which to promote equality must be found under current economic conditions to create a truly sustainable city. Water resource planning is fundamental to balancing water distribution between that required for economic growth and development and provision for domestic consumption and environmental functioning. The Social Assessment and Development Framework developed by the DWA guides water infrastructure planning in a manner which seeks to enhance the focus of attention on social needs (DWA, 2013a). Municipalities have however failed to adopt this approach in their planning initiatives and thus there is a need for innovative approaches to manage, conserve and develop urban water resources and the associated infrastructure to meet social, economic and environmental requirements (DWA, 2013). Increasing pressures from climate change and population growth on urban water resources are the major drivers behind the need for more innovative, ways in which to manage these resources (Carden & Armitage, 2013). Concerns with regard to water resources within urban areas include resource depletion, pollution, over extraction and exploitation, insufficient access to services such as wastewater removal, water supply and sanitation, and resultant negative impacts on human health and environmental integrity (Carden & Armitage, 2013). It is necessary to include the natural system as a component of the human system (Kidd & Shaw, 2007) as this allows for more holistic responses to climate change and population pressures on increasingly scarce resources, one of which being water. As noted by Wilson and Piper (2010), there is a recognised need to integrate planning for water and spatial planning, yet avenues to attain this still need to be developed as this requires significant research.

### Planning and Informal Settlements

Informal settlement well established in many urban areas of South Africa along with other developing countries. Efforts to upgrade urban informal settlements have rather unsuccessful because of ineffective participation in the planning processes. The planning is traditionally spearheaded by land use planners (Maselwanyana, 2010). The housing backlog coupled with a shortage of housing subsidies means that for many South Africans there is no alternative but to live in informal housing and shack settlements (Richards *et al.* 2007). Informal settlements are surrounded by controversy with issues such as land invasion (Huchzermeyer, 2004). Due to their inherent nature, these settlements are difficult to integrate into traditional urban planning. Their sporadic nature has long been a problem for South African Planners (Maselwanyana, 2010). The term 'urban' takes on a dual manifestation in Johannesburg, on one end of the spectrum there is the well-planned and constructed built environment. On the other end of the spectrum there are informal settlements. Urban informal settlements are defined by UN Habitat (2015) as residential areas where:

- inhabitants have no guarantee of tenure regarding the land or dwellings they occupy, with means ranging from squatting to informal rental housing,
- the neighbourhoods usually lack, or are cut off from, basic services and city infrastructure and
- the housing may not comply with current planning and building regulations and is often situated in geographically and environmentally hazardous areas (UN Habitat, 2015).

## 2.9. Conceptual Model

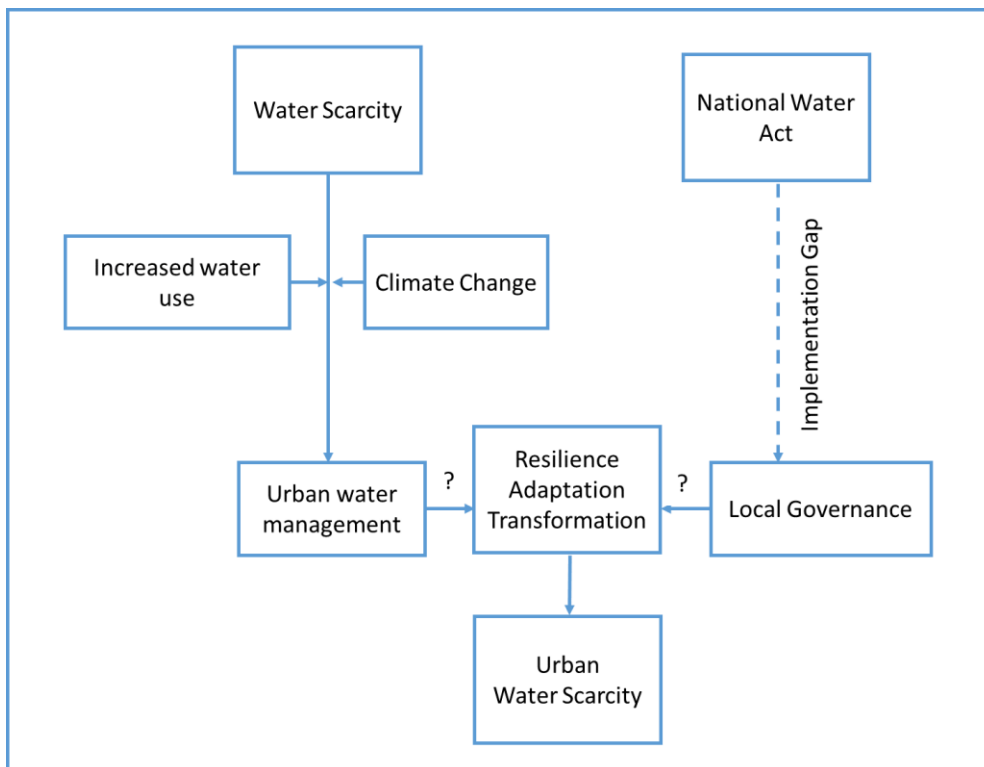


Figure 11. Conceptual model (Author, 2018).

The pathway to urban water security is conceived in the conceptual model above (figure 11). This research culminates in a conceptual model that connects the variables discussed throughout this chapter and are used as a tool to conduct further research. Urban water management and local governance should ideally result in a resilient and adaptive, if not transformative environment to ensure water security in Johannesburg. However, how significant is the role of local governance in influencing the three identified factors of water security; resilience, adaptation and transformation urban water security? This is the objective of the research and the following chapter elaborates on the methods used to reach the research objectives. The methodology further describes how to identify these connections or relations, that way it is clear how this line of thinking has been used to conduct research, this will ultimately aid in answering the researched questions posed at the end of chapter one.

## 3. Methodology

The theories elaborated on in the previous chapter are a foundation for further investigation. In this chapter the methodological background of this thesis is explained. The chosen methodology and methods are explained in more detail and the data analysis and data quality are discussed. The methods have been chosen to collect sufficient data and eventually aid in answering the main research questions.

### 3.1. Research Design

#### 3.1.1. Research Approach

This research explores urban water management in South Africa with a focus on water security in the Johannesburg Metropolitan Area. The study takes on an investigative nature based on theories of governance, resilience and adaptation pertaining to urban water management for water security. The research employs a case study of the Johannesburg Metropolitan Area, augmented with two in-situ cases. The research approach is chosen as the national law and regulations pertaining to water management are the overarching regulations, thus all lower levels are subject to national laws. The aim of this research is to understand to what extent the water crisis in South Africa, and by extension Johannesburg, is due to shortcomings in governance. There has been a marked transition, in relation to policy, goals and objectives, this is indicative upon examination of the National Water Act of 1998. The primary focus within the water sector is to ensure provision of basic water and sanitation services to all, and this resonates the constitutional demand of every citizen's right of access to water, thus a case study approach is used to determine if these provisions translate in administrative action. The process to reform the South African water sector, post 1994, has seen the redefinition of the roles of many of the existing water sector institutions and the introduction of others. This enables an understanding the role of institutions at a local level and how they interact. This thesis makes use of comparative research as the aim and main question is to investigate whether the governance and management of urban water in Johannesburg is sufficient to ensure water security in the metropolitan. By comparing different cases, meaningful conclusions can be drawn from the comparison (O`Leary, 2004). In this research, the case of Johannesburg is used to generate detailed knowledge that will aid in answering the research questions (O`Leary, 2004). Thus, a comprehensive understanding of the impeding and supporting conditions for urban water governance and management in Johannesburg. Furthermore, the role of IUWM in South Africa is examined in order to discuss the possibility and desirability of upscaling of IUWM, or whether alternative options are a better fit.

## 3.2. Data Collection Methods

### 3.2.1. Research Strategy

To understand the temporal dimension in comparison, path-dependency has, according to Booth (2011), become an important concept to review in this regard. Path dependency is neither rooted in planning nor public policy, but in the social sciences and economics specifically. The concept of path-dependency attributes its widespread use because it provides “a rational way of interpreting historical phenomena and explaining the influence of past events” (Booth, 2011 p.20). Path-dependence is important for this thesis to understand the development and perception of water in the urban setting and how management regimes have been influenced by past events and how that may influence future events. This is also important in the context of water security, to understand whether the current practices in urban water management are sufficient to ensure water security in Johannesburg for future generations, or if regimes need to be adjusted and prevent lock-ins. This then links to the concept of adaptation, assessing the adaptive capacity of the Johannesburg Metropolitan Area to climate change and the consequences thereof. This further begs the question if water policy and management are reactive or proactive? To find impeding and supporting conditions to the implementation of IUWM, in-depth knowledge is needed of cases where such implementation has happened. A case study of Johannesburg Metropolitan Area is conducted to gain this in-depth and locality-related knowledge.

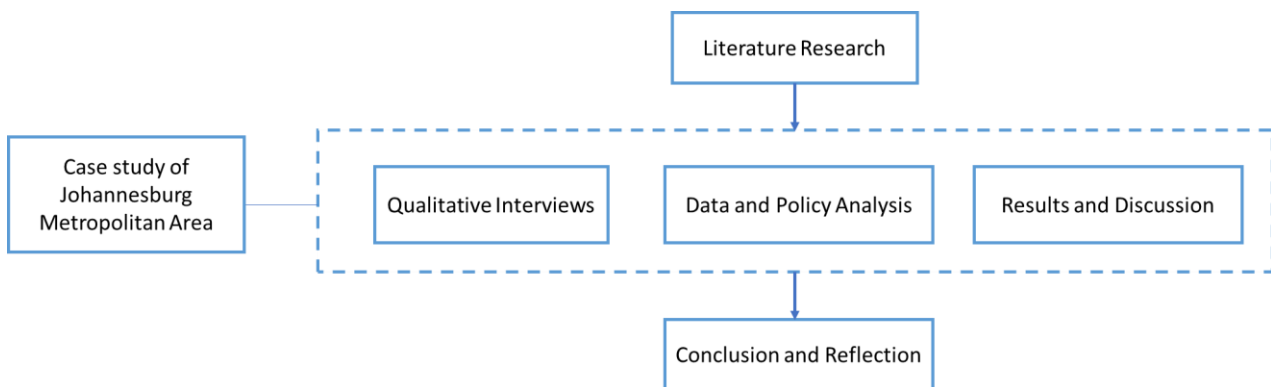


Figure 12. Research strategy, (Author, 2018).

### 3.2.2. Literature study

The literature study performed in chapter 2, provides a basis for the further research in this thesis. As a basis for this study literature on governance. The literature used in this chapter was, excluding some grey sources used to describe the context, obtained from scientific journals and books

### 3.2.3. Qualitative Research

In conducting this research, qualitative methods have proved to be useful for navigating the complexity of the research problem and distilling the research into manageable parts. This descriptive data is gathered from spoken or written communication. Accordingly, qualitative methods have been used because they have aided in explaining linkages and or mechanisms that resulted in the problem in the first place.

In general, the concept of qualitative methodology refers to research that produces descriptive data, in essence, it is a way of approaching the empirical domain. Qualitative research relies on reasons behind various aspects of behaviour and gives an in-depth understanding of the behaviour of humans and the reasons that govern it (Taylor *et al.* 2015; Kothari, 2004). To enhance the quality of qualitative research, systematic collection, ordering, description and interpretation of textual data is necessary. It needs to be considered that the produced findings are not generalizable and universally applicable in qualitative research (O'Leary, 2004).

## 3.3. Specification of research units

### 3.3.1. Feasibility

To allow for in-depth analysis, the research has been limited to the case of Johannesburg. Due to the scope of the master thesis, a larger sample would possibly compromise the quality of the single case. Moreover, as this research has an explorative character the small sample allows for refining the governance assessment, before doing a more thorough analysis.

### 3.3.2. Case Selection

Water security is a pertinent subject which begs to be engaged upon. The selection of Johannesburg Metropolitan as the subject of research has been selected based on the intricate socio-political, socio-ecological and economic interactions and the importance of sufficient water resources, the hydro-social contract. The location of the city, on a watershed also makes for interesting dynamics for water resource availability, this sets it apart from other metropolitans in South Africa. Again, owing to the history of South Africa and the discrepancies in access to resources, the case makes use of two examples which illustrate the starkly contrast in access to water related services.

### 3.3.3. Time Frame

With changing trends in climate and the unpredictable consequences of climate change, water security is a topic that will be relevant well into the foreseeable future. However, for the purpose of this research, the case focuses on a 10-year time period from 2001-2011, as this period has seen significant changes in water resources and the management thereof, leading up to the major the water crisis in South Africa, worsened by the drought that hit the country in the period of 2014-2016.

## 3.4. Data Analysis

The semi-structured interviews conducted are transcribed to enable a thorough analysis of the content, the answers given by the interviewees. Content analysis is useful in interpreting meanings embedded in verbal and written communication (O'Leary, 2004). Data needs to be organised systematically and to do so, coding is a useful tool, for this research, the Atlas.ti software is used. According to Saldaña (2009 p.3), "a code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data". Coding is therefore imperative as it structures the interviews according to themes and facilitates answering of the research questions (O'Leary, 2004).

The legitimacy and credibility of research is determined by the quality of the data, which thus needs to be assured (O'Leary, 2004; Flick, 2009). According to O'Leary (2004), making research credible encompasses an indication of how to deal with subjectivity, methodological consistency, truth, applicability, and accountability. The fulfilment of these criteria is thus determined by the researcher (O'Leary, 2004). Accountability is attained by being open and transparent about the research process, as per this chapter, to make the research auditable, comprehensible and reproducible. Methodological consistency is addressed through consistent, systematic and adequate documentation during the research procedure. The content analysis procedure for instance, is documented in this chapter and the used codes for analysis are disclosed. Authenticity is assured by diligent, thorough and accurate undertaking of research.

### 3.4.1. Semi-structured Interviews

A semi-structured interview, also referred to as an informal or conversational interview, is a verbal exchange where the interviewer gains information from the interviewee by means of pre-determined questions. A characteristic of this method is the flexibility it allows in terms of questioning (Kothari, 2004). The process involves finding enlisting participants, establishing a means of communication (e.g. telephonic interviews) and finally transcribing the interview (Clifford *et al.* 2016). Semi-structured interviews develop in a conversational manner where the participants are at liberty to explore issues they feel are essential, as and when they arise (Clifford *et al.* 2016). This type of interview has often been used to gain information and data on a diverse range of subjects, semi-



structured interviews are adaptable because they can be augmented by numerous other methods. To ensure that the same standard and quality is upheld during all the interviews, a list of standardised questions is used, some more specific depending on the area of expertise of the interviewee. This increases the comparability of responses since similar questions are answered and facilitates organization and analysis of the data. As mentioned above, the line of questioning in the semi-structured interviews has been kept similar. Each interviewee responded to 12-16 questions depending on time constraints. The questions cover various topics, ranging from the water crisis itself and the various causes thereof, to questions about the skills gap of water related experts in the country. An overview of the interviews is provided in table 3 below.

Interviewee	Profession	Date	Method	Duration
1.	Civil Engineer	10 May 2018	Skype voice	00: 27: 26 h
2.	Macro-ecologist and Conservation Biologist	04 June 2018	Skype video	00: 28: 11 h
3.	Water Governance, Trans-boundary Water Politics	06 June 2018	Skype video	00: 40: 40 h
4.	Scientist: Environmental Resource Management	11 June 2018	Skype video	00: 32: 27 h
5.	Hydro-political Scientist (Hydro-politics)	18 June 2018	Skype video	00: 35: 57 h
6.	Consultant: Global Change, Climate Strategist	20 June 2018	Skype voice	00: 43: 54 h

Table 3. Overview of interviewees, their profession, the date of interviewing and interview method. (Author, 2018).

It is essential for the interviewer to be aware of ethical issues that arise while conducting qualitative research, these may be anonymity or confidentiality (Clifford *et al.* 2016). For the purpose of this research, the interviewees are assured of their anonymity, by referring to them as “interviewee 1” for example. However, the interviewees have no issues with the disclosure of their respective identities. The interviewees chosen for this research have a range of professional backgrounds and expertise in order to provide an objective view. Experts from fields such as civil engineering, water policy, governance and ecology and biodiversity management are interviewed. These experts are identified by an active online search across government departments and various institutions involved with water resources in some way. The interviewees are initially contacted by email, many of which have not responded at all, and one declined. The correspondence with the various professionals who have agreed to be interviewed is also by email, followed by the actual interviews conducted over Skype.

### 3.4.2. Policy analysis

The policy analysis in this research is focussed on the formal arrangements national government makes for water management. As the research focuses on urban water management, local policies are also analysed. The OECD Principles on Water Governance are used as a guideline to analyse water policies at both the national and local spheres of governance.

### 3.4.3. Transparency and Ethics

In conducting interviews of any kind, and via Skype especially, it is imperative to be aware of biases both of the interviewer and from the interviewees. Because the conversation is over long distances and impersonal, certain biases may arise in communication. Certain elements are not communicated verbally, such as behaviour, feelings or attitude and cannot be detected. Therefore, there is little flexibility in relating the interview to individuals. To safeguard transparency of the data collection process and the analysis, a database is created. This database contains all analysed documents, as well as the transcripts of the interviews. The data collected will, if not requested otherwise, solely be used for the master thesis and will be deleted after 3 years.

## 4. Case Study

### 4.1. The case of Johannesburg Metropolitan Area 1994-2011

Johannesburg is characterised by huge levels of inequality, and a lack of access to even the most basic services in many informal settlements and townships (Nastar & Ramasar, 2012). The heart of South Africa's economy is built up in Johannesburg (Todes, 2012; World Urbanisation Prospects, 2018). Addressing urban water security in Johannesburg is significant due to exceptionally complex interactions within and between human and water systems in urban regions (Nazemi & Madani 2017b). As defined in section 2.1, water security is a critical challenge confronting the Johannesburg Metropolitan in the 21st century. Furthermore, water scarcity presents a profound challenge to South Africa's social well-being and economic growth. The racial policies of societal segregation of the white South African Apartheid regime (1948–1994), in which race, gender, and class were the dominant factors in South African society, mirrored water access in the country (Förster *et al.* 2017). The trend has lived on through the decades despite major efforts by government to provide access to water to over 11 million South Africans since 1994 (Nnadozie, 2011). Looking at planning in the Johannesburg, what stands out is the need for urgent decisions to be made concerning overlapping freshwater problems such as increasing demands for water for various users, changes in the physical environment which affect the water balance, and disposal of waste, some of which contaminates streams and ground water (Maksimovic & Tejada-Guibert, 2001).

By focusing on the urban context, it is necessary to understand the definition of urban in Johannesburg, the definition stated in section 2.10. The urban water problem in Johannesburg can be interpreted as the relationship between distributional equity in access to water, the ecological sustainability of living environments and the relationship between the social demands for water and the sustainability of water supply (Debbane & Keil, 2004). The ecological sustainability of living environments is under severe pressure as a result of climate change as well as observed changes in rainfall patterns over the country (Debbane & Keil, 2004). South Africa is traditionally a semi-arid country, and significant weather variations and prolonged droughts are nothing new (Muller, 2012). The most crucial balance is that of social demands for water and the sustainability of water supply. As it stands, climate change projections estimate that cities around the world are expected to absorb approximately 60% of the total population growth, which will further stress sustainable water supplies. This stands true for Johannesburg, as population migration studies have shown, Johannesburg is a recipient of hundreds of thousands of migrants, from within and across the borders of South Africa. Table 4 below shows the percentage distribution of migrants in Gauteng province in 2011. It is a breakdown of migrants coming into the province from elsewhere in the country. Johannesburg is the main destination of migrants to Gauteng, attracting 38.4 percent of all migrants to the province, and is also the preferred destination in Gauteng for foreign migrants from outside South Africa - 48.9 percent (Statistics South Africa, 2015).

Province	District										Total	
	Sedibeng		West Rand		Ekurhuleni		City of Johannesburg		City of Tshwane			
Western cape	1690	3.7	2200	4.9	9100	20.2	19610	43.5	12500	27.7	45100	100.0
Eastern cape	5200	4.3	15870	13.3	33960	28.4	40310	33.7	24340	20.3	119680	100.0
Northern cape	730	5.2	1220	8.7	2710	19.4	5390	38.6	3930	28.1	13980	100.0
Free state	13600	20.5	5930	8.9	13980	21.1	16860	25.4	15940	24.0	66310	100.0
Kwazulu-Natal	5210	3.2	8160	5.0	48910	30.2	77420	47.9	22010	13.6	161710	100.0
North west	3170	3.7	15310	17.8	8840	10.3	22710	26.4	36140	41.9	86170	100.0
Mpumalanga	5390	5.7	3370	3.6	28100	29.6	19520	20.6	38410	40.5	94790	100.0
Limpopo	5460	2.2	6830	2.7	61620	24.5	79570	31.6	98150	39.0	251630	100.0
Outside South Africa	15260	3.9	27620	7.0	84210	21.3	193360	48.9	75170	19.0	395620	100.0
<b>Total</b>	<b>55710</b>	<b>4.5</b>	<b>86510</b>	<b>7.0</b>	<b>291430</b>	<b>23.6</b>	<b>474750</b>	<b>38.4</b>	<b>326590</b>	<b>26.4</b>	<b>1234990</b>	<b>100.0</b>

Table 4. Percentage Distribution of Main Recipients of Migrants in Gauteng (Statistics South Africa, 2015).

Johannesburg depends mainly on surface water resources for most of its urban, industrial and irrigation requirements. The most dominant use of water is for irrigation, accounting for over 60% of the total water use in the country. As depicted in figure 13, water requirements for urban and domestic use account for almost 10%, what is left being used for mining, bulk industries and as cooling water for power generation (Basson, 2011). Figure 13 below shows total withdrawals by sector in South Africa, against the global average in 2015.

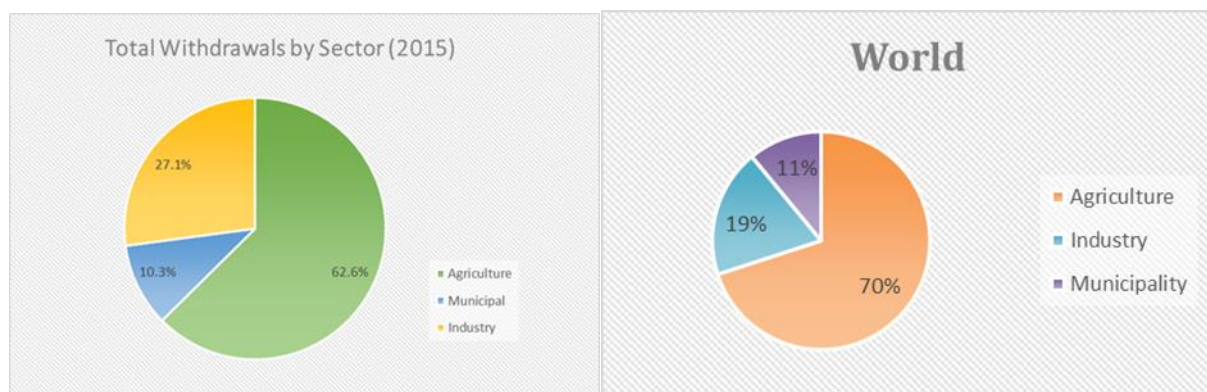


Figure 13. Total withdrawals in South Africa and the world by sector. Adapted from the FAO, 2015.

The variability of water resources is an important factor that contributes to the security and resilience of water supply in Johannesburg and should thus be managed effectively by means of water allocation to ensure the security of supply (Basson, 2011). This is pertinent in the current discourse on water security. The most recent drought that hit nationwide during the period 2014-2016 has had far-reaching consequences on the security of water supply in the city. "What matters is not how much water a country has, but how it is used and by whom, and how well the variability of the resource is managed" (Muller *et al.* 2009 p16).

Considering the key elements for achieving water security (see figure 3 in section 2.1), Johannesburg complies with safe drinking water, coping with uncertainties, water for socio-economic development and to a certain extent livelihoods and values as well as ecosystems are protected. To further enhance water security, the city can benefit greatly from treating a larger percentage of waste water, creating arenas for better collaboration between users and good governance.

#### 4.1.1. Urban water management challenges

The demand for municipal water in Johannesburg is not only driven by the increase in urban population, but also by a tendency for economic development to increase the fraction of the urban population that uses municipal supply (McDonald *et al.* 2014). Moreover, in Johannesburg, the economic development that is oftentimes coupled with urbanization increases per-capita water use, as new technologies such as showers, washing machines, and dishwashers increase residential use of water (McDonald *et al.* 2014; Boccaletti *et al.*, 2010). Schewe *et al.*, (2014) maintain that population changes in the future will invariably increase the pressure on available water resources. Therefore, the effective management of water is a significant component for sustaining human life. The city of Johannesburg needs a plan for a population growth of about 66% in the next 30 years, which includes plans to improve access to clean water, energy and the management of waste and sanitation (City of Johannesburg, 2018).

Along with management of water resources, the matter of the dual nature of cities in South Africa comes to question. Is there a way to plan for informal settlements and formally include them in water service expansion plans? In Johannesburg, the challenge is complex; it is a city in a semi-arid country characterized by low rainfall, limited underground aquifers, and a dependence on significant water transfers from neighbouring nations. Most significantly, the elaborate water transfer scheme pictured in figure 14 below, from the Lesotho Highlands to supply the province of Gauteng, where Johannesburg is situated. There have been many complications with this very project and has not reached completion, certain components of the project are however running, thus providing water. In this regard, some adjustments in the future may have to be made in terms of maximising the water-food-energy nexus. Nazemi & Madani (2017a) add that water-related hazards are expected to become more frequent, more intense and more geographically spread under climate change conditions. Typical water related hazards in Johannesburg are flooding due to insufficient storm water drainage and pollution, and the previously mentioned tendency to drought (South African Weather Service, 2018). The inclination to water scarcity may persist as water levels at the Integrated Vaal River system illustrated in figure 14 below have not risen sufficiently to satisfactory levels (Johannesburg Water, 2018).

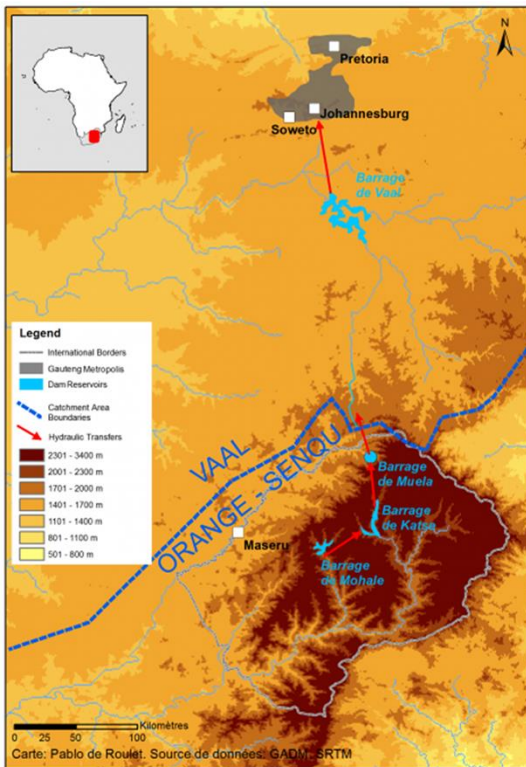


Figure 14. The Lesotho Highlands Water Project's hydraulic transfers between the Vaal and the Upper Orange-Senqu catchment areas. (Rousselot, 2015).

Because of growing levels of scarcity, the City of Johannesburg issued Level-2 water restrictions in 2016. The purpose of these restrictions is to increase reservoir levels and prevent further water shortages caused by demand exceeding supply. Johannesburg is still under level 2 water restrictions despite the recent rainfall following the drought period of 2014-2016 (Jacobs-Mata, 2018; Johannesburg Water, 2018). Pertaining to the level 2 water restrictions, section 44 (3) of the Water Services Bylaw states that “all consumers are forthwith compelled”:

- a) Not to water and irrigate their gardens from 6am and 6pm every day;
- b) Not to fill their swimming pools with municipal water; and
- c) Not to use hosepipes to wash their cars, paved areas, etc.

Beyond jail time and hefty fines, it is not clear what further consequences there are for contravening water use restrictions.

In summation, the urban water management challenges are: Gaps in scientific and technological knowledge which are delaying the implementation of water security interventions, particularly re-use implementations. There is insufficient engagement with, and regulation of, industries as one of the biggest users of water. Skills gaps in government restrict human interactions and leadership with regards to involving communities in decisions about water security and promoting co-operation and transparency. The need to balance land and water reform,

which has further political consequences. Knowledge losses from experts leaving the country or of retiring age and silo thinking and planning among government departments.

#### 4.1.2. Water governance in Johannesburg

South Africa receives significantly less rainfall in comparison to the global average and is ranked internationally as the world's thirtieth driest country (DWA, 2013). The high variability of the spatial distribution of areas with high levels of water runoff results in spatial inequality of water resource distribution across the country. High runoff rates in urban areas, due to a lack of porous surfaces, results in challenges for storm water management including water drainage and pollution (Rodda *et al.*, 2016). Urban flooding is an ever-present threat and along with droughts, these phenomena are projected to increase in frequency and intensity as a result of climate change. Water infrastructure is unevenly distributed throughout Johannesburg; a trend which is apparent within the country's urban areas. The costly nature of water infrastructure and a lack of monetary resources at an institutional level, together with a lack of capacity have resulted in the ageing of vital infrastructure throughout the country. Degraded infrastructure contributes significantly to the inefficient use of water, particularly wastage through faults or leakages within the systems (DWA, 2013a). South Africa has reached a point where water demand is exceeding supply (Department of Water Affairs, 2013). This puts significant pressures on demand side and supply side water management initiatives (DWA, 2013a).

The management of the country's water resources and the ongoing transformation of the South African state and civil state has found its most profound expression in the National Water Act (NWA) that was promulgated in 1998. The NWA manifests a fundamental step in the evolution of South African water law (Malzbender *et al.* 2005). The NWA is the primary piece of legislation of South African water governance; it is a formal macro-level structure of constitutive rules. The NWA makes provisions for the establishment of institutions for water governance, including catchment management agencies (section 2.3). The National Water Resource Strategy 2 (NWRS2) is an amendment of the National Water Resource Strategy (NWRS). The NWRS2 can be regarded as a manual of how to do things in accordance with the NWA. As such, the NWRS 2 provides the procedural rules for implementing the NWA in the country (Förster *et al.* 2017). South Africa, a country that has been acclaimed for its state-of-the-art water legislation, sits at the pinnacle of a paradox as the water administration is not matching up to the standards of the legislation (Herrfahrdt-Pähle, 2014). The new water governance framework reduced the fragmentation of responsibilities and concentrated control over all water resources in the Department of Water Affairs at the national level, figure 15. A major goal of the new legislation was to decentralize water management to the basin level (Department of Water Affairs and Forestry 1997; Herrfahrdt-Pähle, 2014). Policy goes a long institutional way until it meets practice and there are indeed some disparities in bridging this gap (Mollinga 2010). It is in observing the journey between theory and practise that the importance of good governance is understood as well as efforts towards water security.

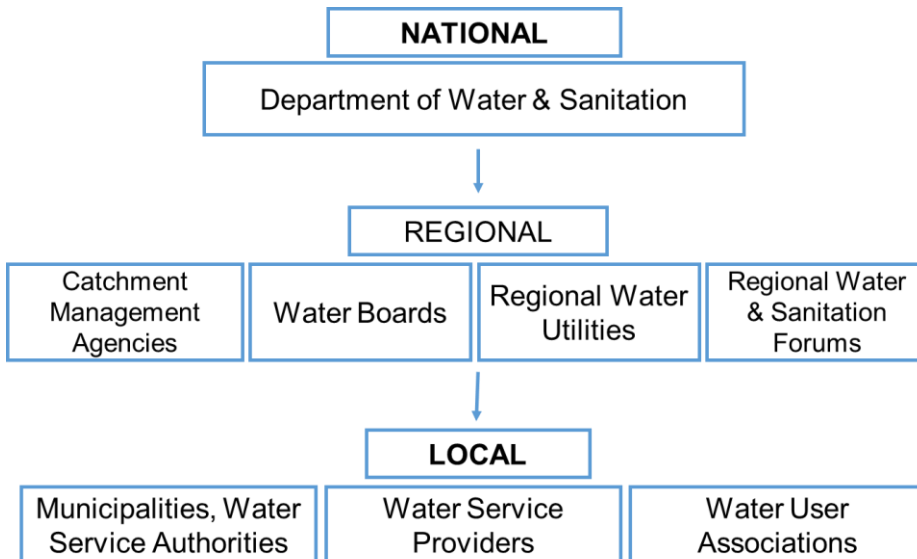


Figure 15. Tiers of water governance in South Africa, the national level is the overarching body with the responsible party being the Department of Water and Sanitation (Author, 2018).

National, provincial and local legislation, policies and institutions guide urban water management in Johannesburg. Management activities include the collection and storage of water resources, transport of water to consumers via treatment facilities, the treatment and subsequent release of wastewater and storm water management (Coombes & Kuczera, 2002). Current approaches to urban water management are characterised by compartmentalisation of management responsibilities delineating processes of storm water management, waste water treatment and water supply (Coombes & Kuczera, 2002). This results in failure to regard the urban water cycle as a complex system in which all components are intrinsically linked, interacting with one another in processes which cannot be separated (Coombes & Kuczera, 2002; Mc Loughlin, 1969).

The department generates national water policies which uphold national legislation and target national development objectives. The policies generated by the DWA are major informants for urban water management strategies (DWA, 2013b). In response to ageing water systems in South Africa, the City of Johannesburg has commenced with an Infrastructure Renewal Plan to increase the renewal rate from 1% to 3.5% to eliminate backlogs (Cairncross & Valdmanis, 2006; City of Johannesburg, 2017). Local government is in a better position to take decisive action and act at a local scale where they can engage citizens, communities and businesses in averting the water crisis. National government is slow to intervene, and when they do their actions are often not at the right scale or timely enough. Generally, cities need more autonomy to act decisively, although proactive, inter-governmental support and cooperation is both helpful and necessary (Winter, 2018). In recent years there has been a paradigm shift in the way in which water is managed. Moving from supply-based to demand-based management. Table 6 below summarises water management institutions. An important facet of the new water policy is to delegate water resource management functions to appropriate institutions the main features of each institution are summarized in table 5 below.



<b>Water Service Institution</b>	<b>Main features</b>
Water Service Authority	<ul style="list-style-type: none"> <li>•A municipality responsible for ensuring access to water supply and sanitation services</li> <li>•Must be a municipality and no other institution</li> <li>•May itself perform functions of water services provider, or enter into contract/joint venture with another WSP</li> </ul>
Water Services Provider (WSP)	<ul style="list-style-type: none"> <li>•Provides the water supply and sanitation services (physically) to consumers under contract to the WSA</li> <li>•WSP function can be performed by municipality, water board, nongovernmental organization, community-based organization, private sector company, or any other private or public body</li> <li>•No person may operate as WSP without approval of WSA</li> </ul>
Water Board (WB)	<ul style="list-style-type: none"> <li>• Is established by the Minister of Water Affairs &amp; Forestry</li> <li>• Primary function: to provide water services to other WSIs</li> <li>• A public water services provider</li> <li>• May perform secondary activities if primary functions and financial standing not compromised – examples <ul style="list-style-type: none"> <li>– Provide management services, training and other support services</li> <li>– Supply untreated water not for household purposes</li> <li>– Provide catchment management services</li> <li>– Provide water supply and sanitation services in a joint venture with WSAs</li> <li>– Perform water conservation functions</li> <li>– With approval of the WSA, supply water directly for industrial use, accept industrial effluent, act as WSP to</li> </ul> </li> </ul>
Water Services Committee (WSC)	<ul style="list-style-type: none"> <li>•A statutory committee that may be established by the Minister should a WSA fail in its duty</li> <li>•WSC does not refer to a community-based organization that performs a WSP function at community level (rural)</li> </ul>
Water Services Intermediary	<ul style="list-style-type: none"> <li>•A person or body providing water to people as a minor part of a contract (e.g. farmer to labourers, landlord of flats to tenants, mining company to employees in housing)</li> <li>• Only applicable where there is an obligation by one party to provide services to another as part of a contract</li> </ul>

Table 5. Water service institutions and their main features. (Department of Water Affairs, 2000)

### 4.1.3. Policy and regulation

The DWA has the primary responsibility of formulating and implementing policies that govern water resource management. Regarding sanitation, there is a worrying absence of regulation at all levels of government. As of 2010 the sanitation function has been moved from DWA to the Department of Human Settlement (DHS), although some regulatory functions remain with DWA, triggering institutional confusion over roles and responsibilities. After a second White Paper on water supply and sanitation policy published in 2002 (after the first White Paper in 1994) a national policy was established to further decentralise the sector, phasing out the national government's involvement in service provision, limiting DWAF's role to policy and regulation (DWAF, 2002).

### 4.1.4. IUWM

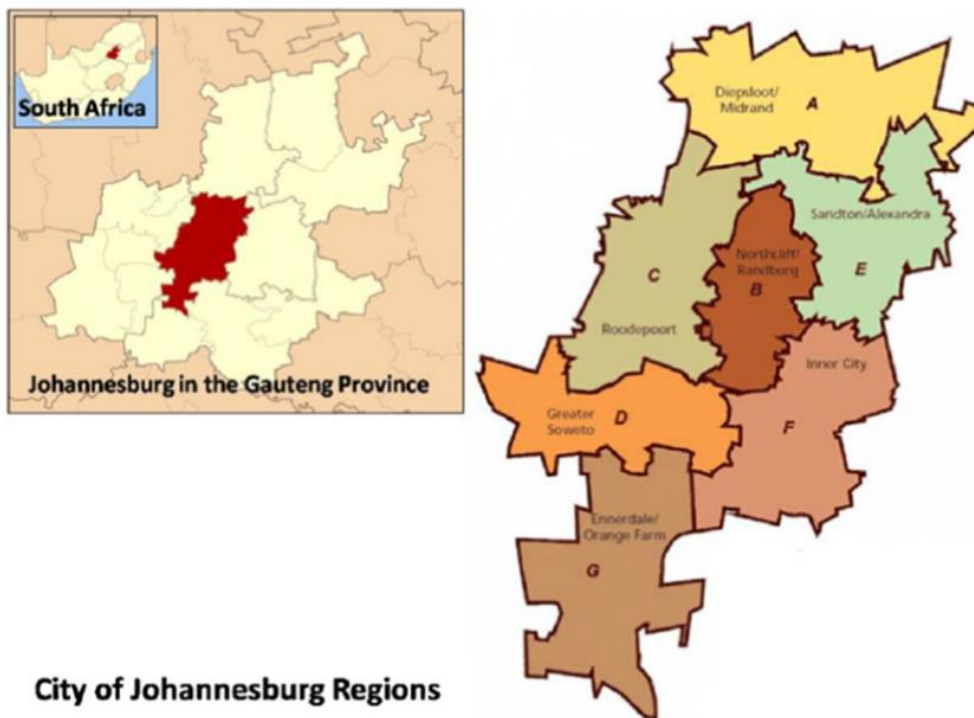
IUWM combines fresh water, wastewater, storm water, and solid waste to allow for better management of water quantity and quality (Bahri, 2012). The principles include environmental, economic, social, technical and political aspects of water management to better align urban water flows with natural water cycles to enable sustainable development and livelihoods for all citizens.

Taking a closer look at the entities of IUWM, fresh water, wastewater, storm water, and solid waste, these are all handled separately by the city of Johannesburg as mentioned in section 2.5. Take storm water management and waste water management components of IUWM for example. In Johannesburg, there is a separate by law to deal with the storm water aspect of urban water. In terms of Section 13(a) of the Local Government: Municipal Systems Act, 2000 (Act No 32 of 2000), publishes the Storm water By-laws for the City of Johannesburg Metropolitan Municipality. Waste water on the other hand is treated by the Johannesburg Water, which is also making efforts to convert the treated effluent to biogas after launching its first pilot biogas project in 2013 (Johannesburg Water, 2016). Another form of waste water, grey water is also handled differently with its own by-laws. Due to a growing awareness of a need for change, the management and use of grey water, including other resource options that have potential in diversifying water resources, as a viable alternative source of water for a range of 'fit for purpose' end-uses is being considered (Water Research Commission, 2018). However, the use of grey water is only advocated for serviced settlements due to the risk of contamination - according to the South African Water Quality Guidelines (DWAF, 1996), gastro-intestinal and other illnesses can be expected to rise when people are in contact with E. coli counts above 400 counts / 100 ml (Water Research Commission, 2018). In South Africa, the use of largely untreated grey water has mainly been restricted to areas where alternative water sources are needed, often during times of drought. This is partially because there are few published local guidelines on how grey water systems should be designed, operated, and maintained as part of an integrated water supply system (Water Research Commission, 2018).

The City of Johannesburg has an Environmental Services and Infrastructure Department. With a focus on environmental sustainability, their aim is to address issues such as limited water resources, poor river health and associated ecological infrastructure, urban sprawl and associated impacts, including land availability (City of Johannesburg, 2018). However, no specific guidelines are provided as to how they go about doing this, or which sectors they will collaborate with to achieve the desired results. As a component of IWRM, IUWM deals with the imposition of society on ecological functions and the natural water cycle in the urban context, as well as the exploration of avenues for improved service delivery through appropriate management and rigorous action. As seen from the text provided above, ecological functions, the urban water cycle and service delivery are all handled by different entities and lack a unified coordinative frame. To date there are no examples of IUWM being carried out in Johannesburg, although variations of sustainable urban water management practices are undertaken at project level conducted by various research institutions.

#### 4.2. The Narrative of urban settings

The two short texts that follow are set in similar geographical settings in the Johannesburg Metropolitan Area, but with starkly contrasted social landscapes. These two cases are used as they highlight the extreme differences in access to water within the Johannesburg Metropolitan Area.



**City of Johannesburg Regions**

Figure 16. The Regions of Johannesburg Metropolitan including Alexandra, and Fourways in Region E. (Nastar & Ramasar, 2012).

### 4.2.1. Alexandra Township

Alexandra, or 'Alex', is a major urban settlement and is the oldest township in Johannesburg. It was established in 1905 (Richard *et al.*, 2007). Alexandra is also one of the region's poorest areas, historically disadvantaged from a lack of infrastructure, overcrowding and a high crime rate (Richard *et al.*, 2007; Nastar & Ramasar, 2012). It is further characterized by high population density, incremental population growth, high levels of unemployment, fairly low levels of education, and low incomes (De Wet *et al.*, 2001). The actual population size of Alex has been the subject of much debate and speculation over the years. The infrastructure was designed for a population of about 70,000. Current population estimates vary widely and have been put at figures ranging from 180,000 to 750,000 in 2005 (Roefs *et al.* 2003; Richard *et al.* 2007). Alexandra is one of the most densely settled residential areas in South Africa, figure 17, covering roughly 5 square kilometres. According to Nastar & Ramaasar (2012), the physical area of Alexandra is divided into 10 unofficial areas for development initiatives. These areas are representative of different forms of housing in the township and include formal houses, yards with numerous houses, apartment blocks and informal shacks (settlements) (De Wet *et al.* 2001). Amongst these different areas, there are apparent differences in water infrastructure. Where some households have piped internal water, others have none at all and rely on communal taps (figure 18). It may seem as if the requirements of water service delivery are being met however the disparity between service levels is significant (Richard *et al.* 2007).



Figure 17. Several residential areas in Alexandra, formal flats and housing as well as informal settlements (Eye Witness News, 2018).

#### Basic Services

Access to water in the township is from communal street taps and sanitation is for the most part sub-standard non-flushing toilets (Nastar & Ramasar, 2012). Some residents have direct access to water in their own yards, however this is a small percentage. Residents' satisfaction with informal dwellings and associated services is very low; the highest level of satisfaction being over 10%. In general, housing is considered inadequate and the service levels below average (Nastar & Ramasar, 2012). Figure 19 below is a schematic representation of water infrastructure in Alexandra.

Because the originally developed area of Alexandra now has a population almost four times of the initially planned size, the waterborne sewerage system has become overloaded and thus frequently

blocks and surcharges (Council, Greater Johannesburg Metropolitan, 2000). The formal residential stands houses that were initially built were designed for single family living, however, backyard shacks now cover the area of most such stands. Structures have been built over sewer lines and manholes, this has made access for maintenance near impossible in most cases. The informal areas built on the riverbanks and tributaries are not connected to the formal waterborne sewerage system and are served by chemical toilets (Council, Greater Johannesburg Metropolitan, 2000).



Figure 18. Community taps in Alexandria. (Eye Witness News, 2018).

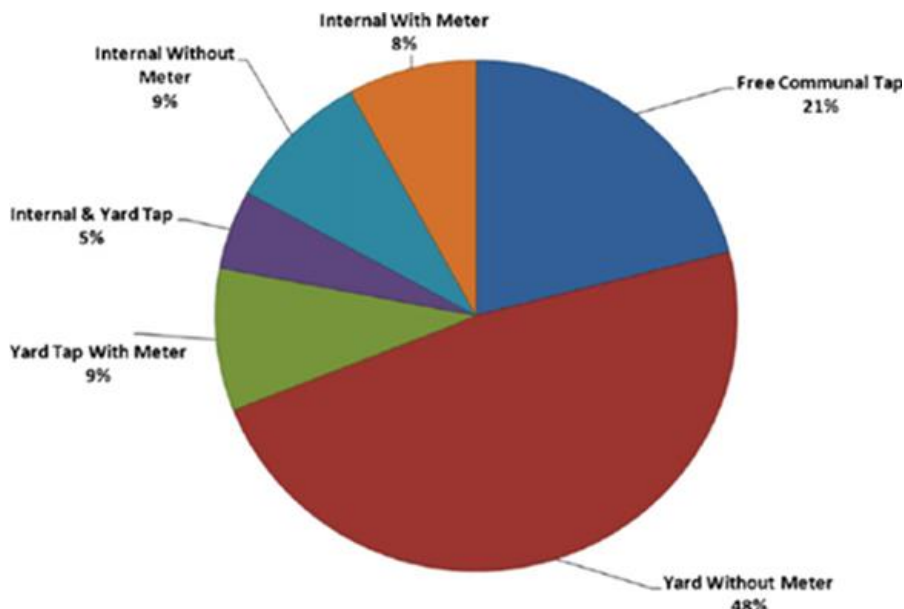


Figure 19. Access to water infrastructure in Alexandria (Natsar & Ramsar, 2012).

One-fifth of residents still rely on free communal taps which require water collection in buckets pictured in figure 18. A significant improvement was made post-1994 in providing water services by including a tap and toilet on each stand in Alexandra. However, According to Nastar & Ramasar (2012), on average there are 19 households per stand in Old Alexandra. This translates to approximately 133 people sharing the same tap and toilet as compared to 7 people per house in the East Bank or less than 5 in houses in the affluent suburb of Fourways (where each house is likely to have more than two taps and toilets).



*Figure 20. A communal toilet and shower in the informal settlement of Alexandra, as well as housing structures built precariously on the banks of the Jukskei River (Council, Greater Johannesburg Metropolitan, 2000).*

Like many informal settlements lack storm water infrastructure, Alexandra is no different. It has insufficient sanitary and drainage infrastructure and inappropriate solid waste management, hence, flooding events in these areas also result in further degradation of urban water quality as contaminated particles are washed out and inserted untreated into the cities' streams pictured in figure 20.

### 4.2.2. Fourways

Fourways, located in northern Sandton, is a mixed-use area. It is one of the fastest growing areas within the Johannesburg metropolitan area (City of Johannesburg, 2018). As an affluent area, it is mainly characterized by formal developments such as upmarket shopping centres, hotels, low rise office development (figure 21). The greater Fourways area has always been a popular residential area, it offers an attractive, secure lifestyle as well as a variety of popular property options ranging from apartments to luxury estate (Property Wheel, 2018). The Fourways area falls within a region that is home to more than 250 000 residents (Klug & Naik, 2007). The population in the region is relatively young, with about 24% being between the ages of 20 and 29. While the formal residential areas house prosperous and well-educated residents, most of the people living in the surrounding townships and juncture-positioned informal settlements are poor, with low levels of school education (Klug & Naik, 2007). The area is therefore characterised by a juncture position between wealth and poverty.



Figure 21. Residential complex in Fourways Johannesburg. (Homes of Distinction, 2018).

## Basic services

The water network has recently been upgraded as part of the new road infrastructure around the 2 major road intersections. The system currently in place does offer capacity and pressure to support additional development (City of Johannesburg, 2005). Sanitation upgrading has taken place recently when sewers were relocated for the more area development. Sanitation has been a problem in the past with developers not adhering to Johannesburg Water standards and specifications. This has however, been monitored more closely by Johannesburg Water (Klug & Naik, 2007). The current systems allow for sanitation services to be offered for further developments with little problem (City of Johannesburg, 2005). Storm water systems are upgraded incrementally as development occurs to avoid flash floods which affect not only the residents of Fourways, but also the residents of Alexandra. There is a perception amongst residents that the municipality is not extending infrastructure and services fast enough to meet the demand and growing population.

### 4.3. Developmental trajectory of the water service sector

In this section, the history of reconstructing the water services sector in South Africa, and thereby in the city of Johannesburg is traced. In so doing, the research attempts to analyse whether the current governing regime is in a lock-in regarding water governance in the country.

The political struggle from the 1950s and the transition to a democratic state in 1994 in was one of the fundamental elements that pressurised the centralized and authoritarian water management system. Historically, the management of water in South Africa was in line with the apartheid policies. This resulted in discriminated access to water across the city of Johannesburg based on racially created spaces (Hemson, 2002; Nastar & Ramasar, 2012). In 1994, post-apartheid, the newly formed government was faced the challenge of addressing the inequality in the provision of basic services, water, sanitation and electricity. This process was guided by a set of policies that set out a vision and mission for South Africa's future. The key documents included the Reconstruction and Development Programme (RDP), and the Constitution of the Republic of South Africa (1996). These policies established the sustainability vision which included equitable access to water. As such, the Constitution states that, every South African has the right to basic access to safe drinking water (Republic of South Africa, 1996).

Subsequently, notable changes started taking place. These changes included the creation of new institutions and a new policy environment for water service delivery. The introduction of the new National Water Act in 1998 and the policy of free basic water in 2001 were key changes that took place (DWAf, 2002). The Constitution provided the foundation for these policies. The mandate of water service provision was delegated down to district and local municipalities. This change meant that the City of Johannesburg, as a representative of the state, became responsible for ensuring all residents had access to safe drinking water within 200 metres from their home (DWAf, 2002). By



introducing new ways of mapping the city, the government attempted to differentiate from the segregation of the past.

Johannesburg was divided into seven service delivery regions (Fig. x) which included Region E, which is the focus of the case study, along with Region D of Greater Soweto. The City of Johannesburg, as the municipal authority, which is now responsible for water service delivery, established Johannesburg Water as its utility responsible for water and sanitation services (City of Johannesburg, 2010). Johannesburg Water was established early in 2001 as an independent company, the city of Johannesburg being the sole shareholder (Nastar & Ramasar, 2012). Johannesburg Water operates by means of a neo-liberal corporate model in providing services along business values (Johannesburg Water, 2011). This is consequently in line with global IWRM principles of managing water as an economic good, from the Dublin Principles. According to the City of Johannesburg (2010), water services payment plans differ based on the needs of residents. This is in spite of the fact that Johannesburg water operates as an independent company. In all cases, the first 0-6kilolitre per connection are free (City of Johannesburg, 2010). Many of the households pay for water on a progressive scale which means that the cost of water increases with increasing volumes of consumed per month. In certain areas which fell under Development Projects, domestic charges were, to an extent, on a lower scale but water is prepaid with a metered system (Johannesburg, 2006). Many new institutions have been introduced to redress apartheid era access.

The accumulation of socio-cultural, economic and institutional changes resulted in new patterns of structural change. This included diffusing power from the traditional regime to the democratic regime. At this point it is crucial to assess the progression of the democratic regime and assess the possibility of the regime being a lock-in. If South Africa's reformed and progressive water legislation is an indication of change, it could be argued that the country is well on its way to equitable water service delivery. However, the effectiveness of the Constitutional provision of water as a basic human right does not translate accordingly in practise, as a result equitable water provision has been questionable (Nastar & Ramasar, 2012). It has also been argued that human right approaches have had little practical impact on tackling the inequality of water distribution in South Africa (Bond & Dugard, 2008). As institutional changes in water governance have not been successful in changing water distribution effectively, in terms of equality of access to water, it can be argued that the regime is in a lock-in situation. As detailed above, the pathway that has led to the status quo is linked with a set of indicators to assess the trajectory of water governance. This can further be deduced from the two cases presented above of Alexandra and Fourways, from the apparent discrepancies in water service provision in Johannesburg.

Two things are critical for water security according to the Global Water Aid are: good quality, well managed water resources and effective water supply services. Water resources cannot be easily accessed without the necessary infrastructure such as pumps, pipes, taps, tanks together with skilled people to manage them as part of a service. Similarly, water supply services alone are of little use

without water resources. If either is unavailable or unreliable, people will not be water secure. From the case study of Johannesburg, it is evident that only a fraction of the population of Johannesburg can be considered water secure.

## 4.4. Policy Analysis

### 4.4.1. National Water Act

The main driver of South African water governance is the Constitution, along with legislation in the form of the NWA and WSA, administered by DWA. NWA was published in 1998 and aimed to reform the prior Water Act of 1956. The 1956 Water Act was founded on the European legislation, assuming a water rich setting. This was not appropriate for South Africa, as it is a water scarce country. The foundation of the NWA is the three pillars of sustainability, environmental sustainability, social benefit, and economic efficiency. It subscribes to the decentralisation ideology, where water resource management is delegated to the lowest level by CMAs. The scope of the NWA in its entirety is too vast for the purpose of this research.

### 4.4.2. Institutional Arrangements

The NWA makes provision for the establishment of catchment management agencies. However, since 1998, only two out of nine have been established (Meissner et al. 2017). The transformation of existing irrigation boards into Water User Associations (WUA), and the possible establishment of an agency to manage the national water resources infrastructure remains a pending decision (HERRFAHRDT-PAHLE, 2010).

There is also a disparity on the spatial and jurisdictional scale (hydrological versus administrative boundaries). The new legislation has produced twofold structures of water governance at the catchment level. The result has been coherent legislation at the national level, but separating competencies is transferred from the national to the catchment and local levels. There is also a disparity on the temporal scale. As the delimitation of WMAs was undertaken without establishing CMAs in a timely manner, as the managing organizations, this created further functional mismatch. This functional mismatch has resulted in different stages of implementation of local government and CMAs, mainly due to the slow and lengthy process of CMA implementation. In line with this, Folke et al. (2007) conclude the optimal fit between institutions and the resources they govern may not necessarily be the best fit (Folke et al., 2007).

Using the Water Governance Principles of the OECD, table 6 below has been generated to analyse the status quo in Johannesburg. This analysis aids in answering the research question posed in section 1.5.

<b>Principle</b>	<b>Dimensions to Water Governance</b>	National Government	Local Government
Data & Information	Efficiency	+	+
Financing		+	+
Regulatory Frameworks		+	+
Innovative governance		+	-
Integrity and Transparency	Trust and Engagement	-	-
Stakeholder engagement		+	-
Trade-offs across users		+	-
Monitoring and Evaluation		+	-
Clear roles and responsibilities	Effectiveness	-	-
Appropriate Scales within basin systems		-	+
Policy coherence		+	-
Capacity		+	-

Table 6. Water governance analysis in Johannesburg, based on the Water Governance Principles of the OECD 2015 (Author, 2018).

## 4.5. Preliminary Analysis of the Case Study

Water scarcity is an important concept to examine for this research because through understanding the causes and implications of water scarcity, it allows for better navigating the set of governance tools that are instrumental in ensuring that water security in Johannesburg. In so doing, the research can determine if governance is indeed a major factor of the water crisis in Johannesburg.

It can be argued that informal settlements represent a strong form of urban resilience since people in Johannesburg have adapted to the limited work and housing opportunities by building their own houses and generating their own incomes. Even though the living conditions in informal settlement such as Alexandra are far from ideal and vulnerable to natural hazards, the settlement provides some valuable services to its inhabitants, and to the city as a whole. For example, many domestic workers and gardeners live in Alexandra and commute to neighbouring Sandton, Fourways and other suburbs in and around Johannesburg.

Resilient cities are characterised by diversity in terms of uses and users, building types and public spaces. The city of Johannesburg has indeed become denser, but not only because of direct government intervention and not always with positive effects on its functioning, its sustainability or the quality of life of its inhabitants. Rather, some of those spontaneous dynamics caused negative feedback since the municipality had not been ready to deal with rising densities in those areas. For instance, in the absence of planning for increased densities, infrastructure and services have become overloaded in some areas, resulting in problems such as traffic congestion, waste in streets and insufficient storm water drainage.

### 4.5.1. IUWM

The IUWM framework has been promoted globally since the early 1990s, yet successful implementation still remains vague. This can be attributed to a lack of distinguishable tools with which to apply these principles practically. There is also a lack of evidence of attempts to implement IUWM in Johannesburg, a city that would benefit greatly from integrating various water services, especially the treatment and reuse of grey water, as well as adequate stormwater management. From the case above, there are limited supporting conditions for implementing IUWM just yet in Johannesburg. Figure 22 below illustrates the envisioned outcomes of IUWM. Urban planning, coordinated with the relevant institutions, along with the management of water services can aid in reaching the goal of sustainable water supply and use.

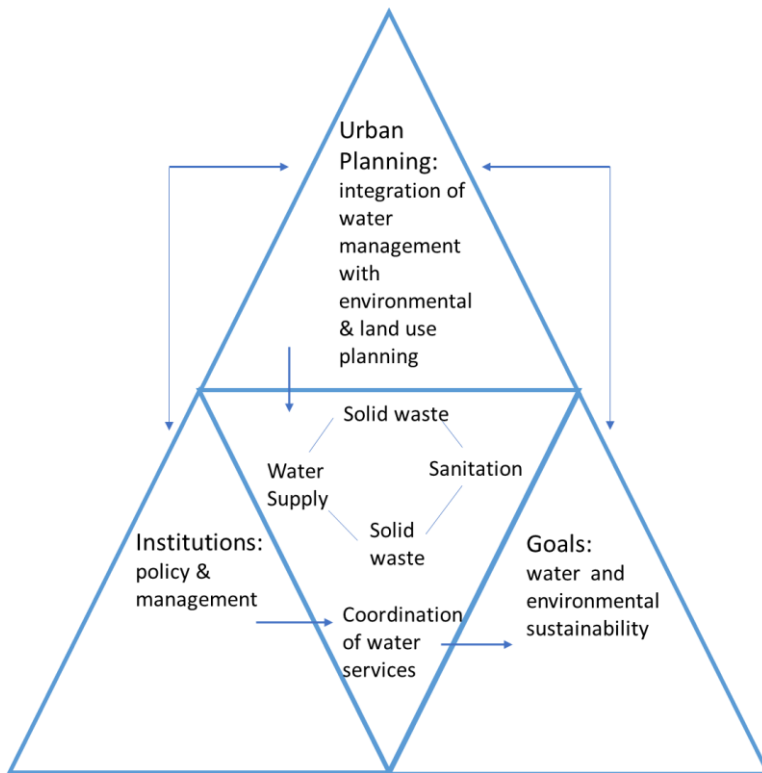


Figure 22. The envisioned outcomes of IUWM. (Author, 2018).

#### 4.5.2. Urban Spatial Planning

The DWS is the most powerful actor in the water planning process since it has the legal mandate to make decisions and the budgetary resources to implement them (Federation for Sustainable Environment, 2018). Johannesburg is South Africa's largest city and metropolitan municipality and its most important economic centre (Todes, 2012). Spatial change in Johannesburg has been rapid since the democratic dispensation in 1994. These changes have been in the form of the emergence of new suburban nodes and edge cities; the growth of publicly provided housing and informal settlements generally on the periphery. Strategic spatial planning in the post-apartheid era has attempted to promote more compact and integrated cities, and to redress patterns of inequality of the past. Some 18.8% of households live in informal housing, including 10.4% in 180 informal settlements across the city (City of Johannesburg, 2008). Despite the challenges, Johannesburg's spatial planning has been innovative in many respects. It has shifted from master planning approaches towards strategic spatial planning, based on a strong link to infrastructure development (Todes, 2012). However, more needs to be done to improve co-ordination within the municipality and across spheres of government, especially around the creation of sustainable living environments. Schäffler & Swilling (2013) point out that more research is necessary regarding the

way ecosystem services are being valued, with a focus on how these services can be implemented into spatial planning and urban design for better water management practices. Embracing change, adaptation and flexibility in Johannesburg is key. This requires a deep conceptual shift, re-centring the planning profession on a paradigm of unpredictability and abandoning the logic of control in favour of a more strategic dimension. This has already been seen to an extent in the shift from master planning to new forms of strategic spatial planning specifically aimed at taking on this challenge. Although many environmental risks, such as the risks of urban flooding, are exacerbated by climate change, they also relate back to products of informal or environmentally unconscious developments and unintended consequences of formal planning (Hetz & Bruns, 2014).

Specific connections between spatial planning and water can be broadly categorised as:

- Intensifying or minimising diffuse pollution (urban and agricultural).
- Influencing the demand for water supply and waste-water treatment from industry and households.
- Limiting or exacerbating flood risk.
- Reducing or increasing groundwater recharge rates.
- Protecting or harming aquatic habitats and biodiversity.

#### 4.5.3. Water Governance

In response to the systems, the City of Johannesburg has commenced with an Infrastructure Renewal Plan to increase the renewal rate from 1% to 3.5% to eliminate backlogs. Local government is in a better position to take decisive action and act at a local scale where they can engage citizens, communities and businesses in averting the water crisis. National government is slow to intervene, and when they do their actions are often not at the right scale or timely enough. Generally, cities need more autonomy to act decisively, although proactive, inter-governmental support and cooperation is both helpful and necessary (Winter, 2018).

## Analysis of the 12 OECD principles

This section summarizes the results of the analysis done for each OECD principles

### Principle 1: clear roles and responsibilities

The alignment between the OECD principles and the water legislation in South Africa is strong. However, there are some discrepancies at the local level, where implementation varies as roles and responsibilities are blurred between water service institutions, for example where water service providers and water service authorities have similar mandates (refer to table 6).

### Principle 2: appropriate scales within basin systems

Managing water at appropriate scales has been one of the main objectives of the department of water affairs, this is reflected in the establishment of Catchment Management Areas (figure 8) within the water management areas (figure 7). There are some concerns however since only 2 out of 19 CMA have been established to date out of the proposed 19, to coordinate with the relative WMA (Meissner *et al.* 2017).

### Principle 3: policy coherence

There is moderate alignment on the encouragement of policy coherence by effective cross-sectoral coordination. Policy impact however is not too strong on the lower levels of government.

### Principle 4: capacity

Adapting the level of capacity to the complexities of the challenges faced is rather poor. Implementation of policies is also variable and ranges between moderate and poor.

These first four principles fall under the efficiency classification. From this assessment, together with table 6 in section 4....it is clear that the organisations whose duty it is to provide water and sanitation on behalf of the Water Service Authorities, face numerous challenges in providing sustainable services. These challenges are for example, due to enormous services backlogs; scarcity of technical and other skills; aging and deteriorating infrastructure; and non-alignment of political will with technical priorities.

### Principle 5: produce and share data and information

The principle of producing, updating and sharing consistent, comparable and policy-relevant water and water-related data and information is in a poor state in South Africa. This can for instance, be attributed to jurisdictional boundaries of the WMA, as these do not coincide with provincial boundaries. The boundaries of these areas are along catchment divides and do not coincide with the administrative boundaries of local and provincial government spheres.

### Principle 6: financing

Water finance mobilization, and allocating financial resources in an efficient, transparent and timely manner is in a moderate state at both national and local levels in South Africa. Johannesburg

Water operates as a private company and works on a cost recovery basis in an attempt to be able to upkeep and maintain its services.

#### Principle 7: regulatory frameworks

There is a strong alignment with the principle of ensuring sound regulatory frameworks. The implementation of these regulatory frameworks is however questionable.

#### Principle 8: adopt and implement innovative governance

There have been some efforts of promoting innovative water governance practices. Especially since the major water crisis triggered by the 2014-2016 drought period. The actual implementation of innovative governance has been poor.

These principles can be categorised under the 'effectiveness' dimension to water governance. In general, on the local level these principles have been poor to moderate. The biggest concerns related to policy coherence and clear roles and responsibilities.

#### Principle 9: integrity and transparency

Mainstreaming integrity and transparency to improve accountability and trust is moderate in South Africa, at all levels of governance.

#### Principle 10: stakeholder engagement

South African water policies are in full alignment with the OECD principle of promoting stakeholder engagement, although there are differences in implementation. These vary at both national and local levels. The governance framework in South Africa is conducive to poly-centric, multi-stakeholder engagement to address water security effectively, but that the uptake of opportunities by stakeholders is unacceptably slow.

#### Principle 11: managing trade-offs

Encouraging frameworks to assist in managing intersectoral, spatial and temporal trade-offs is moderate. Policy impacts in this regard are also moderate.

#### Principle 12: monitoring and evaluation

Promoting regular monitoring and evaluation of policy and governance, at the national level is moderate to strong. On the local level this is moderate to poor and needs significant reconsideration. This again can be attributed to a lack of clear definition of roles and responsibilities amongst local level institutions.

Overall, the OECD Principles on Water Governance are should to contribute to the betterment of the Water Governance Cycle (figure 6) from policy design through to implementation. It has been noted by the OECD (2015) that these principles are merely guidelines as there is no one solution for a vast array of water challenges across the globe. In the context of South Africa, more emphasis is needed on the administration of water policies at the local level, coupled with vigorous monitoring and evaluation.



#### 4.5.4. Resilience

Resilience thinking highlights the capacity of a system to deal with change while continuing to develop and thrive. This is achieved through responding to unexpected change, and (where possible) through anticipating change and restructuring for slow, positive evolution. Society is key in the process of structural change; human beings are active agents, driving change at the physical and nonphysical levels. As discussed in section 2.6, the notion of resilience is key when considering an issue such as water scarcity. The Johannesburg Metropolitan area should be capable of reducing risk by diversifying water sources to include supplies from groundwater, storm water, reused water, treated effluent. Resilient cities also integrate the whole urban water cycle into its water resource management system. This is currently not the case though, due to a lack of sufficient coordination across sectors at both the municipal, and the regional level. Being a resilient city means, for example, being smarter about capturing rainfall across the city, in storing storm water underground, and in reusing treated effluent for a variety of purposes not necessarily for drinking purposes (Winter, 2018).

#### 4.5.5. Adaptation

Referring to the three stages of adaptation to water scarcity discussed in section 2.7, Johannesburg is currently at the second stage of increased adaptation. There are already efforts in place to improve water demand management over the traditional supply-led management. As supply-led management can no longer support the amounts of water required by perpetual population growth and societal welfare increases. However, because growth and societal welfare will inevitably increase, it is possible that the system needs to do more than just adapt, a systems transformation may be necessary for the Johannesburg Metropolitan Area. With its extended system of national and international water transfer schemes and dams, South Africa has a relatively extensive adaptive capacity. However, the benefits of these technical solutions are limited: firstly, due to sharp decreases of river runoff, leading to a reduced amount of water available for capture, storage and transfer; secondly increasing demand resulting from population growth and economic development.

## 5. Results and Interpretation

To interpret the analysed data first a general impression can be given. Water security in South Africa, and the Johannesburg Metropolitan Area is an issue that affects and is affected by multiple factors, given the colourful history of the country and the efforts to correct social injustices inflicted by the apartheid government. The overarching motivation that has over the years reinforced the government's mission to set conditions that are favourable to socioeconomic and political stability.

### 5.1. Urban water security

The narrative of scarcity in South Africa has for a long time coming, validated modernist responses of infrastructure building (Woodhouse & Muller, 2017). Some argue that it is due to this paradigm of scarcity that certain parts of the country are already water scarce.

“So, what I’m saying is that the paradigm of scarcity is taking us into a pathway of destruction” (Interviewee 5).

This paradigm has triggered a sequence of events throughout the history of water management in the country that has resulted in the status quo; water scarcity stimulated by the semi-arid climate experienced in South Africa. However, the age of hard water infrastructure (e.g. dams) may no longer be a viable option for the growing water crisis because of the simple fact that there may be no more water to dam up; “The current thinking has not changed at all. Oh, we can just build another dam, but there’s no more water to be dammed...” (Interviewee 5). Achieving water security in Johannesburg is not without consequences as there are inevitable trade-offs involved in developments around water. Some countries have achieved water security at often unanticipated and even unacceptable social and environmental costs. For this reason, according to Grey & Sadoff (2007), developing countries must not see water infrastructure alone as a panacea:

“We have to go to the paradigm of abundance which is now about building more ecologically resilient infrastructure, what’s the word.... Nature based solutions. The whole thing is working with nature rather than against nature that’s where we have to go with this new paradigm of abundance” -Interviewee 5.

The geographic location of Johannesburg (refer to section 2.1) does not help the situation very much. Johannesburg relies heavily on water transfer schemes from water reservoirs in the country. The Lesotho Highlands Project is yet to be completed. This further exacerbates the problem for Johannesburg as water levels in the main water supply reservoir, the Vaal Dam have been below average since 2014-2016 drought period. Even after sufficient rainfall was received in 2017, this proved not to be enough to quench the thirst of the ever-growing city of Johannesburg. Even after water restrictions have been introduced to curb water use, the citizens of Johannesburg do not perceive water scarcity further than their running taps. At this point it appears the situation is not

only a fundamental national issue for the government to be concerned over. It is perpetuated by the fact that inhabitants do not conceive the magnitude of the water crisis, when engaging with one of the interviewees on the issue of water scarcity, it became apparent. However, in remaining object certain generalizations do not give an overview of the bigger picture:

“at individual level is there seems to be a notion of, how can I put it... That as soon as you open the tap and water comes out, you are water secure. So, but when a drought hits, people keep on continuing with their behaviour so governance at that level, at the individual level is also for me problematic...” -Interviewee 3.

“I think certainly the last 2 years the drought we’ve experienced has fundamentally helped that transformation. Uhm you know people’s behaviour around water now is very different if you asked that 2 or 3 years ago.” -Interviewee 4, contrary to what is said by Interviewee 3.

From the case study of the Johannesburg Metropolitan Area, the vulnerability of informal settlements to hazards such as water shortages, floods and the rapid growth of water demand in the city is highlighted. It is not only the poor and marginalised that are at risk. The continued growth of the city and constant influx of inhabitants continuously adds additional pressure to the already stressed water supply.

“The water crisis is a typical wicked problem where it’s just a combination of people immigrating into the city, then the population of Johannesburg has really increased, and that’s actually because of good governance because things were working so the pop has gone up.” -Interviewee 2.

“So, I think we need to bring in the individual and communities much more to the fore in conversations and say let’s admit that we have a developing country government, we don’t have all the resources, resources are very stretched and so what can we as individuals do for ourselves, how can we have a more self-governance type of arrangement to manage our water resources you know?” -Interviewee 3.

In matters such as water security, everyone is in some way accountable for their actions and behaviour, governance transcends administrative boundaries and should be reflected on right to the level of self. The scarcity of water in the country is an important stressor that can lead to livelihood vulnerability and have significant impacts on other sectors, especially water-intensive ones, such as energy generation, agriculture and residential use. In this regard, local government has made efforts to be more water conscious, going from supply-led, to demand-led water management.

“You know we had a very a skewed view that water was a resource that is always readily available even though we’re sitting in a water scarce country you know, and our risk and vulnerability in terms of water insecurity is very high, it continues to be.” -Interviewee 4.

“...the demand management approach is a perfectly good approach which is being promoted in certainly in SA for fifty years, but it has its limitations and interestingly, it’s unfortunately the engineers who have tried it and have experience of it, who better understand its limitations.” -Interviewee 1

## 5.2. Urban Water Governance

The narrative that South Africa has world class water policies is well founded, however when these policies cannot be implemented correctly, what value lies therein? According to the OECD (2015), a water crisis is usually the result of a governance crisis. There is a need to understand that it is a broader political governance issue that proceeds all other issues in the water security debate.

“I think that pretty true but true everywhere is that you can have a brilliant policy but if you don’t actually implement and enforce it then it’s not worth the paper that its written on.” - Interviewee 2.

When engaging the interviewees on the issue of water governance, the same line of thought was expressed by some of the interviewees. “While water governance is often perceived as a technical matter, its conceptual and practical components are in fact based on multiple values that, nonetheless, often remain implicit” (Schultz *et al.*, 2017 p.241). Through conducting the research, it has become evident that the water crisis in the country is not only due to natural phenomena such as droughts and climate change. There have been mixed views on the administrative capacity of government, at all levels. When analysing the OECD Principles on water governance in section 4.1.2 for example, it seems that administration on the part of government is partially the issue. It has also emerged that the issue lies in the combination of governance mechanisms, most apparently on the local level. As previously expressed, such issues transcend the reach over government and can be traced down to the individual. Various views on the issue of governance, both at a national and local level have been expressed:

“There is undoubtedly a shortfall, uhm, the municipal level, I think it’s not as bad in the metros, but even that can’t be said with full certainty...” -Interviewee 2

“I think the challenge is that our governance you know around the resource, it leaves much to be desired. We’ve had issues around misappropriation of funding towards water projects and things like that, that’s more of a political issue rather than a real tangible issue but obviously lends itself to a situation where we don’t have water in the city of CT for example” -Interviewee 4.

However, as with any argument it is essential to remain impartial, even though the research expresses a certain view on the stance of governance, there are differing opinions that have been expressed:

“Just because lots of people write that they don’t like what the city does, doesn’t mean there’s evidence of shortcomings in governance...” -Interviewee 1

“...we have very good public administration in government so that does really good work and they govern very well but often there are other things that come in like ideology and party politics and things that bedevil things. I would say that at those different levels you will find a combination of very good governance being practices and then something bedevilling it.” - Interviewee 3

Focusing on the local level, there are numerous institutions involved (see section 4.1.2), generally with water services, as well as water provision. The general perception is that the national level is functioning, and well at that improvements can certainly be made in terms of administration on the local level.

“...at the National level I’d like to think that SA is pretty good.” However, “When it comes down to the municipal level, municipal government I think were struggling a bit because most water management is still done by engineers using the same techniques developed in the 70s” -Interviewee 2.

Municipalities are mandated to implement demand management and water conservation, which have been promoted as the most important drought coping strategies. However, due to a lack of capacity at the municipal level, they are often not able to reach their mandate;

“I think municipalities have got this huge capacity constraints in the regard. Even when you do have people who have the expertise, they’re just so thinly spread that they don’t have the time to address a specialised task of implementing these high-level ideas” -Interviewee 2.

According to Interviewee 3 “I think there’s a combination of governance issues that’s not gelling very well especially in SA’s institutions, but also not only in SA’s institutions but also at the household level”; “...good public administration in government so that does really good work and they govern very well but often there are other things that come in like ideology and party politics and things that bedevil things”.



Figure 23. Water management and governance at the local level in Johannesburg. Adapted from figure 15 (Author, 2018).

From the schematic above, it appears that water governance/management at the local level is straightforward and concise, however, when the institutions are carefully analysed, it appears there are a number of institutions that may have overlapping responsibilities. The democratic government overhauled the non-inclusive policies of the apartheid government, in an attempt to ensure that all South Africans have equal rights to water. However, as ambitious as the water regulations have been since then, Table 6 outlines the main institutions as well as the main features, from this, it is evident that there is an institutional overload, considerably so with the water service providers.

“I don’t think that we will need more institutions we have enough. It’s just that those institutions need to be better managed and I think with problem lies with ideology. We have a very stringent and top down type of ideological enforcement through the ruling party you know and it’s very hierarchical...” -Interviewee 3.

The policy and framework for water governance and its interactions with other elements of the hydrological cycle is broadly developed. However, delays in the development of key regulatory instruments have meant that the institutional and practical implementation of this framework is not well developed. Specific governance issues related to the water environment include governance of CMAs, within a paradigm of cooperative, integrated, developmental and participatory management at all levels. However, as discussed in section 4.4.2, this may be far from realised due to a lack of action in establishing all the required CMAs.

“But governance is a sustainability paradigm, uhm governance is the overarching circle. One can have the social issues, ecology issues as well as the biophysical and economic and all of that well mapped out but the way you manage those circles within a governance framework will ultimately tell you whether you are making it to the end goal or not.” - Interviewee 4

Johannesburg is the financial epicentre of SA, providing of 13% of the country’s GDP. Nevertheless, the legacy of inequality in access to services has left the city deeply polarized. Having received the bulk of its resources during the apartheid years, affluent white people living in the northern suburbs today enjoy a standard of municipal infrastructure and services on par with the world’s wealthiest city districts. Even though demographics have changed considerably since then, the urban poor, predominantly black South Africans, live mainly in township areas and informal settlements.

“The wealthy people are inconvenienced by the water restriction but are not going without water. People in poorer areas are the ones who are suffering.” -Interviewee 2.

This is essentially how water security can be perceived, that it is essentially the urban poor who have been and will continue to be most affected by water crises.

Another pertinent issue which has surfaced regarding urban water management is a lack of expertise and skills from the water sector. The main concerns have been a loss of these expertise and skills due to the migration of scientists and experts to other parts of the world. Moreover, those that remain are mostly of or reaching retirement age. This will have dire consequences for the already stressed local level in matching and bridging these skills and knowledge gaps, which may further delay any good regulatory work carried out towards securing adequate water resources.

“Yes, I think there is definitely demand for more capacity to be transferred, the needs to be better succession planning that needs to happen amongst some of the ageing and outgoing engineers and chief engineers and you know specialists in the field...” -Interviewee 4

### 5.3. IUWM Paradigm

For this urban water management function to be implemented in Johannesburg, it is necessary to review the underlying philosophies of IUWM;

“But what doesn’t happen is at a fundamental level uhm, we, we you know change the underlying paradigms and philosophies because these things contain philosophies that are not indigenous to SA and even the African context you know” -Interviewee 3.

IUWM is defined in section 2.5, when addressing the concept-of-fit of IUWM, it is clear that the intentions are to harness the potential of cities and the different systems that interact at various levels. There is abounding literature available on the principles of IUWM, the benefits of implementing this urban water management paradigm, but in practice this is not what is happening, and not at all in Johannesburg, after a thorough literature search and consultation with water experts.

“The simple answer is no. We talk about it, publish papers and such but there is no evidence of it all, absolutely none!” -Interviewee 5

“those 2 concepts are sort of largely western European concepts of limited value in a developing country context”; “idea thought up by some people who want to promote particular priorities and it has limited relation to practice”; “you’ll find that water managers do a lot of things including much more sensible things than are proposed within the sort of theoretic IUWM frame” (Interviewee 6). The other respondents share the same sentiments about this water management paradigm. An extensive review of IUWM revealed that the available models generally fail to balance between the scope and detail of an IUWM system (Armitage *et al.* 2014). Previously mentioned in chapter two is

the fact that IUWM is for the most part a global north paradigm (Cameron & Katzschner, 2017). As illustrated by the case study, Johannesburg Water's service provision is based on cost recovery and water demand management, which is in line with the provisions of IWRM. There are however certain ambiguities that cloud the intended vision of IWRM, and by extension, IUWM. One such ambiguity is for example in the 'I' in IUWM. The lack of a unified understanding about what is meant by 'integrated' has built up a lack of conceptual clarity thus impeding the uptake and execution of IUWM in Johannesburg. The case of Johannesburg, what happens is that the entities of IUWM (fresh water, wastewater, storm water, and solid waste) are managed in silos. This is problematic as it absolutely defeats the purpose of an IUWM system. One such example is waste water. Johannesburg produces large quantities of wastewater. Where waste treatment is inadequate – or, indeed, entirely absent – waste disposal sets in motion a cascade of events that reverberates across a range of ecosystems. IUWM is too often undermined by institutional paralysis and a subsequent lack of physical change in cities. For concepts such as IUWM to be effective in Johannesburg, first of all what needs to happen is to plan for the future in order for the benefits of IUWM to be experienced, in a wholistic manner. This cannot be done unless the principles of IUWM are adapted to fit the wider South African context, and then Johannesburg. The interviewees expressed a common notion that IUWM does not quite yet have a place in South Africa, not until it is fully understood by researchers and practitioners, and subsequently adapted to suit the political and social climate of the country.

“...what happens if you apply a paradigm and you don't understand the context, it tends not to work” -Interviewee 1.

The same sentiments are echoed by other respondents:

“I do think that, we cannot just adopt it *carte blanche* because SA has very different circumstances to the developed countries in the North”;“...so just adopting IUWM is not the right way to go but there are some components of it which are very useful” -Interviewee 6.

Moreover, a great deal of thought and consideration for local conditions would take the water management paradigm further where it is most needed. The operationalisation of IUWM in Johannesburg is a process which requires learning-by-doing. The need to develop guidelines on how to approach institutional and policy processes to revise current urban plans and make them more adaptive will also require more research. The fact that there is no one unique way to achieve IUWM implies that each case study and project will be different across the city, and that technology and policy solutions will have to be tailored to fit each situation. Furthermore, implementing an IUWM approach needs to be combined with assessment and implementation of different solutions (Jacobsen *et al.* 2012).

The challenges to implementing IUWM, infrastructure, investment and institutional challenges, discussed in section 2.5 first need to be overcome in order to create an enabling environment for



IUWM. As the success of IUWM depends largely on cross-scale and cross-sectoral linkages, it is not the responsibility of cities or the water sector alone. A high order of internal integration and alignment between various levels of resource management are necessary first in the Johannesburg Municipality. The city needs to create a set of tools that are tailored to the needs of the Johannesburg Metropolitan Area.

#### 5.4. Urban resilience

In this research, the concept of water security is analysed through the theory of resilience in section 2.6. Going back to the plural manifestation of urban areas in Johannesburg, the research provides a definition of urban resilience by Meerow & Newell (2016). In the context of Johannesburg, this does not however seem to be the case. This is indicative of the narrative of the haves and have nots. The poor are vulnerable to the impacts of climate change, in this specific case, water scarcity. However, the case study has shown that informal settlements are within themselves resilient, due to the very fact that they are informal.

“So, my simple observation is that the essence of an informal settlement is the fact that its informal, in a response to a set of circumstances of which the individual has no control. The minute you try and control something which is naturally spontaneous I think you defeat the objective.” -Interviewee 5.

In assessing resilience in the face of major perturbations, it is necessary to go back to the five W's of resilience in table 2 of section 2.6.2. In so doing, the research establishes who is resilient to what in the city of Johannesburg, as well as the trade-offs in efforts of achieving urban resilience.

It is suggested that the resilience of a system can be measured with according to its performance. The fact that Johannesburg is a world class city suggests that generally, the system is functioning well. However, when you take a very close look at the system, there are aspects which local government is not getting right, which could in the long run affect the entire system. During the occurrence of a disturbance, the extent to which the function of a system can be maintained is determined by the system's robustness. This can be understood in this case, as its strength to withstand the water crisis. Up until recently, the reality of water shortages vis a vis the Water-Food-Energy nexus have not been fully comprehended by society at large, the inhabitants of Johannesburg, which leaves the system open and vulnerable. According to Stead (2014), after the disturbance has taken place, the system regains some level of normality, stability or equilibrium, and the speed with which this recovery of function is achieved reflects the system's rapidity (or flexibility of response). This however is a difficult process to envision as crises of this nature are highly unpredictable and water scarcity for one, is something that has been long on the cards for South Africa as a whole;

“...it’s not a natural disaster per say, it’s a definitely related to climate change. We’ve seen bouts of extended droughts around the world etc. and we’ve known about this for a long time in terms of climate projections” -Interviewee 6.

“...that we haven’t really taken these climate change projections seriously” (Interviewee 5).

Increasing resilience, according to Stead (2014), entails mitigation and adaptation activities take place before a disturbance. In Johannesburg, it was only after the severe droughts of the period 2014-2016 that the city issued level 2 water restrictions as a measure to curb water shortages. This in turn, has left the city more vulnerable. Moreover, due to a lack of preparation, the city has been left with an even bigger gap to bridge in terms of mitigating the effects as they opted for short-term adaptation in the form of water restrictions, over long-term mitigation. Stead (2014 p.17) further reiterates that “it is absolutely not the case that adaptation activities are only needed after a disturbance”. Consequently, urban resilience can be regarded as a guiding principle, a work in progress rather than an end-state. As cities are complex socio-ecological systems in constant flux, the urban resilience notion can be understood as a way of conceiving and guiding change and evolution to a desirable state (Stead, 2014).

The concept of resilience in general is associated with bouncing back or forward or establishing new equilibria (Davoudi *et al.* 2012). For the notion of falling forward, conflicts may be expected, particularly across actors and organisations. The manner in which different groups of society are able to cope with absolute scarcity is crucial. For low income inhabitants in informal settlements and townships, rebuilding to a pre-disaster state may be important not only for economic and technical reasons, but for emotional and social reasons as well (Sanchez *et al.* 2018). In addition, the threat of crumbling and ageing infrastructure due to a lack of maintenance and renewal leaves little to be desired. Connectivity across network scales has been raised as a central characteristic of resilient urban systems, this research has however, established that at a policy level, there is a disjunct. In essence, improved vertical and horizontal cohesion across and within sectors is desirable, as this has the potential to move the system away from fragmentation. The desired cohesion in return has the capacity to enhance the adaptability of the system, while preserving the networks that are instrumental in the system’s ability to act and transform (Sanchez *et al.* 2018). The case study in chapter four allows for a closer review of questions to consider when talking urban resilience.

Who?

In reality, it is the inhabitants, the citizens of Johannesburg who should decide as a collective, what is desirable for the city in which they live. However, due to a myriad of socio-political inconsistencies, power relations make it such that fundamental decisions are not made considering the grassroots level. Johannesburg is a world class city, it is inevitable that some parts of the city are far better off than others. Often times the urban system is selectively inclusive and not all inhabitants are equal.

“...so, there is I think pockets of it, there is resilience in specific areas” -Interviewee 4.

“So, I would say on average Johannesburg is not resilient at all. There are pockets of the county that are quite resilient so the wealthier suburbs, and people and the well-established industries.” -Interviewee 2

What?

Water scarcity has far reaching consequences and affects many if not all components of an urban system. Information communication technology and transport are example of networks imbedded in the city of Johannesburg, which can be instrumental in navigating the vagaries of a water crisis.

When?

The notion of resilience implies an ongoing state. At times ad hoc measures must be taken to mitigate impacts in the short term. Water restrictions imposed on Johannesburg were such short-term measures. However, the capacity to adjust to slow onset changes such as water scarcity requires long-term planning with a focus on maintaining good standing of the current generation, with the water needs of the next generations in mind.

Where?

Boundaries of urban systems are sometimes difficult to define as functions are spread across cities and transition subtly from one to the next. Building resilience should be a wholistic effort that considers the system as a whole so that as many components as realistically possible are included.

Why?

The goal of urban resilience is to ensure that all synergies are maintained in the system, and that the system may continue to function in the face of adverse circumstances. The underlying motivations for building resilience are to safeguard the natural environment, while encouraging society to be more mindful and positively adapt and transform to more sustainable ways of consuming water resources. Both the process and outcome of resilience are important, but the process takes precedence over the outcome as systems are in constant flux and the process needs to be adjusted and tweaked continuously.

## 5.5. Adaptation

“...if I’m not mistaken they mentioned that the options for building more dams in that area is running out because they don’t have suitable damn sites, so they are now really looking like 40 years ahead to say what changes need to be implemented now so that we can, we don’t run out of water because we can’t build more dams.” – Interviewee 3.

To reach the third level of adaptation discussed in section 2.7, a level of further increased adaptation, a systems change is necessary. Johannesburg houses various industries and sectors alike, many of which are in the true sense unsustainable. For one, the production of food (agricultural) may eventually no longer be viable and may need to be moved to areas with direct access to the amount of water necessary. The same goes for other water intensive sectors such as manufacturing. In terms of social adaptive capacity, the willingness is there from society at large, people are slowly acclimatizing to conditions of water scarcity and are learning to live within sustainable water means.

“...people are capable and able to do things and they can to affect the future, whether positively or negatively. I don’t think Johannesburg is doomed in that regard because in my opinion people will take action.” -Interviewee 3.

“...how are we going to sit down and go with representatives of each major sector in the country and say listen guys, there’s not gonna be enough water for us to continue the way we have so where do we put manufacturing in the country, that’s water intensive, uhm where do we build facilities whether they are dams or water uhm sanitation or, I mean desalination, or the ground water recharge processes and so on so that we have water where we need it most.” -Interviewee 6.

Be that as it may, previously unsustainable water-use need be turned around to sustainable practices. The process puts great demands on the adaptive capacity of societies, in order to move from the current state.

“I think as things currently are, it is so dysfunctional that the system is gonna fail. And it’s only after the system fails will we then be able to reset the system. So, we have some cross-roads. At a T-junction rather, I think that’s a better analogy. At the T-junction, we are either going to say right: we now need to collectively as a nation make a decision about improving governance and then realising the value of technical people in positions of authority and advising etc. and in the short term or else we must ignore it and let the current political discourse take its course which I believe is then ultimately brings on another revolution” - Interviewee 5.

“...that sort of flush and forget syndrome, we shower, flush our toilets drink water but nobody sort of thinks what happens.” -Interviewee 6.

The interviewees express the views similar to that in figure 9 in section 2.7, where low social adaptive capacity will result in environmental deterioration and social instability. Again, it is indicative that a transformation of the system is required, especially in terms of social thinking, political will.

## 5.6. Urban Spatial Planning

There remains limited research on how strategic planning should be made operational to enable a transformation towards more water sensitive practices in Johannesburg. Planning systems are usually organised around a spatial hierarchy of plans, often operating at national, regional and local levels. This enables environmental problems, many of which cross administrative boundaries, to be addressed at an appropriate spatial scale.

“There again it’s an issue of scale, I think at a national level and perhaps even at a provincial level there is a lot of planning going into this, for example critical biodiversity areas are identified with ecological processes in mind, I think these larger catchment processes are being integrated into national and provincial level planning.” -Interviewee 2.

As spatial planning exerts an influence over various sectors including housing, transport and energy generation it provides a framework for holistic cross-sectoral thinking and policy making, which is ultimately necessary to both understand and address contemporary water scarcity problems. From the case of Johannesburg in chapter 4, it is apparent that the gap between the urban poor and rich needs to be reconciled to a state where all the inhabitants Johannesburg have equal opportunities.

“They have an absence of options and they have to settle somewhere so for me I think what’s important in that is how does for example the city respond to these rapid changes, that for me is tricky part, because you know like a within the space of 3 months you might have 5000 people in an informal settlement which was never planned for, it’s got major issues around storm water management, around you know, sewer reticulation, your urban planners, your IDP planning and so forth so those are the kind of issues that I think definitely have a major impact in that regard...” -Interviewee 4.

“I think most of our major problems are not due to bad planning, it’s just due to informal settlements that have grown in very unpredictable and unplanned ways...”; “The same is true for urban planning and municipal planning. It’s done pretty much on an ad hoc basis...” - Interviewee 2.

## 5.7. Interpretation of Results

The analyses and findings made during this research have led to the understanding that the multiplicity of conditions under which water is used and consumed in Johannesburg makes it problematic to define any single coherent policy for the governance thereof. Water issues are no longer such that they require technical measures with blueprint solutions that can be implemented in any context without consideration for prevailing local conditions. Instead urban water security issues have migrated to a dimension which calls for transdisciplinary action and interventions for a wholistic consideration of the issues at hand and how they can be dealt with going into the future.

With that being said, the Johannesburg Metropolitan Area is treading precariously on the brink of a prolonged water scarcity which may result in water insecurity. The relationship between decision-makers and scientists or researchers to inform policies, which may be instrumental in ensuing water security, has not been received well due to the historical relations stemming from the apartheid era. This is consistent with the findings from the interviews. In theory however, this is not the picture painted. Compounded by the imminent skills vacuum in the water sector, water resource management in South Africa has a historical journey of importance. Early reform initiatives supported transforming management structures from centralised to decentralised modes of operation.

In as much as the water policies in South Africa may be of world class, there appears to be a prevailing dominance from the national government in relinquishing power and control to the lower levels of government. Decentralisation in water governance is desired but the reality of the complex nature of the interactions of the urban system has resulted in other sectors receiving more fiscal and administrative support over water resource management. Essential and non-essential services have been decentralised to municipal entities, where the city of Johannesburg retains ownership. The system is somewhat decentralized but still fragmented and very much technocratic. This is further supported by literature findings. Water security in the Johannesburg metropolitan is a joint effort from all parties involved, meaning that it is not an issue that concerns national government alone, it is one that warrants support from government, industry and individuals alike. Governance and policy travel a long institutional way until it meets reality. The ambitious structures of South African water governance that were put in place by the democratic government have not encountered enough agential power in practice to successfully implement new collaborative institutions of water governance. The newly introduced policies have been slow to translate into the actual devolution of power, due to inappropriate strategies. This is however contrary to findings in literature as there is a widespread belief that the NWRS2 has resulted in improvements in water management. There have been major improvements in terms of providing previously disadvantaged areas with water and the related services, however this may have been done without consideration for the security of water supplies. For the future of South African water governance, it is therefore imperative to strengthen agential powers on all levels of water governance. This is especially crucial for local levels to further

increase social cohesion. Local government devises policies and strategies for prioritising, sharing, and managing available resources, while considering local demands. To be successful, the Johannesburg Metropolitan Municipality must look beyond the water sector in isolation. Housing, energy, land use, urban and rural agriculture, and waste management policies all have an impact on the sustainable management of urban water.

IUWM depends on decentralisation, further than the devolution of administrative functions, local government must also have political and fiscal authority. From the case of Johannesburg, the research shows that decentralisation is what is desired in Johannesburg, however, due to the DWS only establishing two of all the designated CMA, jurisdictional problems stand in the way of realising full decentralisation. IUWM also offers a socio-technical transformation in a sense that it advances both technological solutions for water management and simultaneous modifications in behaviour, attitudes, institutions, financing mechanisms, and training. These factors are instrumental in ensuring water security. However, such transformations need to be accompanied by robust monitoring mechanisms. Successful management approaches are adaptive and , so that water management systems can respond promptly to unexpected changes. Indeed, IUWM involves learning how to act in conditions of uncertainty and imperfect knowledge. Perhaps what is necessary for South Africa, and more specifically Johannesburg, is an IUWM approach which is tailored to the context of the country, both on a physical and abstract level. The interviews pointed out that to date, no tangible efforts of IUWM have been realised in the Johannesburg Metropolitan Area, this may be an indication that perhaps IUWM is not suitable at all for Johannesburg. As pointed out in chapter two, there are quite some challenges that need to be overcome first. As previously mentioned, government funds in South Africa are often diverted to more urgent sectors. IUWM requires significant financial investments, thus economic and investment challenges prevail. There may be some form of an institutional saturation with all the water service institutions in Johannesburg, these challenges may further impede the planning and implementation of IUWM.

Resilience is enhanced by the capacity to anticipate, respond, recover and adapt. The inherent nature of the communities in Johannesburg is one of resilience. Being a world class city with a thriving economy and one of the most prosperous cities on the African continent, the inhabitants have assumed some notion of resilience. The case study and results show that there are indeed pockets of Johannesburg which are resilient, the challenge however is to ensure that the whole system is in sync and thus wholly resilient and able to withstand and recover from perturbations. Coupled with resilience, in the long term, adaptation is essential. It will require bold new leadership to steer the city and its citizens into this era of uncertainty brought on by water scarcity. In sum, a water secure future for the Johannesburg Metropolitan Area lies in an integrated approach to urban water, one that goes beyond merely looking at the resilience to drought, and the reliability of water supply.

The research has demonstrated that the present conditions of water scarcity in South Africa are also dependent on the social status, the degree of social adaptive capacity (see figure 9, section 2.7). To ensure water security, increased social adaptive capacity is necessary, a significant factor that can help build resilience and reduce vulnerability, especially of the urban poor. The adaptiveness of governance mechanisms and processes, their accountability and legitimacy are also a factor that contributes strongly to water security. The implementation of adaptive governance features requires adequate financial and technical capacity, as well as the flexibility to adjust existing practices accordingly. To some extent, a degree of self-organisation is necessary.

The pressing issues identified by this research, for example water resource availability, increasing and spatially discerned vulnerability and population growth in the urban setting and the incoherent relationship between people and nature have direct spatial implications for Johannesburg. Spatial planning is central to the problem of coordinating and integrating the spatial dimension of sectoral policies by means of strategies based on scale. This is essential because it then addresses possible tensions and conflicts that may arise between competing policies and various land users. In so doing, well-informed activities that will better align policy objectives need to be promoted. Regarding the necessity to address future urban water availability and urban water management practices while encouraging sustainable livelihoods, spatial planning stands out as a tool for integration and sectoral collaboration.



## 6. Final Conclusions and Discussion

### 6.1. Conclusions

The purpose of this research has been to understand urban water security and the implications of ongoing user trends on future urban water supply in Johannesburg. By navigating the regulations and provisions made by the national government, and assessing the efforts made by DWS to oversee these, the research has been able to assess the standing of water practices for present and future water security in Johannesburg. The narrative of South Africa's water resources demonstrates that effective water resource management in situations of water stress inevitably go far beyond city boundaries. Collective effort is necessary to ensure that the Johannesburg Metropolitan Area mobilizes its resources to ensure that the system as a whole may withstand any pressures onset by water scarcity. This notion also highlights the importance of considering the research area as a complex system due to the various interactions of the components contained therein. It must however, be acknowledged that there are some constraints faced by the local government. Complex issues relating to local agency and leadership at different tiers of government and governance do to some extent prevent local government from acting accordingly. More fiscal and agential support from regional and national governments can strengthen the Johannesburg Metropolitan Municipality and its associated faculties.

To further inform the research process, pertinent questions have been posed, these questions also provide further support for the research.

What are the implications of water scarcity on the growing population of Johannesburg? Access to quality water and the associated services is key to economic prosperity and better living standards. Manufacturing activities, farms, and mining processes all require plenty of water to thrive. A lack of water means that very limited economic activities will take place, which will continue enlarging the gap between the urban poor and the rich. Absolute water scarcity in Johannesburg may further result in heavy competition for resources, which may result in social upheaval. A lack of water in Johannesburg may also have consequences beyond the borders of the metropolitan.

What is the concept-of-fit of urban water management paradigms such as IUWM in Johannesburg? IUWM is in theory suitable for general urban water management. In the context of Johannesburg though, the provisions for IUWM need to be tailored to suite the moderately stable socio-economic dimension of the Metropolitan. In addition, the various institutions involved in water servicing and provision need to be ironed out adjusted first before adding more and risking institutional overload. There is also a need for a stronger cohesive force amongst different departments to encourage coordination of complementary functions that work towards urban water sustenance. Ultimately, the essence of the IUWM goes beyond the achievement of a good water standing, it requires an

evolution in the intricate relationship between human societies and the water environment, something that spatial planning processes have the potential to help stimulate.

What needs to be done for Johannesburg to realise the full benefits of the world class water policies in South Africa?

Several areas can be improved upon to ensure that the water regulations produce the intended outcomes. Due to the deficit in skilled and knowledgeable experts in the water sector, mentoring and training young professionals is a first step to bridging the knowledge and skills gap. 'Veteran' experts can also benefit from networking and frequent skills evaluation to ensure that they build on their existing knowledge. With proper administration and a clear outline of tools to implement policies and strategies in the NWRS2, water governance in Johannesburg may stand a chance of being implemented as it was intended when amending the NWRS. South Africa could also benefit greatly from treating a larger percentage of waste water and then channelling that back to service sectors that are water intensive consumers such as mining, manufacturing and agriculture. What is also necessary in Johannesburg is governance right down to the level of the self. This is pertinent as individuals hardly perceive water issues beyond their running taps. This level of self-governance will also strengthen the social adaptive capacity in Johannesburg

To what extent are the current water management structures of government enough to sustain present and future water needs of the Johannesburg Metropolitan Area?

South Africa has done well in redressing discriminative policies of the apartheid era. However, it is necessary to move on from that and focus on the status quo. It is difficult to fully grasp the magnitude of the problem without referring to the past but what needs to happen is a shift away from that and addressing developmental issues for what they are. The democratic government inherited a mammoth task in terms of water provision and the related services. Water was declared a basic human right in the constitution of the country, numerous governance frameworks and structures were set up to see to it that all South African citizens realise their constitutional right. The Water Act, the NWRS and NWRS2 are instrumental pieces of legislation that have been designed to safeguard and maintain the country's water resources. South Africa is inherently a semi-arid country and natural phenomena such as droughts prevail in this part of the world. Tremendous efforts have been made to support the country's water resources and keeping water flowing to all the various users and sectors through intricate technologies and technical engineering implementations. Current water management provisions of the national government are well suited to see sustainable water use in the country. The problem however lies in the administration of the governance structures and the appropriate tools to effectively guide the implementation of water legislation in the country. At the national level there is sufficient coordination and strategic knowledge to see this through. The local level of government, the municipal level can benefit tremendously from improved cross sectoral coordination and administrative support from the national level. It is apparent though that merely adapting policies and regulations is not enough, based on the outcomes of the research, a complete

systems transformation is necessary in South Africa to equalise the innumerable social, political and economic discrepancies. So, there is a need for better coordination between knowledge institutes and policy makers to explore solutions together for a water secure future in Johannesburg. Governance however goes beyond formal structures. To strengthen social adaptive capacity, self-governance is also an aspect which should not be neglected. Implementing resilience and adaptability in practice from theory still remains a key challenge for the future of urban water security.

Resilience is recognising the ability of a system to change, adapt and transform. Johannesburg, where certain parts of the city can be resilient specifically in terms of water security, it is important to then understand what is necessary for the parts of the city which are not resilient to water crisis. Urban resilience policy is a complex and evolving field characterised by significant challenges associated with urban governance systems, political pressures, uncertain and emergent nature of threats, speed of change and the level of complexity of long-lived networks that form cities.

Urban planners have an important role in helping governments overcome fragmentation in policy formulation and decision making by connecting planning with the activities of other policy sectors, such as infrastructure provision, and adopting collaborative approaches that involve all stakeholders in determining priorities, actions, and responsibilities. The research has shown that the disparities in water services greatly affects the poorer urban dwellers. It can thus be deducted that communities in informal settlements are those likely to be worst affected by water scarcity. The very same group of people can be considered least likely to be water secure. For urban water services to be sustainable in the long run, an accountable government (at both national and local level) is necessary. to inform the actions required to ensure service delivery, social advancement and economic growth into the future, robust measures of success and failure in the sector are required with the flexibility to adapt to changing circumstances brought on by uncertainties. Systems thinking and solution-oriented, integrated planning approaches are key to the sustainability of any water services delivery. For example, there is room for greater integration of the water supply, stormwater and wastewater components of the urban water cycle in WSA South Africa, but it is in the non-technical areas where the most significant improvements can be made such as information dissemination, skills enhancement, and performance assessment of local government.

## 6.2. Discussion

This research, both implicitly and explicitly deals with power relations complexity and uncertainty, and institutional design which links to planning theory. This research provides key extracts from literature that have sought to engage with current and evolving practices of urban water management and consumption both theoretically and in practice through laborious academic research. The interaction of these enables a more holistic response to the issues surrounding current urban water context in Johannesburg. The hope is this research contributes to an improvement in the water literacy within the spatial planning processes and outputs in Johannesburg.

Meaning/Contribution of the study for planning theory and practise.

From Almendinger's 'Planning Theory' (2017), it is known that there is no one kind of planning theory, however throughout the course of Planning Theory the importance of adaptive planning, flexibility and collaborative planning are stressed, these factors are also relevant for urban water management in Johannesburg. As climate change will bring with it many uncertainties in the future, this area of research may also benefit from these concepts. So, this kind of thinking should be developed further in SA. The contributions from the Johannesburg case have a link with planning practice in the sense that a clear and better link needs to be made with spatial planning and urban water management, rather than regular land use planning. This is since spatial planning influences various policy sectors as well, thus encouraging collaborative planning.

This line of reasoning may be highly beneficial for the other SADEC region as these countries face similar, if not worse situation compared to South Africa. South Africa shares some of its major rivers, which are important sources of water, with Lesotho, Zimbabwe and Mozambique for example. Given that the context may differ, however the line of reasoning is a motivation for further application in different countries around the world where for example desalination is not yet an option because of the huge financial implications. Issues such as urban population growth, climate change and water scarcity are not unique to South Africa, in many parts of the world informal settlements inevitably form, it can be said that it has become more the rule than the exception, due to uncontrolled population growth resulting in urban sprawl. Access to safe water and adequate sanitation are two of the foundations for human well-being and dignity in South Africa. Water security is therefore not only relevant for ensuring environmental sustainability, it is also relevant to issues of economic equity and social justice.

## 7. Reflection

Reflecting upon the research conducted on urban water security, many factors influence how urban water is managed. Given the history of South Africa, it is difficult to properly detail the trajectory of general water resource management without mentioning the political history of the country.

The theories used in this research were appropriate, it was however, difficult to get to the essence of each theory in relation to water security and urban water management, due to the vast body of knowledge available on each of the theories. The theories used were chosen specifically to distil the essence of urban water management with socio-ecological considerations in mind.

In this research, the qualitative data collection method applied was semi-structured interviews. The methods chosen to conduct the research could have, in hind sight, been augmented with more interviews, however there was a general reluctance and unwillingness from most people approached. The research could have been greatly enriched by interviews from urban planning at the City of Johannesburg, as well as local government officials directly involved with urban water management. Newspaper articles and candid online interviews (YouTube) were a valuable source of additional information to supplement the interviews. The research strategy was an attempt to make full use of the conceptual model which guided the 'thinking process'.

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Master Thesis

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