Chapter 1 Water security and South Africa

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Abstract

In this chapter, we will give an overview of water security in the South African context. To do this we will discuss a number of issues pertaining to water security in terms of elements that are 'good', 'bad' and 'ugly' found within and outside South Africa influencing water security. These issues include South Africans' ability to cope with water scarcity through the construction of water infrastructure projects like large dams and extensive irrigation projects. This hydro-ingenuity started in the late 19th century and was influenced by government observers wanting to put agriculture on a sustainable footing. That South Africa's water security woes can still be ameliorated in this way is part of the dominant water resource management discourse. Another issue that has gained traction over the past couple of years is that of ecosystem services and their ability to provide water resources for socio-economic development. We briefly discuss this matter and how ecosystem services are under threat. We then discuss water access and use, followed by the link between legislation and water security, and government initiatives to get waste water treatment and water purification plants back on track through the Green and Blue Drop Programmes, respectively. Water for growth and development as a topic is next on the list before looking into the future risks the country could face in achieving water security. As part of this we consider climate change and how it could impact on water security followed by urban migration and the Fourth Industrial Revolution. Finally we end with a discussion on adaptation and resilience and how what we know of water management need to change in order for South African to create sustainable water sensitive cities, able to adapt to change.

Keywords: hydro-engineering, climate, water use, ecosystem services, adaptive water management, water sensitive cities

1. Water security in the South African context

Where do one start when you want to understand water security of a country, region in a country, or even a community? What does water security even mean? More often than not, it causes one to look at the word "security" and it conjures up images of military-like action guarding water to keep it safe. This is not completely wrong as it is in part exactly what you'll find if you Google "Water security in the United States". If only it was this easy. It is only when one looks at water security as a whole in all its facets that you also discover that water

(or H_2O) is multifaceted and not only have different phases (gas, liquid, solid) but means different things to different people. Some know it to mean 'the need to quench a thirst' and some know it to mean 'life'. Some understand it to mean a pH of 7 and others know that it symbolises the journey from poverty to making a living and creating wealth, while others still craves the cleanliness it offers.

So what does water security really mean and what does it imply for a country like South Africa? The term water security is of considerable global and political significance because it directly links to the Sustainable Development Goal (SDG) 6, focusing on water and sanitation, as part of the 2030 Agenda for Sustainable Development (UN-Water 2016a). Furthermore, UN-Water's definition of water security is directly relevant to the South African context because of the South African government's obligation to implement and report on the SDGs.

While numerous definitions of the term 'water security' exist, for this chapter we have chosen to apply the working definition developed by UN-Water. The international organisation defines 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*' (United Nations-Water 2016b).

For UN-Water (2016b), water security comprises a host of complex and interconnected challenges, and highlights the core role that water plays to enable society to achieve greater levels of security, sustainability, development and human well-being. Biophysical, infrastructural, institutional, political, social and financial factors, which are external to the water domain, also contribute to water security. As a result, water security is intricately linked to many other security areas, including human security and national security. Achieving water security therefore requires interdisciplinary collaboration across sectoral, communal and political boundaries.

In order to understand more about water security and what this really means for South Africa, it is important to understand more about South Africa and the road we travelled from a water resources management perspective, the country's geography, its peoples, smells and sounds, and contrasts. In this chapter we will present these various perspectives by reporting on a number of water security aspects facing South Africa and the people living within its borders. We will start with an overview of what we call the good, the not so good and the

future of water security. Under this heading we will report on ecosystem services, society and water security; water for society in terms of access and use; sanitation; legislation linked to water security; water for growth and development; future risks for achieving water security; climate change; global urban migration; and the so-called 4th industrial revolution within the South African context. In the penultimate part, we will discuss resilience as a key imperative to achieving water security before ending with a conclusion. In other words, this chapter will set the scene from a holistic perspective before we dive into the perspectives and understandings of what water security entails at local and individual levels.

2. The good, the not so good and the future of water security in South Africa

As its title suggests, this book addresses the societal problem of understanding water security at local government level in South Africa. Before we can report on our investigation on water security at local government level, it would be necessary to first give an overall context of water security in South Africa. This will help to paint, for the reader, a general picture of water security and, later, assist the reader to situate her-/himself in the local government context with the South African water security context as a backdrop. This chapter, therefore, will touch on water security at local government level by focusing on water security in South Africa nationally, in terms of the country's history, geography, climate, the things we are proud of, those aspects we need to improve, and lastly those aspects that we should focus on for a more water secure future in South Africa. This chapter will set the scene from a holistic perspective before we dive into the perceptions and understandings of what water security entails at national-, local government, and individual levels.

2.1.Hydro-ingenuity

Water security is an important topic for academics and practitioners to consider given South Africa's water scarcity. Not only is South Africa a dry country, water resources are also unevenly distributed across space and time. Geographically, the country's water resources are not always where it is needed (Ashton et al. 2006), which compelled successive governments and the private sector to implement massive water augmentation projects like large dams, irrigation projects and inter-basin transfer schemes (Figure 1) (Turton et al. 2004).

Figure 1: Some of the large water infrastructure successive South African governments and private entities have constructed to copy with times of drought. The Gariep Dam and its extensive reservoir (top) on the Orange River supplies much needed water to the Eastern Cape to sustain the Province's agricultural, domestic and industrial economic sectors through an inter-basin transfer scheme (photos courtesy of Wilmot Webster). The Hartbeespoort Dam supplies water to the Hartbeespoort Irrigation Scheme (second from the top) and Hartbeespoort and Brits towns. A weir on the Olifants River (middle left) supplies water to

irrigation farmers near Marble Hall in Sekhukhune. The Hereford Irrigation Board's weir (middle right) on the Olifants River supplies water to the privately-owned Hereford Irrigation Scheme near Groblersdal in Sekhukhune. The Inanda Dam (bottom left) on the uMngeni River supplies water to the eThekwini Metropolitan Municipality and its complex economy. The De Hoop Dam (bottom right) on the Steelpoort River in Sekhukhune supplies water to chrome and platinum mines in the Burgersfort and Steelpoort areas.

Temporally, the South African climate is to a large extend influenced by the El Niño-Southern Oscillation (ENSO) phenomenon in the equatorial Pacific Ocean (Shirvani & Landman 2016; Meissner & Jacobs-Mata 2016). Broadly speaking, South Africa's climate oscillates between droughts (Figure 2) and floods, which is to varying degrees influenced by either El Niño (ENSO's warmer and drier phase) and La Niña (ENSO's cooler and wetter phase), respectively (Archer et al. 2017; Conway et al. 2015; Mpheshea & Landman 2015). It is within the ambit of this distributional scarcity across space and time that defined the water security in the South African consciousness for more than a century. Not only has government and the private sector implemented large dams and inter-basin water transfers on the rivers situated in South Africa, but also on those across rivers in the territory of South Africa's neighbours. The most well-known example is the Lesotho Highlands Water Project (LHWP) built in the Lesotho's Maloti Mountains that conveys water from the Senqu River's headwaters to South Africa's economic heartland situated in the Gauteng Province (Figure 3, Figure 4, Figure 5, Figure 6, Figure 7) (Turton & Meissner 2002; Meissner & Turton 2003; Heyns et al. 2008; Meissner 2005; Turton et al. 2004; Jacobs 2010; Meissner 2015). We can, therefore, safely say that water security has for decades been defined through an engineered and technocratic approach. This implies that water security, as an aspiration, had been, over the years, a central objective of the governors that held sway over the country. Water scarcity prompted successive governments to investigate new sources of water (Meissner 2004; Meissner 2015) that facilitated an ever increasing hydrological engineering project across the length and breadth of South Africa (see Turton et al. 2004 and Van Vuuren 2012 for historical perspectives on numerous water engineering works implemented in South Africa and its neighbours).

Figure 2: A parched landscape during the drought of 2015 to 2017.

By briefly reviewing the history of dam building in South Africa, we see how water security, and water insecurity, for that matter, had been defined over time. Although farmers had been constructing farm dams since 1828 in the Cape Colony (Brown 1877; Turton et al. 2004; Meissner 2014), dam building started in all earnest in the Cape Colony in the latter part of the 19th Century. This was after a number of irrigation schemes and transfers had been proposed to establish sustainable agriculture and making agriculture less reliant on rainfall. One such proposal involved the utilisation of the Orange River for irrigation purposes. This scheme became known as the Pote canal, after its proposer Charles Pote, a Member of the Cape Parliament that tabled the proposed scheme to Parliament in 1866. Pote was adamant that such a scheme be constructed because he argued that the Orange River's water flowed to the sea and was, therefore, wasted. Instead, he proposed that the Orange River's water be 'turned to account, and making what were at present wildernesses into highly productive localities: and by so doing, the Northern Districts [of the Cape Colony] would be capable of supplying more than all the breadstuffs now [1866] imported' (The Argus, 16 October 1866: 2 cited in Turton et al. 2004: 108). Although Parliament refused the proposal, Pote created a

vision of the Orange River becoming a source of irrigation water (Turton et al. 2004: 108) that would be realised long after his proposal to Parliament.

Figure 3: Katse Dam (Photo courtesy of Suzan Oelofse)

Also of importance regarding water insecurity and to improve the situation with large water augmentation schemes are the publications by J.C. Brown in 1875 and 1877 and John G. Gamble's report of 1877. Brown was a former botanist at the Cape of Good Hope, and in his 1875 publication, *Hydrology of South Africa*, he reported on an investigation into drought problems and how to alleviate these. According to Brown (1875: 216 cited in Turton et al. 2004), the country's aridity was caused, firstly, by '... the elevation of the land, and the consequent flow of the water, which falls upon it as rain, by gravitation to the sea.' Aridity was, secondly, caused by '…the evaporation of the remaining water, by which the aridity has been brought to the degree it has attained—the desiccation thus completed having been promoted by long continued destruction of forests, and bush, and herbage, and grass, chiefly but not exclusively by fire.' For Brown (1875: 227 cited in Turton et al. 2004), in South Africa there is an '...abundance of the water supply to counteract the evils induced by the drought within the [Cape] Colony.' In his I877 book, *Water Supply of South Africa*, Brown made a stronger plea for the conservation of water through the building of dams and utilising

irrigation projects for economic gain. The purpose of his 1877 publication was to show the practical measures that could be implemented to check the desiccation and floods of South Africa, and how such measures can be coupled with ‘agricultural operations’ (Brown 1877: 9 cited in Turton et al. 2004). These sentiments, voiced over a 130 years ago, are still applicable today as we experience occasional water shortages and floods across the country.

Figure 4: Part of Katse Dam's reservoir (Photo courtesy of Suzan Oelofse)

Figure 5: Outlet from the Katse Reservoir (Photo courtesy of Suzan Oelofse)

The Civil Commissioner of Crown Lands and Public Works appointed John G. Gamble, a hydraulic engineer, to investigate the development of irrigated agriculture in the Cape Colony in 1875 (Lewis 1934; Turton et al. 2004). Parliament published the Gamble Report in 1877. In this report, Gamble notes that he had undertaken an expedition to the

northern border of the Colony in June 1876. In the report, Gamble gave general suggestions to develop irrigation works. He remarked that there was much 'ignorance as to the difficulties involved' in implementing irrigation projects. He also cited 'some points in the experience of other countries which may be of use to us in South Africa.' These countries were India, Italy, Spain, Egypt, Germany, Belgium, Chile, and Victoria (Australia). One of the most important remarks made by him regarding irrigation projects was the following: 'In starting irrigation works in an entirely new country like South Africa… we are under the disadvantage of having no previous successes or failures to follow or avoid' (Cape of Good Hope,1877: 2-9 cited in Turton et al. 2004). This last remark indicates that irrigation projects had not yet been considered by the Cape Colonial government before 1877 (Turton et al. 2004) and that the government of the Cape Colony would start in earnest with such projects. Subsequent irrigation works, like the one at Prieska on the Orange River, would be suggested for construction based on Gamble's report that government should start investing in such works on numerous rivers not only in the Cape but in other parts of South Africa as well, like the Vaal River (Cape of Good Hope 1877; Cape of Good Hope 1885; Turton et al. 2004). With irrigation projects came the knowledge to construct weirs across rivers and later, as the country's population and economic sectors needed more water, larger dams and hydroelectric power stations (Figure 1). What is important to note, within the context of water security and water insecurity, is that Brown and Gamble, who investigated droughts and the possibility of irrigated agriculture, respectively, defined water insecurity as the absence of water and the presence of drought. Water security for these early observers was, conversely, seen as the availability of water through hydraulic engineering works to make agriculture sustainable. This perception of water security is one that is still dominant in South African society.

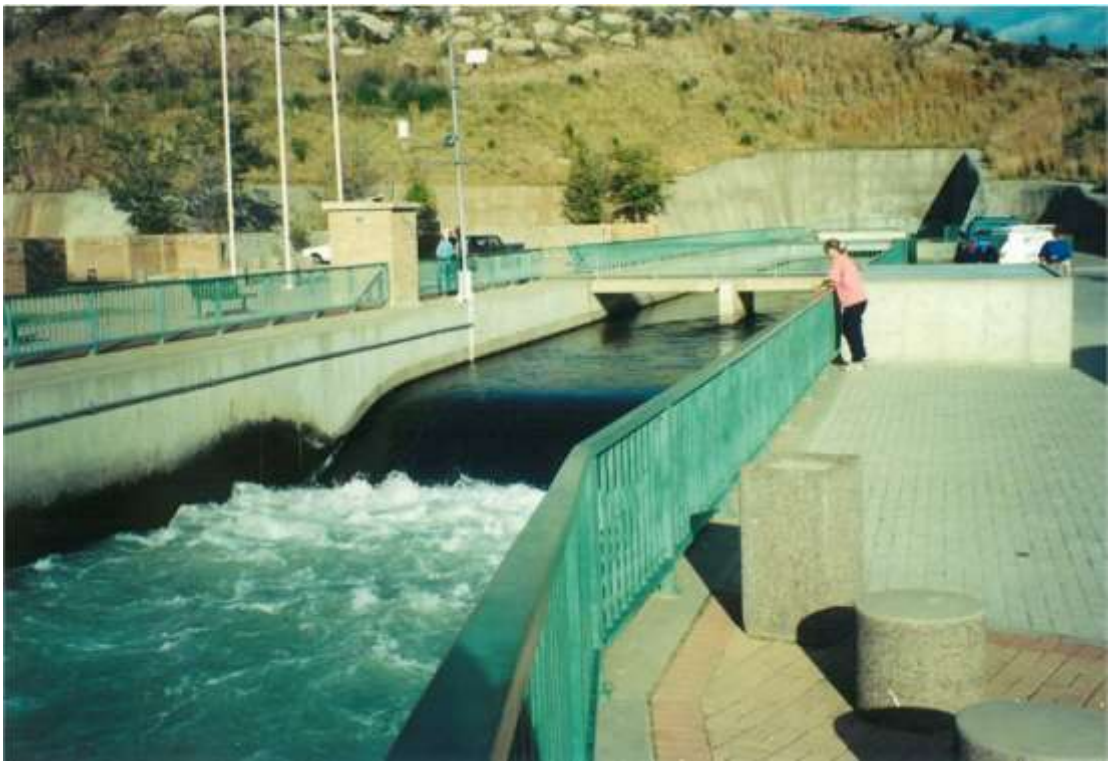

Figure 6: Water from the Katse Reservoir in Lesotho arriving at the outfall to the Ash River in the eastern Free State, South Africa (Photo courtesy of Suzan Oelofse)

Figure 7: Mohale Dam (Photo courtesy of Suzan Oelofse)

That said, water security, as a perspective of the country's available water resources, plays a crucial role in promoting sustainable social and economic development. Even so, the study we conducted speaks to national, provincial, and local government water and sanitation delivery imperatives, and not just delivery of irrigation water as envisaged by Brown and Gamble in the 19th Century. Our project also supports local, national, and regional water management through the research and development of integrated water assessment tools such as the state of water security at local government level (Chapter 3) and the water security typology (Chapter 4).

From the above discussion, we can ask why it is important to achieve water security at a more local level. As already mentioned, water security entails a society's ability to safeguard sustainable access to good quality water and a sufficient quantity thereof to support livelihoods, human wellbeing, ecosystems, and social and economic development (e.g. water use for industry, agriculture, construction, or mining). Furthermore, water security involves local government institutions being able to protect citizens against the negative effects of water pollution and water-related disasters (e.g. UN-Water 2016a). A lack of water security cannot only spell violence and unrest, but can also negatively influence human health (e.g. Meissner et al. 2018). Achieving water security is not, however, limited to national and local government; rather it speaks to an integration of solutions through the involvement of other societal actors that includes, but not limited to, private individuals, scientists, media personalities, local communities, the private sector, and the international community. For instance, for environmental interest groups, non-governmental organisations, and businesses, a priority around achieving water security could be to promote the safeguarding of ecosystems (Meissner and Ramasar 2015) and the supply of ecosystem services for much needed socio-economic development.

Although South Africa has a rich history of ingenious engineering skills to build storage dams (Figure 8) and water infrastructure projects, like extensive irrigation schemes, dams significantly alter the free-flowing nature of rivers. Dams and weirs impact the natural sequence of floods or low flows and subsequently restricts the movement of sediment through the river system. While globally free flowing or dam-free rivers are rare, only 4% all river systems in South Africa remain dam-free (WWF 2016). Since South Africa's water resources are already highly developed, and optimal sites for dams have all been developed, opportunities to augment supply through additional dams are limited. Future dam sites could come at a high social, economic and environmental cost (DWS 2018). This means that although large water augmentation schemes have been responsible for securing water

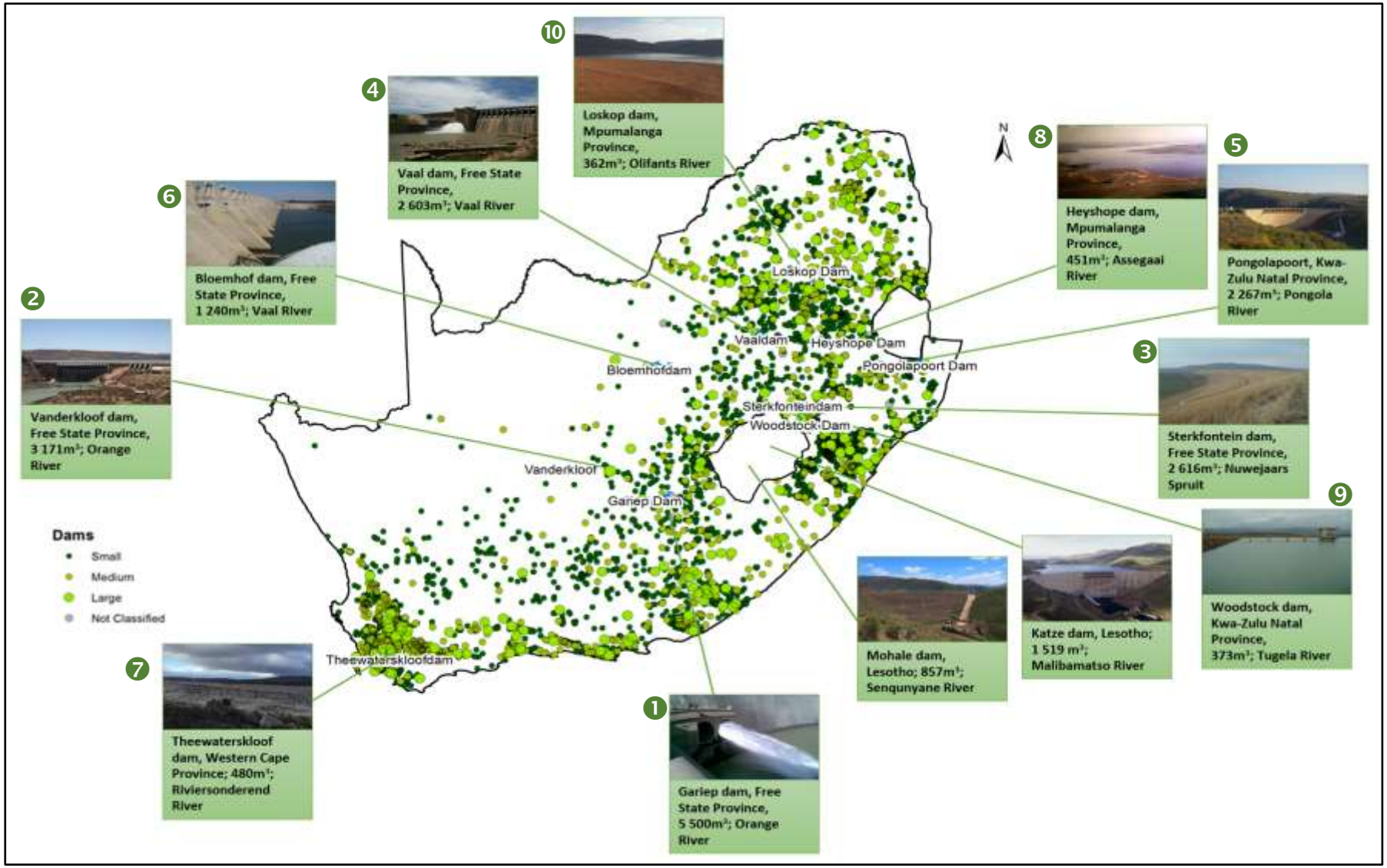

Figure 8: Ten biggest dams (capacity) of South Africa amongst 500 registered DWS dams (Source: DWS 2018)

resources to enhance socio-economic development for some, they also hold adverse consequences for the environment, which is, ironically, an important source of water. In this sense, and looking at water augmentation schemes, we could ask water security according to who, for who, and for what? In the following sections we will answer some of these questions.

2.2.Ecosystem services and water security

As already alluded to, South Africa is a water-scarce country. The primary input to our water resources is rainfall. South Africa receives a mean annual rainfall of 490 mm, about half of the global average rainfall of 814mm (WWF 2016). It is widely recognised that a sustainable supply of fresh, healthy water is needed to equitably meet our country's social, economic and environmental water needs for current and future generations. South Africa's National Development Plan (NDP) therefore recognises water scarcity as a binding constraint to national development and highlights the importance of carefully managing this limited resource.

Freshwater resources and ecosystems are under threat worldwide and this is also true of freshwater resources in South Africa. Nel et al. (2011a) found that of the freshwater ecosystems types in South Africa, 65% of wetland, and 57% of river ecosystem types are threatened (critically endangered, endangered or vulnerable). South Africa has a lack of natural lakes and water supply is completely dependent on man-made reservoirs and run-of-river abstractions. Most of the freshwater resources are already developed (Nel et al. 2013) and allocated for various uses (Figure 9). The remaining quantities are reduced with industry pollution, urbanisation and informal settlements,

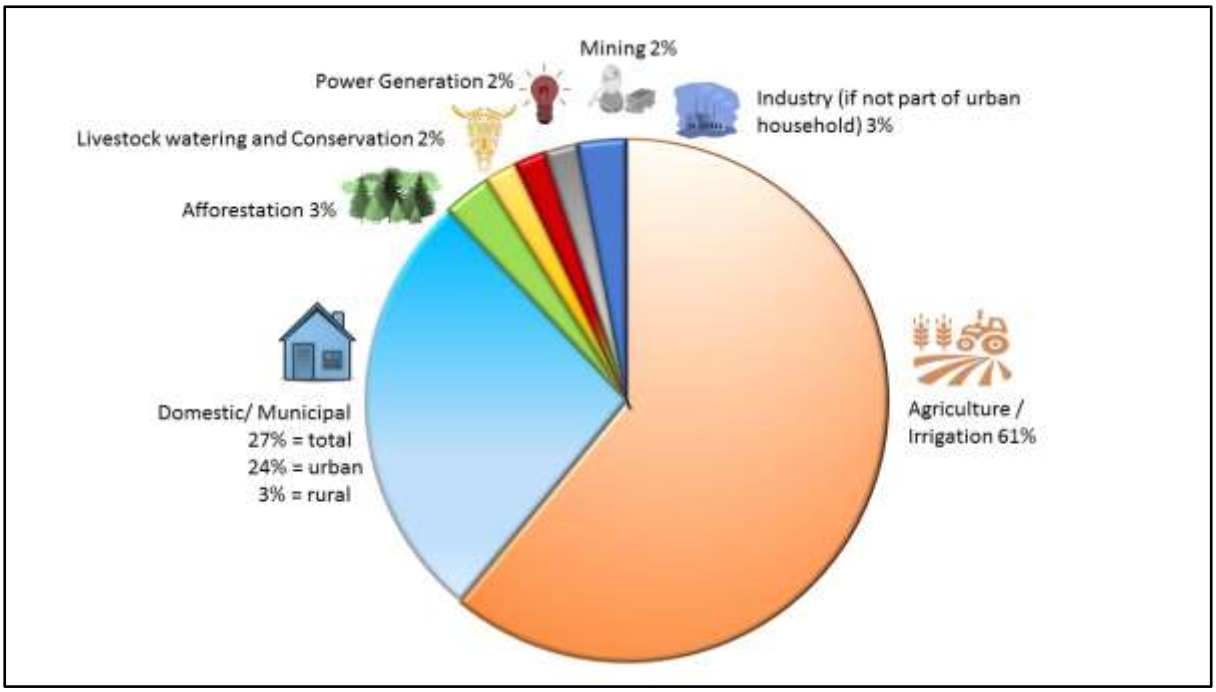

Figure 9: Water use per sector in SA (Source: DWS 2018)

agricultural return flows, untreated sewage, acid mine drainage and deforestation. Urbanisation and agricultural activities reduces water quality by sedimentation, nutrient enrichment and microbial pollution (Nel et al. 2011b, Nel et a. 2013). Many South African rivers carry a naturally high suspended-solid load and excess sediment to river systems not only impacts river ecology by degrading habitat quality for aquatic fauna such as fish and benthic macroinvertebrates, but increased sedimentation also leads to dam siltation (Pegram and Gorgens 2001, Dallas and Day 2004, Le Roux et al. 2008).

The quality of the country's water resources has been on a steady decline as a result of increased pollution from a variety of sources and production processes. Around 40% of South Africa's fresh water systems are in a critical condition from a water quality perspective, while 80% are threatened (DEA 2017).

Reports on the continued degradation of South Africa's freshwater resources led to the development of the National Freshwater Ecosystem Priority Areas (NFEPA), which identified priority areas for conservation while developing an institutional basis for the effective implementation of priority freshwater and estuarine areas at national, sub-national and local levels of management (Nel et al. 2016). Key findings from this project were that only 35% of the length of SA's mainstem rivers is in a good condition (Figure 10), tributaries were in an overall better state (57% in a good condition), only 22% of South Africa's river length has been identified as freshwater ecosystem priority areas and only 62 free-flowing rivers (4% of

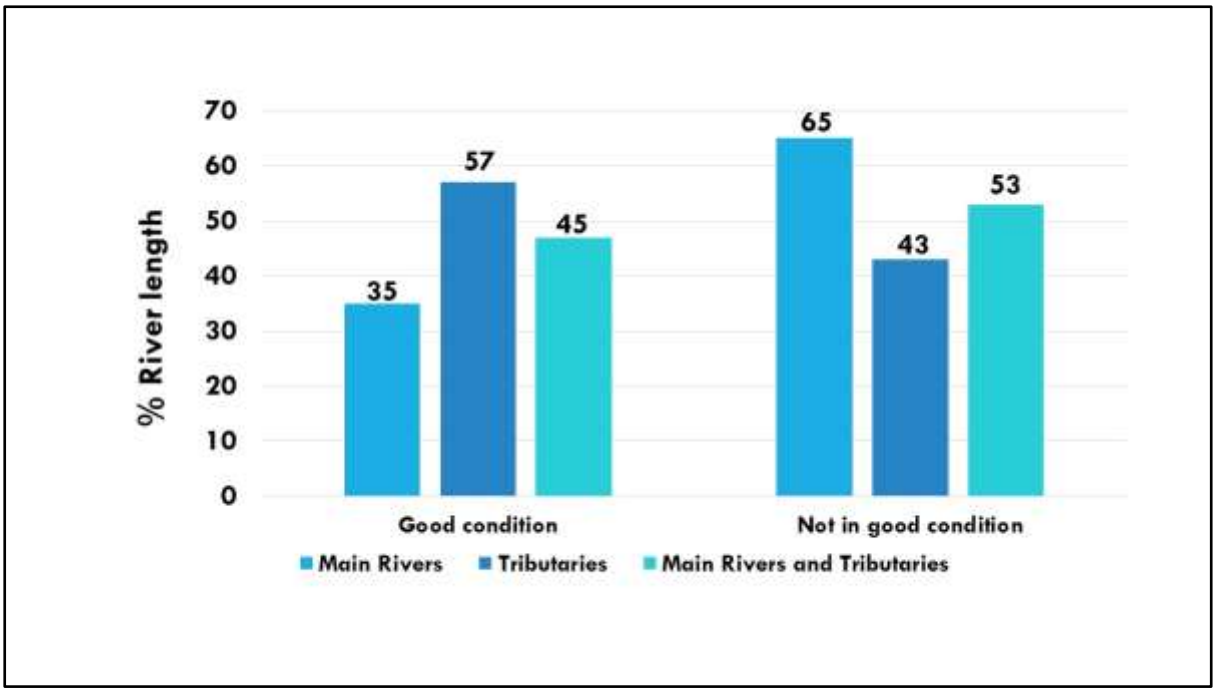

Figure 10: Decline in river condition, South Africa 2011 (Source: Driver et al. 2012)

river length) remain free flowing (Nel et al. 2011b, Driver et al. 2012). Figure 10 shows that 65% of the main rivers are in a poor condition as they tend to be larger rivers and therefore harder working, experiencing the impacts already mentioned (Driver et al. 2012).

2.3.Water for society - access and use

Since the end of apartheid in 1994, and promulgation of the National Water Act (1998) there has been a substantial improvement in access to services (Figure 11). Approximately 88.6% of all South African households now enjoy access to piped water. Since 2002, when only 56.1% of people in the Eastern Cape had access to piped water, this has increased to 74.2% in 2017. Access to water in dwellings, off-site, or on-site was most common in Nelson Mandela Bay (100%), the City of Cape Town (99.3%) and the City of Johannesburg (98.4%). An estimated 46.4% of households across the country had access to piped water in their dwellings in 2016. A further 26.8% had accessed water on site, while 13.3% relied on communal taps and 2.4% relied on neighbours' taps (Stats SA 2017).

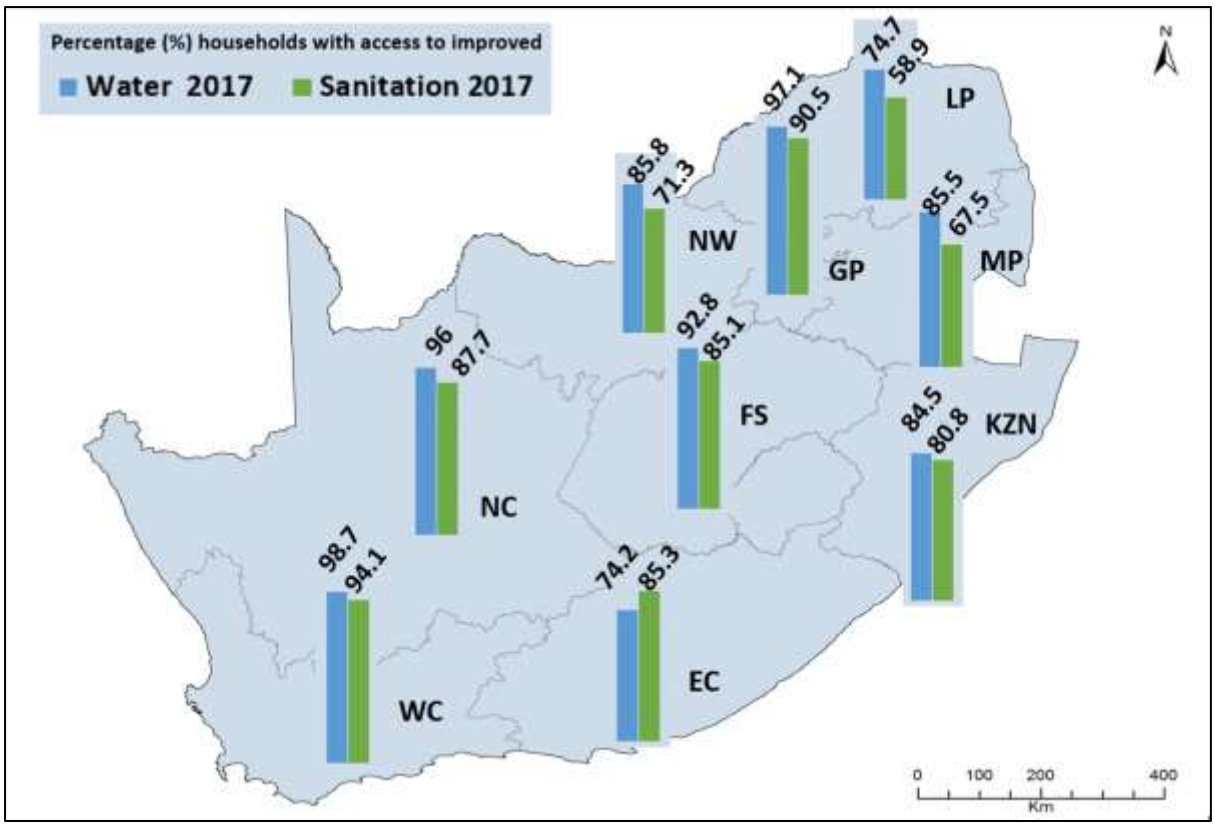

Figure 11: Provincial breakdown (% households) of improved access to water and sanitation in SA (STATS SA 2018)

Although generally households' access to water is improving, 3.7% of households still had to fetch water from rivers, streams, stagnant water pools, dams, wells and springs in 2017 (Figure 12). This is, however, much lower than the 9.5% of households that had to access water from these sources in 2002. More important, though, is the satisfaction from citizens with water-related services like water and sanitation provisioning. Even though access has steadily improved, satisfaction has been eroding since 2005 when 76.4% of users rated water-related services as good compared to only 63.9% in 2017 (Stats SA 2017).

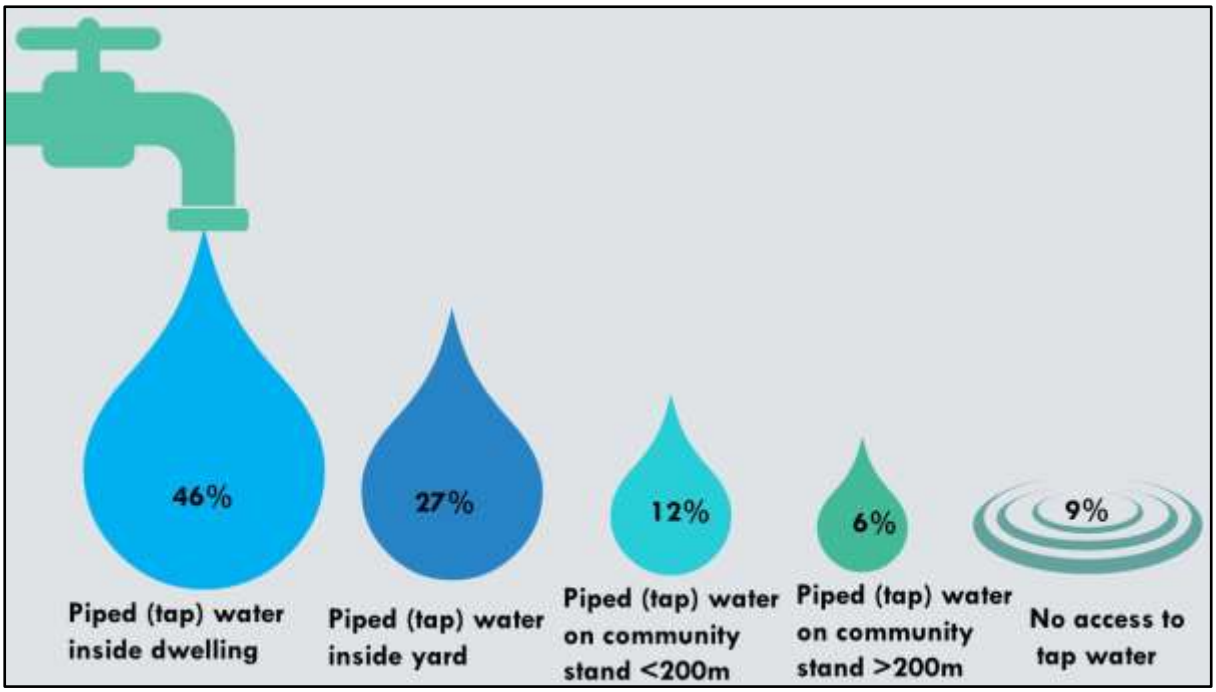

Figure 12: Breakdown of access to drinking water in South Africa (Source: STATS SA 2018)

Since 2012, an additional 20.5% of households in South Africa received access to improved sanitation in 2017 (**Error! Reference source not found.**11). While the Western Cape (94.1%) and Gauteng (90.1%) had the highest access to improved sanitation in the country, provinces such as Mpumalanga and Limpopo had the lowest percentages at (67.6%) and (58.9%), respectively. The City of Johannesburg (95.1%) was the metropolitan area with the highest percentage of households with access to improved sanitation. Nationally, the percentage of households without sanitation, or those who used the bucket toilet system decreased from 12.6% to 3.1% between 2002 and 2017 (Stats SA 2017). Figure 13 provides a breakdown of the sanitation access in South Africa.

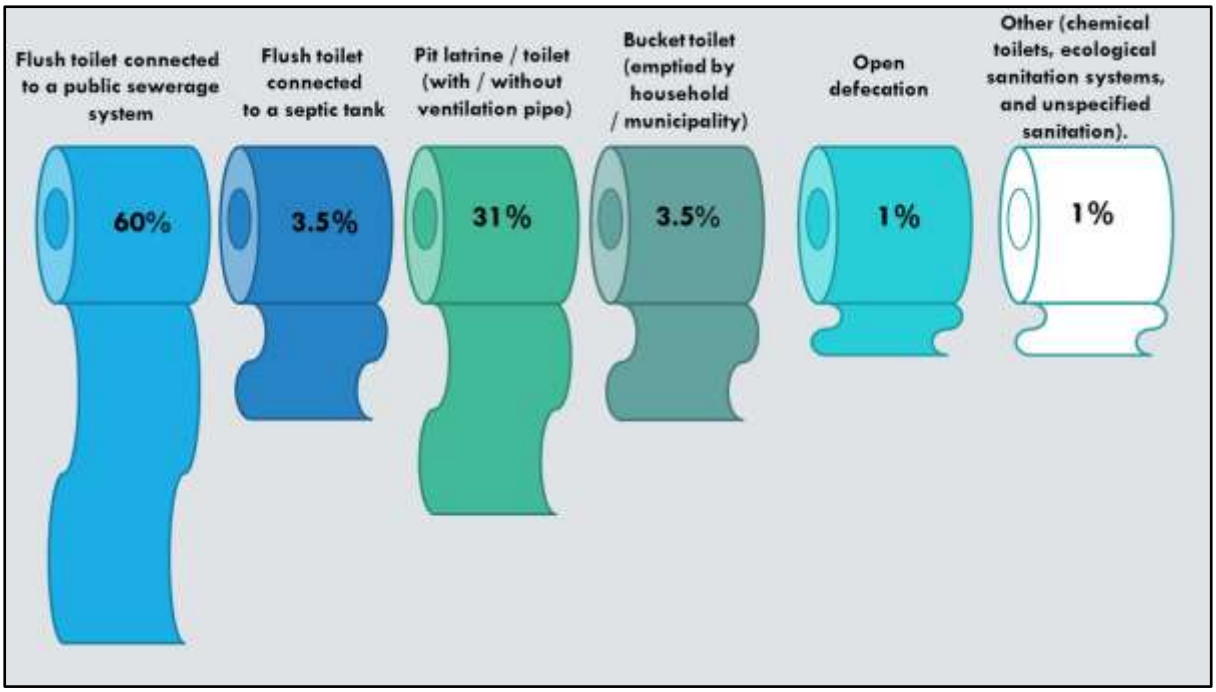

Figure 13: National breakdown of access to sanitation (STATS SA 2018)

2.4.Legislation and water security

Although the term water security is not explicitly mentioned in most of the South African water-focused policies and legislation, it is front and centre of the final draft version of South Africa's National Water and Sanitation Master Plan (DWS 2017). This plan explicitly highlights the challenge that water security presents to South Africa's social well-being and economic growth, unpacks and discusses this challenge in considerable detail and puts forward a response to ensuring water security. This is particularly necessary to prevent the projected 17% water deficit by 2030 (DWS 2017). In this regard, the Master Plan conceptualises water security as the availability of water for socio-economic development. What this means is that policy structures are important not only to define water security, but also how water security as an aspiration could be achieved for the country's entire population. In this regard, the National Water Act (No. 36 of 1998) (RSA 1998) comes to mind.

Since the advent of democracy in 1994, and the subsequent rewriting of South Africa's water legislation, South Africa has prided itself on having developed one of the most progressive national water laws in the world (Funke et al. 2007). Just one of the many progressive components featured in The National Water Act (RSA 1998), and closely related to the water quality component of water security, is that of the Reserve. The Reserve consists of the basic human needs reserve as well as the ecological reserve that water development planners determine for every significant water resource or part thereof in South Africa. The

basic human needs reserve secures sufficient water to be set aside for drinking, food preparation, and personal hygiene. The ecological reserve, on the other hand, is water allocation set aside to protect the water ecosystems that provide water resources, and to ensure acceptable water quality for future use (RSA 1998, DWAF, n.d.). In other words, this water allocation ensures, among other things, the correct functioning of ecological infrastructure that is part of ecosystem services to supply water for future needs. This reserve, therefore, is of critical importance for water security as an aspiration and end goal.

A second example is the principle of the decentralisation of certain water resources management functions to catchment management agencies (CMAs). Catchment management agencies are institutions linked to South Africa's water management areas. Through the provision of extensive public participation processes interested and affected stakeholders support decision-making within CMAs (RSA 1998; DWAF n.d.).

Although the idea of the reserves and decentralisation were well intentioned, as time passed, these proved quite difficult to implement together with other provisions of the National Water Act. For instance, according to the National Water Resources Strategy 2 (DWA 2013), the ecological component of the reserve, which equates to approximately 25% of the country's mean annual runoff, has not been fully implemented in many water management areas such as the Olifants and Limpopo. Some of the barriers responsible for this state of affairs, include severe water quality problems caused by a number of water use activities and poorly functioning wastewater treatment works (WWTW) (DWA 2013).

Regarding decentralisation, the originally planned 19 CMAs were reduced to nine, of which only two have been successfully established the Breede-Gouritz and the Incomati-Usuthu CMAs (Meissner and Funke 2016; Meissner et al. 2016; Meissner et al. 2017). Given the many challenges characterising the establishment and running of the CMAs, including stakeholder fatigue and inequalities linked to public participation, DWS decided in June 2017 to establish a single CMA. The main reason behind this decision was linked to the considerable costs associated with establishing multiple institutions, and the need to, therefore, consolidate these institutions as a cost cutting measure. The Department had also identified the country's current institutional arrangements as one of the main causes for the continuing decline of South Africa's water resources, and therefore chose to address the CMA situation as a matter of priority (DWS 2017). DWS plans to run the single CMA as an institution focused exclusively on local water resources management (and separate from policy and regulatory roles), to provide a more effective mechanism to facilitate stakeholder

engagement and partnerships, and to provide greater transparency relating to decisions and performance around water resources management (DWS 2017).

While this decision may make sense from a cost cutting point of view, it seems contrary to the idea of decentralised water resources management. If too many challenges were present in taking on board water users' opinions and needs in the context of 19 and later on 9 CMA forums, how will it be possible for all of the country's stakeholders to have their voices heard in the context of a single CMA? Will it be a case of those with the most resources, contacts and agency having the most access and influence at the expense of other, more poorly capacitated stakeholders? More importantly, how would such an arrange influence water security now and into the future? Despite these questions, South Africa's overarching water legislation framework, the National Water Act, could significantly influence the nature and extent of the country's water security. Even so, we should bear in mind that it is not the Act itself, but the implementation by water managers at various levels that is, in this regard, influential.

2.5.The Blue Drop and Green Drop Programmes

Two innovative and unique incentive-based programmes that DWS had launched in 2009 to encourage municipalities to implement a series of measures to obtain Blue Drop (high quality drinking water) status or Green Drop (high quality wastewater treatment) status have since reportedly been discontinued (Ntombela et al. 2016). In January 2017, DWS briefed Parliament on the latest round of results that had been made available in 2014. While the overall performance of municipalities in terms of obtaining Blue Drop certification decreased from 87.6% in 2012 to 79.6% in 2014, the certification process was useful in that it highlighted a number of areas related to water treatment in which municipalities were underperforming. Challenges identified included not having enough skilled process controllers to manage water treatment plants; inconsistencies and lack of adherence to monitoring programmes; problems related to data uploading; lack of preparedness for emergencies; and lack of investment in infrastructure (PMG 2017). These problems paint a complex picture around the management of water purification and waste water treatment plants, something that under-resourced local governments find hard to cope with.

Be that as it may, the 2014 Green Drop certification results showed a decline of WWTPs that were categorised as low risk to 135 plants in 2014, but at the same time exhibited an increase of 212 plants being categorised as critical risk plants in 2017. More than

258 plants were labelled high risk and 218 plants were labelled medium risk. In response, DWS stated that the plants that regressed, and that showed an increase in risk status, would be placed under surveillance and would be monitored every quarter to implement corrective actions and enable risk mitigation measures to be taken (PMG 2017) by the Department.

It is likely that the Blue Drop and Green Drop programmes have been discontinued for a number of reasons, including the increasingly long gaps between reporting periods, and fear by the ANC-led government that opposition parties would use the less than favourable results as evidence to show how poorly ANC-led municipalities were performing on issues of basic service delivery (Meissner et al. 2016).

That said, we aimed to demonstrate some of the novelty, uniqueness and acclaim of South Africa's water legislation, but also to point out how difficult it has been to implement such ambitious laws in the post-apartheid state. According to DWS (2017), much remains to be done before the country can achieve the water security it so urgently needs, as emphasised by DWS in the National Water and Sanitation Master Plan.

2.6.Water for growth and development

Water is important to human wellbeing and widely perceived as an end-of-pipe "social" sector, important for health, livelihoods, and the environment. However, economic growth depends on achieving water security. So far we have indicated that the importance of securing water for different uses to allow for socio-economic development is therefore undeniable. Investments in water resource development should therefore be a priority for any society to achieve socio-economic development goals. Yet, the actual priority it receives on the political, economic and environmental agenda, local and national budgets and investment programmes, and allocations from financing institutions, unfortunately does not match this rhetoric (WWC and OECD 2015). This is one of the dilemmas water development planners and practitioners would be facing for a considerable time to come; societies do not have unlimited resources to prioritise all aspects influencing the wellbeing of their human populations and environment.

In this regard, the green economy, as concept, has increasingly attracted a lot of attention internationally as well as in South Africa. The concept "green economy" is defined as: "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011:16). In order for such an economy to be successful in its vision, it has to be low-carbon, resource efficient and

socially inclusive (UNEP 2011). First introduced in 1989 by Pearce et al., the concept emerged out of concerns with the value or "price" of natural resources and pollution in the market system, which according to them, has caused a culture and economy of over consumption and widespread pollution. According to Pearce et al (1989), this state of affairs has led to an unsustainable situation where the resource base of societies and ecosystems have increasingly become depleted and ecosystems' capacity to regenerate resources or assimilate pollutants has been exceeded. The global financial crises of 2008, in conjunction with an increased awareness worldwide with regards to the heightening environmental and associated social crises, gave rise to a more widespread adoption of the concept (Barbier 2009). Indeed, organisations such as the United Nations Environment Programme (UNEP) (2011), adopted this concept more broadly as an opportunity to revive the global economy, create more jobs, alleviate poverty, and curb environmental degradation in an effort to ensure the sustainable use of natural resources. As such, UNEP (2011) called for what it called "a global green new deal", which could inspire and stimulate widespread investment, pricing, and policy reform in an effort to promote sustainable development.

According to Musvoto et al (2015), South Africa has also sought to engage with the concept of a green economy quite extensively and through its efforts has become a leading example globally. In 2010, South Africa defined a New Growth Path which seeks macro- and micro-economic interventions towards a greener economy. Additionally South Africa has mapped out its green economy vision in a number of high profile documents such as the National Development Plan (NDP), the National Strategy for Sustainable Development (NSSD) and the Green Economy Accord (Musvoto et al. 2015).

Water security has been inextricably linked to the successful implementation of a green economy. The Global Water Partnership (GWP) (2012: 3) notes that "water is not just part of the economy; it is embedded within the economy. Without it the economy could not function. Thus water will be central to the innovative thinking and effective solutions required to establish the green economy."

Water is essential for all life and well-being and, therefore, requires the integration of all aspects of natural resource management toward inclusive and sustainable growth and development (GWP 2012). Proponents of this integrative notion, argue that this is why good, integrated water management is needed that is built upon the foundation of social inclusiveness, resource and energy efficiency while at the same time assuring biodiversity and sustainable ecosystem services (UNW-DPC 2012). Table 1 provides a summary of the different characteristics of both green growth and water security. The comparison of the characteristics illustrates not only the overlapping ethos but also how these two approaches are complimentary and reinforcing of each other's goals. The GWP (2012) notes that achieving water security is dependent on a green growth approach to economic development, something that South Africa has already adopted as a principle in its numerous strategic documents.

Possible box:

It is recognised that the concept Green Economy is one that is multi-faceted and open to much debate and interpretation. As such the concept may be best understood in terms of its principles which are generally well understood an agreed upon. The principles are as follows:

1. The green economy is a means for achieving sustainable development.
2. The green economy should create decent work and green jobs.
3. The green economy is resource and energy efficient.
4. The green economy respects planetary boundaries or ecological limits or scarcity.
5. The green economy uses integrated decision making.
6. The green economy measures progress beyond GDP using appropriate indicators/metrics.
7. The green economy is equitable, fair and just – between and within countries and between generations.
8. The green economy protects biodiversity and ecosystems.
9. The green economy delivers poverty reduction, well-being, livelihoods, social protection and access to essential services.
10. The green economy improves governance and the rule of law. It is inclusive; democratic; participatory; accountable; transparent; and stable.
11. The green economy internalises externalities.

Table 1. Synergies between water security and green growth (GWP 2012).

Characteristics of green growth	*Characteristics of water security*
• More effective use of natural resources in economic growth • Valuing eco-systems • Inter-generational economic policies • Increased use of renewable sources of energy • Protection of vital assets from climate related disasters • Reduce waste of resources – and finance	• Ensure enough water for social and economic development • Ensure adequate water for maintaining eco-systems • Sustainable water availability for future generations • Balance the intrinsic value of water with its uses for human survival and welfare • Harness productive power of water • Minimise the destructive power of water • Maintain water quality and avoid pollution and degradation

Gulati et al (2013) argues that in order for the world to have a sustainable and secure future we need to be more aware of the complex relationship between water, energy and food. In this relationship, resources are interdependent where the demand for one drives the demand for another and the production efficiency of one resource can be negatively affected by the cost of another (Gulati et al. 2013). As such, the interdependent relationship between water, food and energy is highly vulnerable to environmental pressures and climatic changes. This is especially the case in the developing world, South Africa included. For instance, African countries have been identified as especially vulnerable to the impacts of climate change specifically in relation to food security due to the threat to agricultural production because of increased drought and water scarcity (UNEP 2013). Indeed, the African Climate Policy Centre (ACPC) (2013) argues that climate change will increase the pressure on availability and accessibility of water, a resource that is already severely burdened. This increase in pressure in an already stressed system will place further demands on economic development as well as the ecosystems and biodiversity of African countries (ACPC 2013).

The green economy concept, idea, and practice could play an important role in reducing some of the inherent vulnerabilities of the water-energy-food (WEF) nexus, not only for Africa as a whole, but particularly for South Africa as well. Brears (2018) argues that through the promotion of equitable and sustainable growth through the green economy a

resilient and productive environment could be stimulated. Equitability and sustainability are principles already enshrined in South Africa's legislative and strategy instruments. According to proponents of the idea of building resilience through the green economy will require a number of elements. These include ensuring an enabling environment that enhances equitable access to resources; the promotion of integrated thinking between different interest groups across government as well as civil society and the private sector; and increase in good, reliable and relevant information across the WEF nexus towards increased cooperation and resource sharing. It would also entail the development and roll-out of resource efficient technologies in order to reduce pressure on natural resources, the ecosystems producing these, as well as the nexus; and, introducing and optimising market-based instruments for resource use efficiency for both producers and consumers (Brears 2018).

2.7.Future risks for achieving water security in South Africa

When assessing water security one can not only look inwardly but needs to assess external impacts and stressors. In their Global Risks Perception Survey (GRPS) the World Economic Forum (2018) found that environmental risks have grown in prominence in recent years. Amongst the most pressing environmental challenges facing the world currently are extreme weather events and temperatures; accelerating biodiversity loss; pollution of air, soil and water, failure of climate-change mitigation and adaptation, and finally the transition risks as we move to a low-carbon future. The more pressing concern is the inter-relatedness of these environmental challenges and other risk categories for example water crises and involuntary migration, displacement of people as a result of weather-related events as well as disruption in already strained agricultural systems. This is not to mention the water-related pollution and associated hygiene related risks and diseases linked to such events. Bringing this closer to home, South Africa did not fare well when compared to 180 countries in a global assessment known as the Environmental Performance Index, receiving a below average score of 44.73 and ending 142nd (EPI 2018). These risks are, in broad strokes, some of the elements that could threaten South Africa's water resources and by default water security. In the next section, we will look in more detail at climate change as a particular future risk.

2.8.Climate Change

Scientists and the majority of policy makers are convinced that climate change presents the single biggest threat to sustainable development everywhere, with the biggest impacts likely

to affect the poorest and most vulnerable (UNFCCA 2016), particularly those in developing countries. The IPCC (2007) considers Southern African to be particularly vulnerable to climate change impacts. Climate change experts see water, specifically, to be at the centre of this vulnerability as the potential impacts on water due to climate change are projected to increase in magnitude, severity and diversity (IPCC 2007). The IPCC, however, notes that even without the threat of adverse climate change impacts, the African region (IPCC 2007), and specifically southern Africa as well (Kusangaya 2013), is already facing a multitude of problems with regards to its water, which climate change is likely to exacerbate (Lioubimtseva 2014). This assessment and conclusion goes for South Africa as well. Some of the existing water problems linked to climate change are water availability, accessibility, and demand, which may increase the pressure on already over-burdened economic sectors, ecosystems, and biodiversity.

Using a suite of global climate models the South African Second National Communication on Climate Change (DEA 2011:71) has identified a number of regional climate change responses or trends relating to South Africa, they are:

- "Likely strengthening of upper air subsidence over the continent, with implication for stronger elevated inversions that can inhibit weak convective events";
- "Shifts in the spatial west-east positioning of the summer rainfall gradient";
- "Stronger long-shore winds on the west coast with implications for coastal upwelling";
- "Increased atmospheric moisture content over the continent, which could translate to potentially more intense precipitation and a likely increase in orographic cloud cover and topographically-induced rainfall";
- "Weaker frontal systems to the south, which could translate to weaker penetration of fronts onto the continent, drier conditions in the Western Cape (possibly compensated for by an increased orographic rainfall on mountain ranges)."

Figure X shows the rainfall (measured in mm) over South Africa and clearly indicated the predicted pattern of a wetter north-east and a drier south-west.

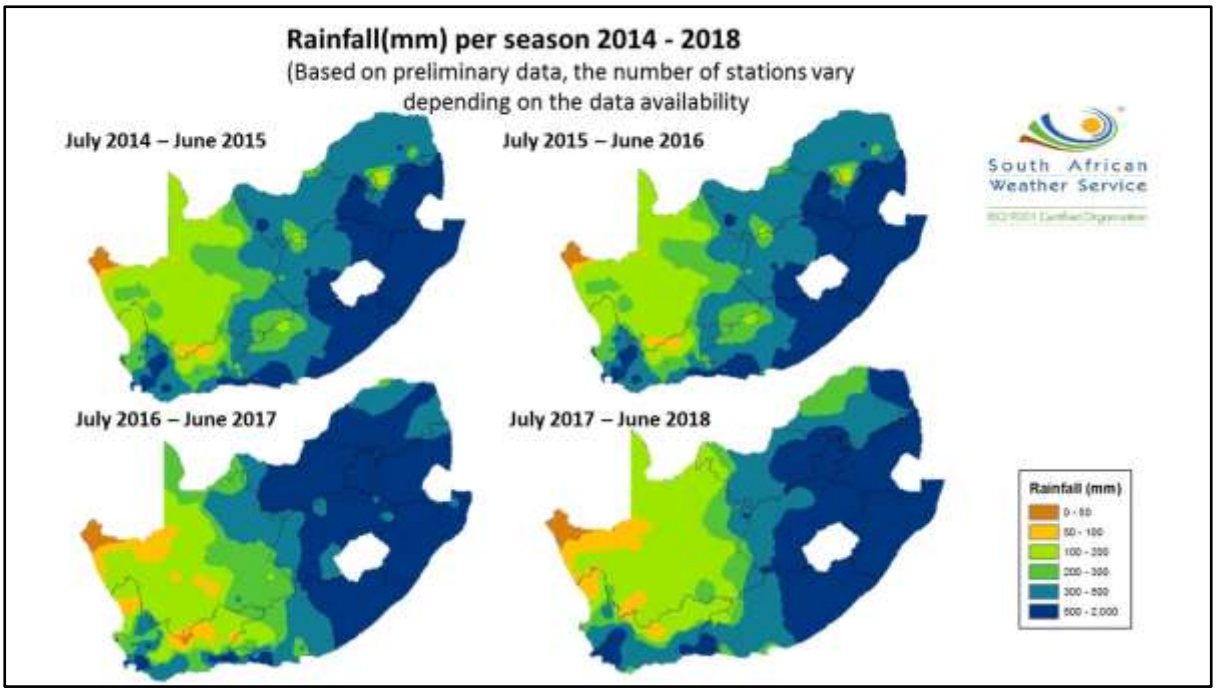

Figure 14: Historical rainfall (mm) measured in South Africa, 2014 - 2018 (Source: SAWS 2018)

According to Cullis (2015), the South African Long Term Adaptation Strategy (LTAS) has identified a number of key climate change impact channels of significance to South Africa. The LTAS was developed in line with the South African National Climate Change Response White Paper which seeks to "provide a coherent view of South Africa's climate change vulnerabilities over the short (next decade), medium (next two decades), and long term (mid-century to end of century) across multiple sectors" (Cullis 2015:1). The LTAS identifies water as a prominent impact channel. Other impact channels that the LTAS also identified are: agriculture and forestry; fisheries; human health; human settlements (urban, rural, and coastal); ecosystems and biodiversity, and disaster risk reduction and management. These are all in some way and extent linked to water security either as an aspiration or practice.

Schulze (2011) suggests that not all climate change impacts will be negative for South Africa. However, it will be most likely that some areas in South Africa will benefit from the impacts while others will experience detrimental effects like prolonged drought. It is, therefore, important to look at both these scenarios when considering the future of water security in South Africa.

Ziervogel et al (2014) notes that in terms of water projections for southern Africa, higher frequencies of flooding and drought events are on the cards. This should also be seen

in conjunction with the complexity inherent in South Africa's hydrological cycle, the particular ways in which people use and manage land as well as the strong links with society, health and the economy (Ziervogel et al. 2014). Taking this together, South Africa faces a complex situation in its water sector, which could be more tenuous than for other sectors.

According to the WWF-SA (2017), water is increasingly becoming a scarce resource. In 2004, the Department of Water Affairs (DWA 2004) already warned that water availability in the country is severely limited with the majority of catchments already well in excess of the natural availability. Now, more than ten years later, the WWF-SA projects that if current usage trends persist, South Africa is expected to be confronted with a water deficit of 17% by 2030, which could be worsened by climate change.

The recent severe drought in the Western Cape is a case in point. This drought caused much uncertainty and citizens and water managers called for crisis management in Cape Town, the Province's largest city. The City Council instituted level 6B Water restrictions, which meant that people were only allowed to use 50L of treated tap water per person per day. The Council put the restriction in place to prevent a situation termed Day-zero—the day that Cape Town would close the taps, and where people would have to fetch 25 litres of water per person per day to survive. Dam levels were at their ultimate low. Figure 15 shows Theewaterskloof dam in the Western Cape and how NASA (NASA Earth Observatory, 2017) reported through their "Images of change" how the reservoir shrunk from October 2014 to October 2017 followed by photographs of Theewaterskloof taken during the recent drought.

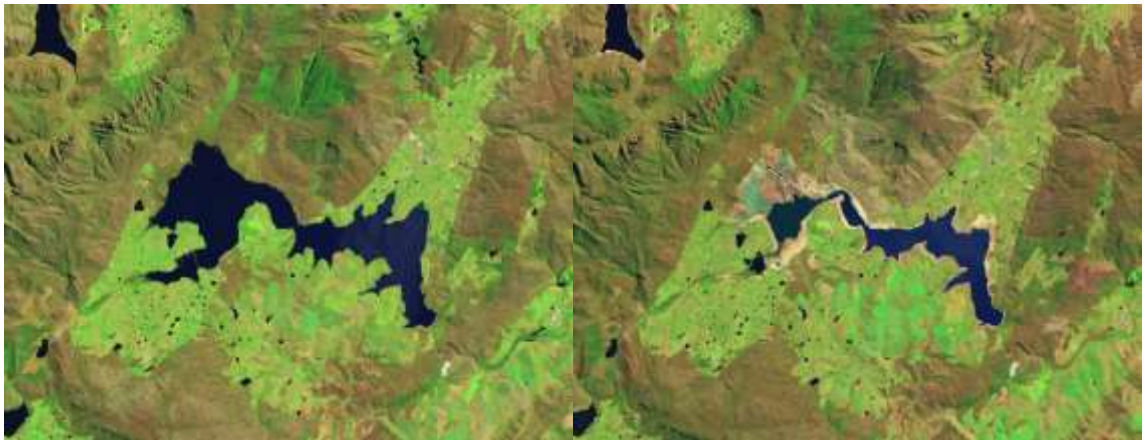

Figure 15: Images of change: Theewaterskloof Dam, October 2014 –2017 (Source: NASA Earth Observatory 2017); Photos of the dam taken during the recent drought, June 2017 - 2018. (Photos courtesy of Paul Oberholster).

2.9.Global urban migration and water management

Apart from climate change, urbanisation is increasingly being acknowledged as one of the defining issues of the twenty-first century. In 2018 the world reached the tipping point where more than half of its population now reside in urban areas. The UN (2018) estimates that 68% of all people will be living in cities in 2050. Africa remains mostly rural (57%), and together with Asia, is home to more than 90% of the global rural population.

Consistent with most of the world, South Africa has experienced rapid urbanisation. While about 60% of the population in South Africa is currently urbanised, the National Planning Commission of South Africa (NPC, 2012) projected this to be about 70% by 2030. They argue that this trend is mostly associated with the fact that urban living offers individuals a wider range of opportunities (NPC, 2012). Urban developments to support ever growing communities have increasing consequences on the land and water environments. Internationally, urban water management is therefore gaining increasing attention. Rapid population growth, urbanisation, industrialisation and climate change are impacting water resources and the environmental capabilities of urban centres. The main challenges include: over-exploitation of water resources; pollution of ground- and surface-water resources; access to services (especially for the urban poor); health impacts (from inadequate sanitation facilities and contaminated drinking water supplies); and leakage/wastage of up to 50% in some urban water distribution systems are amongst the main challenges (UNW-DPAC 2010).

Besides the water availability and water quality challenges experienced globally, South African cities are also under pressure to respond to issues of economic transformation

and social division. Despite accelerated basic service delivery, Carden and Armitage (2013) reports that many local authorities are battling to keep pace with urbanisation, intensifying competition for scarce resources and raising social tensions.

Informal settlements present a particular challenge in South Africa. Job seeking migrants often move into informal settlements as this provides for a more affordable entry into the city. However, the majority of migrants cannot break into the urban labour market and therefore take longer to move out of shacks into more formal accommodation. The average residence period within urban informal settlements has increased from about two to four years in the early 1990s to 10 years currently (NPC 2012).

4th Industrial Revolution

Besides climate change, and unprecedented population growth and urbanisation, the world is also facing technological changes in light of the 4th industrial revolution. Earth is under severe pressure. The World Health Organisation (WHO) reports that more than 90% of people now live in places where air quality is unsafe and predicts a 40% shortfall in freshwater needed to support the global economy by 2030. With unprecedented population growth and risks to our environment so large and so urgent, transformative change is a must. They (WEF, 2017) describe the 4th Industrial Revolution as an inevitable future that involves a fusion of technologies that is blurring the lines between the physical, digital and biological spheres. The era is predominantly driven by advances in digital systems complimented by technologies such as artificial intelligence, automation, biotechnology, nanotechnology and communication technologies. It is expected to be broader and faster than any prior revolution, particularly focused on digital technological development and will impact most, if not all economic sectors, as well as the broader society. Due to its integrated nature, it will likely extend to business systems, technology developments and society in general.

Water is the ultimate shared resource. Since the beginning of time, humans have dammed, dredged and drained freshwater ecosystems to suit their needs. They dump their waste into the same rivers from which they draw their water and catch their fish. It is therefore not surprising to see that the top finding from the WEF 2016 Global Risk Report is "the potential for climate change to exacerbate water crises, with impacts including conflict and more forced migration, calling for improved water governance to adapt to climate change and accommodate a growing population and economic development."

WWF International (2016) states that recognition of the seriousness of climate change and the risks it pose, is a crucial step toward decisively addressing the problem. When it

comes to improving water governance and building resilience to climate change, technological fixes alone won't get the job done. WWF urge that while the 4th Industrial Revolution will bring new technologies, it must be accompanied by an ideological shift that recognizes instead that healthy ecosystems underpins all economic enterprises. To ensure a more prosperous and sustainable future for all, and to combat the risks posed by climate change and the additional pressure on water governance, a changed mindset is needed towards collective action in order to optimize water for all users – communities, companies and nature itself. Such a mindset will shape the 4th Industrial Revolution and a sustainable future for all.

3. Resilience key to achieve water security in SA

Changing weather, evapotranspiration and rainfall patterns as a result of climate change, urban migration and population growth, changing river flows as a result of upstream water and land use changes, technological advances and the development of new preferences and norms are all instances of drivers for changes in the way water is being managed.

Urban design for resilience, to overcome the impact of climate change and population growth, predominantly in regards to sustainable management of water resources and the protection of water environments, is one of the main challenges facing urban communities (Wong and Brown 2009). Harrison et al (2014) defines resilience as the *"capability of individuals, social groups, or social-ecological systems including urban centres (towns and cities) not only to live with changes, disturbances, adversities or disasters but also to adapt, innovate and transform into new more desirable configurations"*. One of the key factors that need to be addressed in South Africa on our road to adapt to global climate change and become a more resilient country, is to fully understand how we need to move from integrated water resources management (IWRM) and adaptive water management to "water integrated management" (Hoekstra et al. 2018) and change from being merely water supply cities to become water sensitive cities (Wong and Brown 2009).

The top priorities for urban water sustainability include the provision of safe drinking water, handling of wastewater for public health, and protection against disasters e.g., flooding (Larsen et al., 2016). As a result, 'water security' is often seen to imply just 'water supply security' (e.g. Lundqvist et al. 2003, Padowski et al. 2016, Grafton 2017), hence the term water supply cities. Urban water management however extends significantly beyond just security of supply and should instead follow a total water cycle perspective, as this is likely to

result in more resilient solutions over the long term (Wong and Brown 2009; Hoekstra et al. 2018).

It is now widely acknowledged that the conventional urban water management approach is highly unsuited to addressing current and future sustainability issues (Butler & Maksimovic 1999; Newman 2001; Ashley et al. 2003, 2005; Fisher- Jeffes et al. 2017). Traditionally, water supply, sewerage and storm water services have been compartmentalised, both physically in terms of infrastructure, but also institutionally in terms of responsibility with regards to service provision, operation and maintenance. In turn this has led to philosophical compartmentalisation and shaped perceptions of system boundaries with sub-optimal outcomes (Ashley 2005; Brandes & Kriwoken 2006; Brown 2008). This has also been the case for South Africa.

A new hydro-social contract that requires a significant paradigm shift in urban design through the urban water transitions framework (Figure 16) is presented in Brown et al. (2009). This framework illustrates the six typical states cities transition through when pursuing change towards a more sustainable future. The dominant socio-political drivers and service delivery functions are also indicated. As a city moves from one state to the other, previous states within the continuum influences and shapes the subsequent transition states. Brown et al. (2009) therefore calls for water supply cities to become water sensitive cities. A water sensitive city is a fundamental building block towards a sustainable city and may be characterised by three key attributes:

❶ access to a diversity of water sources which is underpinned by a diversity of both centralised and decentralised infrastructure;

❷ provision of ecosystem services for the built and natural environment; and

❸ socio-political capital for sustainability and water sensitive behaviours.

According to Brown et al (2007) "*a Water Sensitive City would ensure environmental repair and protection, supply security, public health and economic sustainability, through water sensitive urban design; enlightened social and institutional capital, and diverse and sustainable technology choices*".

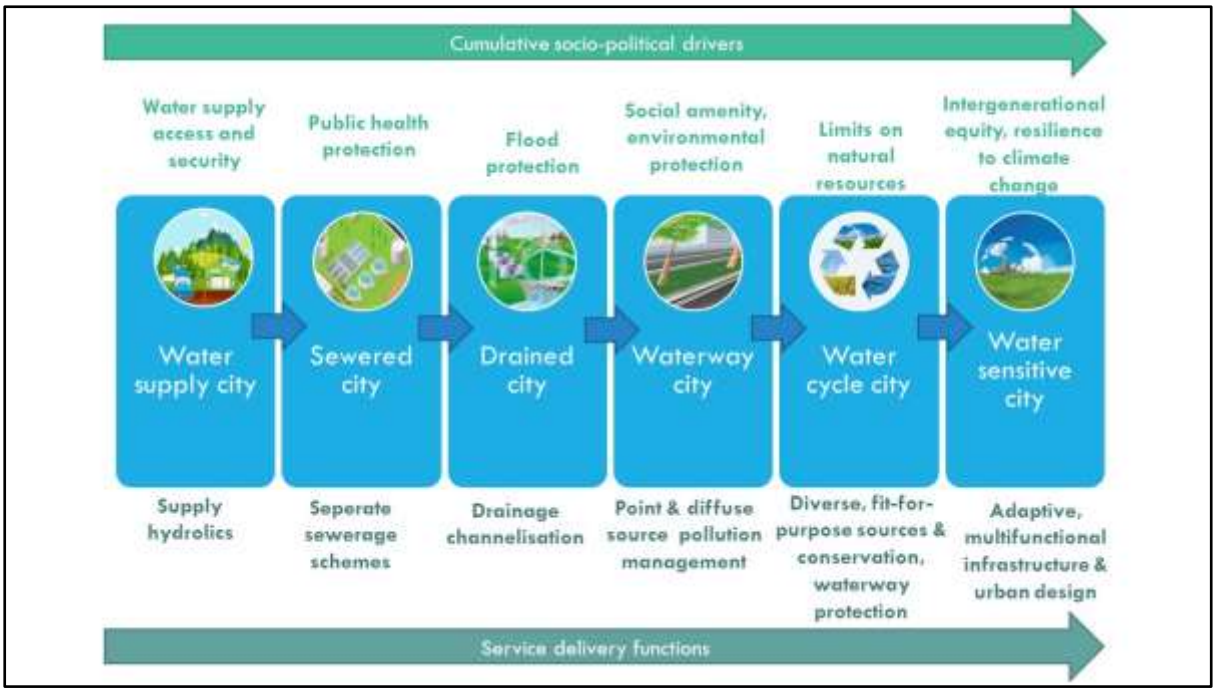

Figure 16: Urban water management transitions framework (Source: Brown et al., 2009)

Hoekstra et al (2018) agrees and mentions that planning for and designing liveable and environmentally responsible communities requires a "*clear appreciation of the interconnections between key design elements that affects the ecological footprint of urban environments, particularly in relation to energy and carbon emission, water conservation, environment protection, and biodiversity*". They further mention the importance of a transdisciplinary approach with active stakeholder engagement and participation throughout the transition process.

In order for cities to transition to water sensitive cities, we need a better understanding of the full potential of water sensitive design, rainwater harvesting, recycling, reuse, pollution prevention and other innovative urban water approaches. Hoekstra and co-authors (2019) mentions the need to consider not only 'integrated water' approaches, but also 'water integrated' approaches where water forms a fundamental part of urban dynamics and urban design.

According to Fisher-Jeffes et al (2017), within cities and towns, municipalities in South Africa must find ways to adapt to, and mitigate the threats from, water insecurity resulting from increasing water demand driven by population growth and rising standards of living. In agreement with the shift from water supply cities to water sensitive cities, storm water harvesting (SWH) provides for an alternative water resource (Fisher-Jeffes et al. 2017) that could supplement traditional urban water supplies, while at the same time offer a range of

benefits including the management of flooding and the provision of recreational areas. Similarly, alternative water resources in the form of managed aquifer recharge and ground water augmentation, as well as water reuse, should be investigated and planned for.

4. Conclusion

From this chapter it is clear that South Africa has a rich history and amidst the apartheid legacy and the economic difficulty, is trying to build the rainbow nation and provide for an environment to sustain both economic development and communities with improved quality of life in urban cities of the world. Climate change and the related pressures from unprecedented urban migration and growth, not to mention the vast changes as a result of technological innovation call for a shift in how we approach and manage our precious resource. Engineering solutions (e.g. dams) alone won't solve our problems if we receive no rain. No longer can we water our gardens or wash our cars with treated drinking water. Transitioning from water supply cities to water sensitive cities are key for our future.

South Africa will need to focus on water integrated design underpinned by integrated decision making and planning for disasters (e.g. droughts and floods) while at the same time including aesthetically pleasing and liveable environments for all. We need to invest in planning towards alternative water sources and a combination from centralised and decentralised treatment solutions. We need to plan for the past-paced growth of urban populations and their increased water needs while securing water for future economic development. Implementation of the National Water and Sanitation Master Plan (DWS 2018), is therefore key to our country's water future. We should note however, that sustained political will has been the main critical missing link according to Biswas and Tortajada (2018) to improve urban water management globally.

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