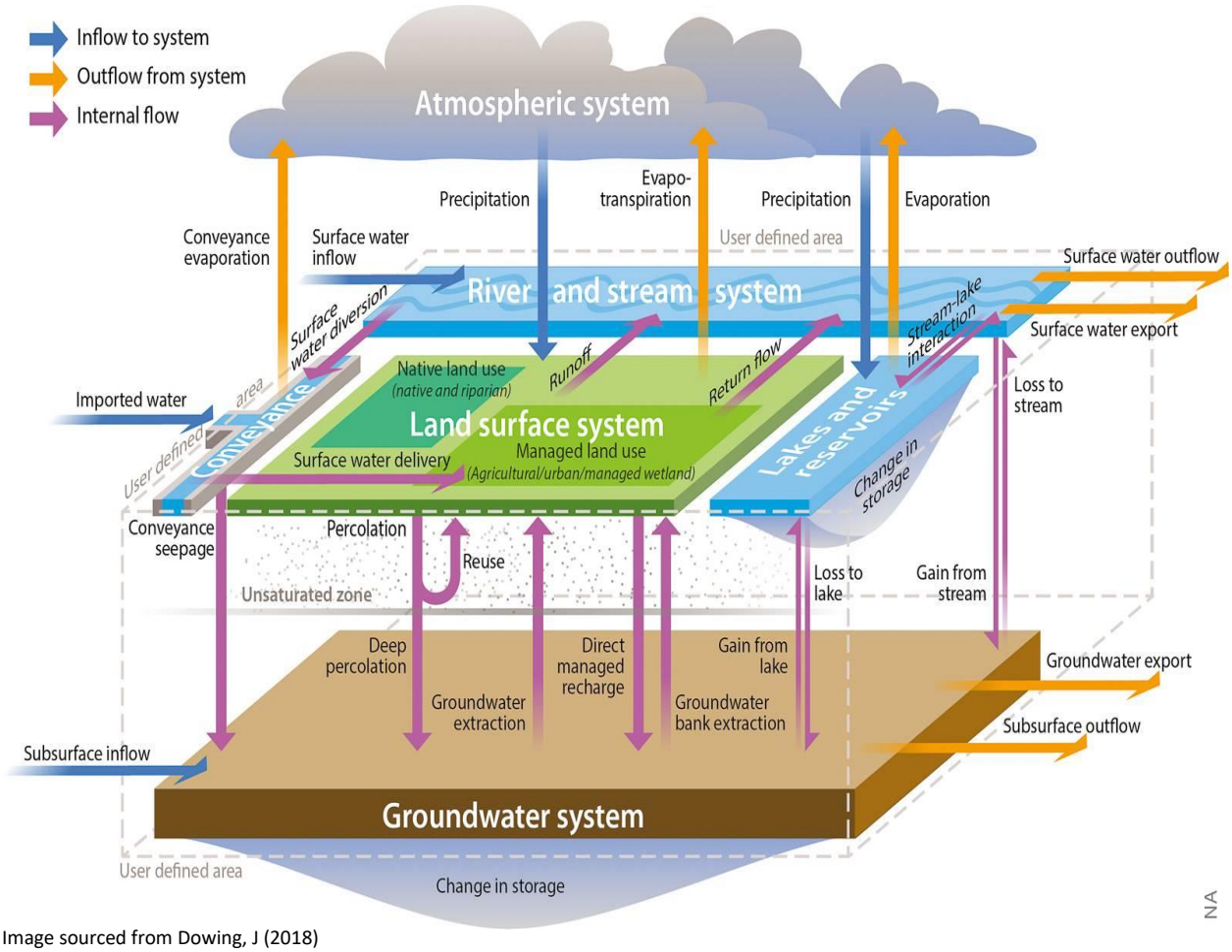

Image sourced from Dowing, J (2018)

POLICY-BASED RESEARCH ON GROUDWATER MANAGEMENT AND USE IN SOUTH AFRICA

2022

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Table of Contents

2030 NDP

ACRONYMS

AfDB	AFRICAN DEVELOPMENT BANK
AMCOW	AFRICAN MINISTERS COUNCIL ON WATER
ASR	AQUIFER STORAGE AND RECOVERY
AU	AFRICAN UNION
AWSS	AMATOLE WATER SUPPLY SYSTEM
CMA	CATCHMENT MANAGEMENT AGENCY
CoCT	CITY OF CAPE TOWN
CoJ	CITY OF JOHANNESBURG
CoT	CITY OF TSHWANE
DK	DENMARK
DWAF	DEPARTMENT OF WATER AFFAIRS AND FORESTRY
DWS	DEPARTMENT OF WATER AND SANITATION
ECA	ECONOMIC COMMISSION FOR AFRICA
EIA	ENVIRONMENTAL IMPACT ASSESSMENT
EM	EKURHULENI METROPOLITAN
EU	EUROPEAN UNION
GBWSS	GREATER BLOEMFONTEIN WATER SUPPLY SYSTEM
IWRM	INTEGRATED WATER RESOURCE MANAGEMENT
MCCM	MULTI-COUNTRY CONSULTATION MECHANISM
NDP	NATIONAL DEVELOPMENT PLAN
NGA	NATIONAL GROUNDWATER ARCHIVE
NGS	NATIONAL GROUNDWATER STRATEGY
NMBM	NELSON MANDELA BAY METROPOLITAN
NRF	NATIONAL RESEARCH FOUNDATION
NWA	NATIONAL WATER ACT
NWI	NATIONAL WATER INITIATIVE
NWRS	NATIONAL WATER RESOURCE STRATEGY
NWSAS	NORTH WESTERN SAHARA AQUIFER SYSTEM
NW&SMP	NATIONAL WATER AND SANITATION MASTER PLAN

ORASECOM	ORANGE-SENQU RIVER COMMISSION
OSS	SAHARA AND SAHEL OBSEVATORY
RBO	RIVER BASIN ORGANISATIONS
RFQ	REQUEST FOR QUOTATION
RIDMP	REGIONAL INFRASTRUCTURE DEVELOPMENT MASTER PLAN
RISDP	REGIONAL INDICATOVE STRATEGIC DEVELOPMENT PLAN
RQOs	RESOURCE QUALITY OBJECTIVES
RSAP	REGIONAL STRATEGIC ACTION PLAN
RWP	REGIONAL WATER POLICY
RWS	REGIONAL WATER STRATEGY
SADC	SOUTHERN AFRICAN DEVELOPMENT COMMUNITY
SAP	STRATEGIC ACTION PLAN
SPZ	SOURCE PROTECTION ZONE
TDA	TRANSBOUNDARY DIAGNOSTIC ANALYSIS
VWSS	VAAL WATER SUPPLY SYSTEM
WARMS	WATER USE AUTHORISATION AND REGISTRATION MANAGEMENT SYSTEM
WMA	WATER MANAGEMENT AREA
WRC	WATER RESEARCH COMMISSION
WSA	WATER SERVICE AUTHORITY
WSDP	WATER SERVICES DEVELOPMENT PLAN
WSP	WATER SERVICE PROVIDER
WSS	WATER SUPPLY SYSTEM
WUA	WATER USE ASSOCIATION
WUL	WATER USE LICENCE
WWF	WORLD WIDE FUND
WWF	WORLD WATER FORUM

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1. Introduction

It can be argued that managing water has become a conundrum of our lifetime, thus becoming of humanity's most critical priority in modern history. While surface water resources are typically societally managed and relatively well understood, the same cannot be said about groundwater resources which are often hidden and more difficult to conceptualise. Water scientists and managers agree that the replenishment of groundwater cannot match past and current rates of depletion in many parts of the world including South Africa. As much as access to water is deemed a human right, water as a resource is by now overwhelmingly regarded as a public good that needs to be protected by everyone with interest (Pierre & Debbie, 2003; WRC, 2014; WWF, 2016).

Historically, in South Africa, the opposite was the case for groundwater. Being a hidden resource, it was often treated as a private good accessible to owners of land and out of the purview of public regulation. Water rights were essentially a subsidiary component of land tenure rights, where the right to use groundwater was conferred on the owner of the overlying land, and that the owner of the land could essentially abstract groundwater with little or no control. This riparian system was founded under the principles of Roman-Dutch law which was invoked during the colonial period under British control followed by apartheid rule by Afrikaner nationalists from about 1810 to 1990s. However, the political reforms in 1994 gestated water reforms in the country (Pietersen *et al.,* 2011). The groundwater, which was previously a neglected resource, started receiving strategic role in monumental programmes that sought to bring about basic water infrastructure coverage to more than 95% of the population (Adams, *et al.,* 2015). Currently, groundwater is an integral part of water resource planning and provided for in the national water policy and legal framework.

In 2015 the Water Research Commission (WRC) conducted “The assessment of the implementation national water policy (1994 to 2013)” on the request of the Department of Water and Sanitation (DWS). One of their findings under future consideration of water policy in South Africa was on groundwater management and use where they argued that the current water policy has limited positions on groundwater management. This finding expressed that the existing policy positions focus on the need to collect information and data on groundwater for the sound management of the resource. The National Water and Sanitation Master Plan also

proposed the development of new policies and strategies on matters not previously addressed, in consultation with all stakeholders, to facilitate the sustainability of various water sector programmes.

Based on the above introduction, the primary purpose of this report is to conduct a systematic search and mapping of all available policy and regulatory tools for groundwater management and use in South Africa. This is done with a view to draw a conclusion on whether there is a need to strengthen the existing policies and whether there is sufficient legal framework for the management and use of groundwater in the country. It is against this background that this research report aims to:

a) Conduct a review of local and international literature on groundwater management and use;
b) Assess the strength of the current policy and legislative framework on groundwater management and use;
c) Identify gaps from the identified literature and highlight lessons on how the gaps are addressed in other parts of the world.

The report does this by providing a clear, factual description of groundwater management in international perspective with Denmark, Australia and California being chosen as case studies. The report goes further to look at the global groundwater assessment framework and positions South Africa within this framework. In terms of looking at the groundwater management and use in the African continent, the report looks at the African Union (AU) Agenda 2063 vision for groundwater management and use and the related strategies put in place by the African Ministers Council on Water (AMCOW) to effect groundwater management and use in Africa. The report then funnels the scope to the groundwater management and use in the Southern African Development Community (SADC) and makes references to the regional policy framework and take lessons from certain countries that are effective in the management and use of groundwater resources in the SADC region. Finally, the report looks at the groundwater management and use in South Africa, and makes reference to policies, legislation, strategies and plans that the country has put in place to ensure effective and sustainable management and use of groundwater resources. The municipal by-laws provide a very strong regulatory tool to

manage groundwater at a local level, therefore the study also assesses a few municipalities to determine the extent to which groundwater management is addressed.

Critical lessons from the international and local review provide a benchmark for the current policies and legislative framework in South Africa. Thus, giving the country a view of how South Africa is doing things and how the country can improve on aspects that are not covered by the national policy and legislative framework, taking a cue from the international trends on the thematic area of groundwater management and use.

2. Terms related to Groundwater

2.1. Definition

The definition of terms is very important as it allows the readers to be familiar with how terms are used throughout this report. This section defines key concepts such as groundwater, groundwater divide/ groundwater watershed, groundwater flow, groundwater management and groundwater governance, policy, regulation and legislation.

Groundwater: Water found in the subsurface in the saturated zone below the water table.

Groundwater Divide/ Groundwater Watershed: The boundary between two aquifers which is represented by a high point in the water table or piezometric surface.

Groundwater Flow: The movement of water through openings in sediment and rock; occurs in the zone of saturation in the direction of the hydraulic gradient.

Groundwater Management: The management of groundwater sub-basins to provide for multiple long-term benefits without resulting in or aggravating conditions that cause significant economic, social, or environmental impacts, such as long-term overdraft, land subsidence, ecosystem degradation, depletion of surface water bodies, or water quality degradation. Groundwater management is what the actors (i.e. government, private sector, civil society, academia, etc.) do within the governance framework; activities related to the development and protection of groundwater to implement the policies and plans which have been established.

The hydrogeological conditions and distribution of human activities will determine where these management activities are required.

Integrated Groundwater Management: A structured process that promotes the coordinated management of groundwater and related resources (including conjunctive management with surface water), taking into account non-groundwater policy interactions, in order to achieve balanced economic, social welfare and ecosystem outcomes over space and time. One of the emerging issues which put a spotlight on integrated ground water management is that of sand mining. This is brought about by rapid urbanisation, which is the major cause for increased demand for sand, resulting in unsustainable extraction of sand from dried river paths and in streams alike with devastating effects on both the quality and quantity of groundwater.

Groundwater Governance: Groundwater governance comprises the enabling framework that establishes who formulates policies and strategies and is responsible for their execution (the actors) and how different stakeholders interact (the legal and institutional framework). Decisions made by the actors regarding what to do in pursuit of societal goals are driven by information, knowledge and science, and result in policies and plans which define why activities are needed and when they should be undertaken or completed.

Groundwater Use: The utilisation of groundwater resources to meet social, economic and environmental requirements.

Policy: Can be regarded as a high-level document describing a course of action, a statement of intent in short terms.

Regulation: A rule or directive made and maintained by an authority.

Strategy: Provides a detailed outline of how actions specified in the policy are to be implemented, and therefore, it can be regarded as a long-term plan for achieving policy goals with defined targets.

Legislation: Can be defined as laws and rules made by the government.

2.2. Groundwater Management and Use

The WRC (2015) study describes groundwater management and use in specific as well as in broad aspects. The aspects relate very closely to the recent study of Fourie (2020) on "The twelve Underlying principles of groundwater management that investigated the term "Groundwater Management" and what the specific aspect or principles it underpins. Table 1 provides a comparison between the two studies.

Table 1: The comparison of the WRC report and Fourie study on twelve principles of groundwater management

WRC (2015)	Fourie (2020)
• protect the public • sensitive areas may be declared where notice of intention to drill will be required • buffers and groundwater recharge areas • rehabilitation • protect other users as well as the resource itself	protection
• allocation licence and groundwater permit systems • register new wells (to provide technical information for planning as well as for monitoring water use) • registration of drillers • ensure compliance with general requirements	regulation
• groundwater abstraction is impacting on other water users and on the environment	use
• planning and resource development, • new development of groundwater resource • groundwater to be managed with surface water,	panning and infrastructure
• monitoring, • knowledge and information on groundwater resource,	monitoring
• conservation of groundwater resources	conservation
• operating conditions	operation

• assessment (understanding of the sustainable yield of the local groundwater sources)	assessment
• include in a Catchment Management Plan	institutional arrangements
• efficient catchment management	Capacity and skills; and awareness, information sharing, and stakeholder participation

One clear distinction that comes out of the study is that the term "management" represents a number of principles of which 'use' is one of them. All twelve principles need to be addressed when discussing groundwater management. This report will address groundwater management in the context of the twelve principles and the 'use' will not be dichotomised from the management aspect thus 'groundwater management' and 'groundwater use' will be used interchangeably and sometimes together in the report.

3. International Trends on groundwater

Globally, groundwater is arguably a core pillar in freshwater resources which is used for both socio-economic and environmental systems (Knuppe, 2011). The current environmental conundrums which result in intensifying water security, environmental degradation and climate change around the world, elevate the status of groundwater, thus the enhanced and growing attention towards groundwater development and management (Clifton *et al.*, 2010). What is becoming important is that groundwater, surface water, humans and ecosystems are all interconnected in ways that necessitate an integrated approach to resource management. For each country to effectively manage this, it requires an understanding not only of a component aspect of the problem but also components of interconnectedness thus a paradigm of integration and nexus have been with us to understand an efficient way to manage and use resources at our disposal (Fienen, & Arshad, 2015).

According to Ross (2015), groundwater makes up 30 % of the world's fresh water and 99 % of the world's liquid freshwater. It supplies over 40 % of global irrigation water and 50 % of municipal water withdrawals. It is reported that approximately two billion people depend on

groundwater for drinking water. In Africa alone, the volume of groundwater is estimated to be 20 times more than the freshwater stored in rivers and lakes (Tijani, 2020). The consumption of this resource is growing rapidly driven by increases in global population and agriculture and over-extraction, resulting in increasing pollution of groundwater in many parts of the world.

This is reducing groundwater reserves and harming rivers and lakes that are connected to groundwater (Henriksen *et al.*, 2003; Ross, 2015). The demands for groundwater use for consumption and environmental use is growing globally, while the supply remains constrained by unsustainable use of the aquifers contributing to the threat of water security. Giordano in 2009 reported that the global groundwater extraction was more than 650 km^3 per year, with India, USA, China, Pakistan, Iran, Mexico and Saudi Arabia collectively accounting for 75% of the global annual water extraction at the time (Jorgensen *et al.*, 2017). Figure 1 below depicts groundwater use by country as reported in Giordano report (2009).

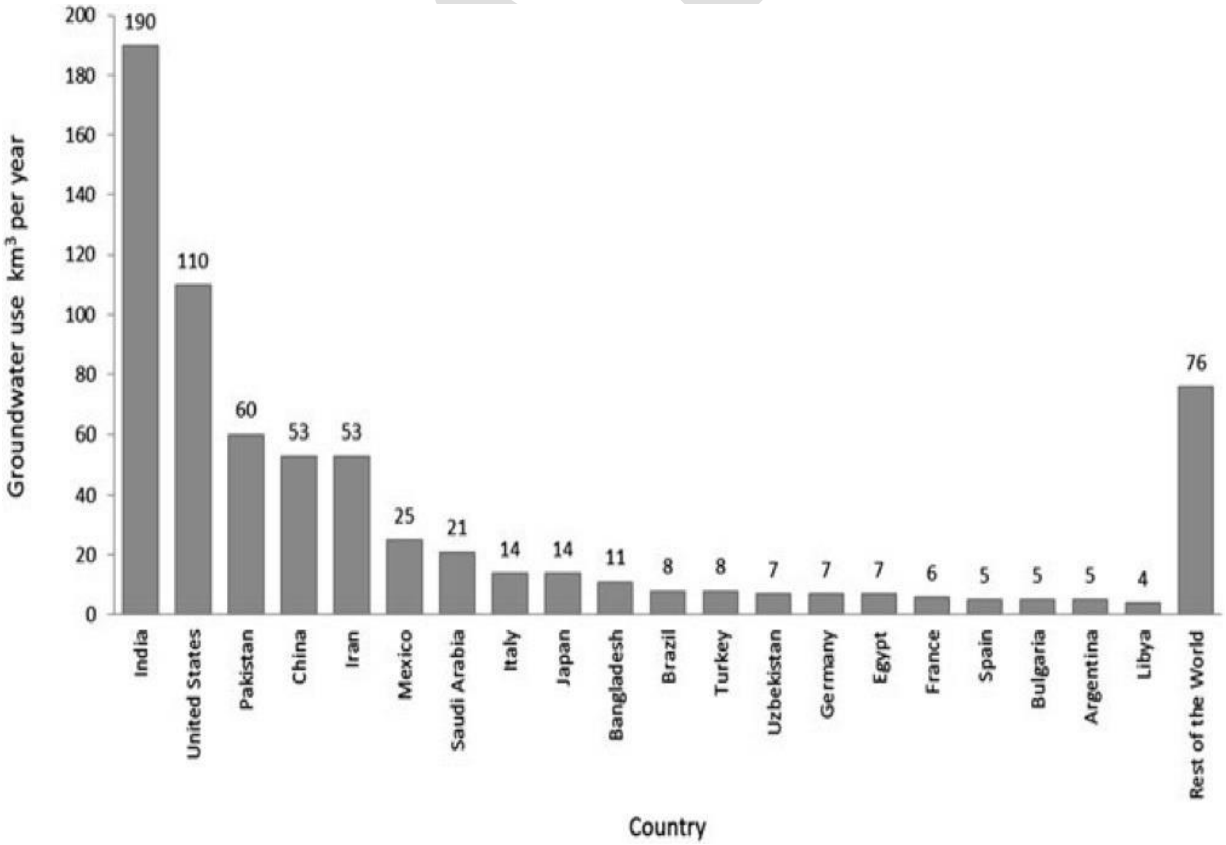

Figure 1: 2009 groundwater use by country

3.1. Groundwater Management and Use in Denmark

Denmark is chosen as one of the case studies as groundwater management and use is deeply rooted in a knowledge-based approach and the willingness among the country's authorities, the research community and industries to work together. This collaboration between different sectors enables the country to face new challenges together. The Danish have a long and strong tradition and standing research community especially in the hydrogeology and environmental sciences fields (Henriksen *et al.,* 2003). What makes Denmark to stand out is that it's groundwater management and use is an evolving endeavour, with strong roots in an informed, engaged and socially coherent population. Denmark has been known internationally for excelling and achieving sustainability goals in groundwater use and management, this can be attributed from the fact that the country solely depends on groundwater (Jorgensen, *et al.,* 2016).

Denmark is well bestowed with groundwater resources, thanks to its excess net rainfall (rainfall minus evapotranspiration) and good aquifer systems, dominated by sand and limestone aquifers. Having a temperate climate means Denmark is experiencing relatively low evapotranspiration rates, and average groundwater recharge of 300 mm/y (Stisen *et al.*, 2012). Denmark does not have a uniform groundwater availability because of the trend of rainfall distribution and recharge capacity, where recharge is mostly generated in the western part of the country where rainfall is higher and aquifers are unconfined, as compared to the eastern part, with less precipitation and confined aquifers overlaid by till, which generates more surface and drain runoff (EDMS, 2007; Henriksen *et al.,* 2003). Combined with the higher population density in the capital area of Copenhagen in the east, this causes higher stress on the water resources in the eastern part of the country, as well as around other large cities. However, what is amazing with Denmark is that it is one of the few countries in the world that relies on groundwater for all its uses, with 100% water use derived from groundwater for drinking as well as for industrial and agricultural purposes as shown in figure 2 below.

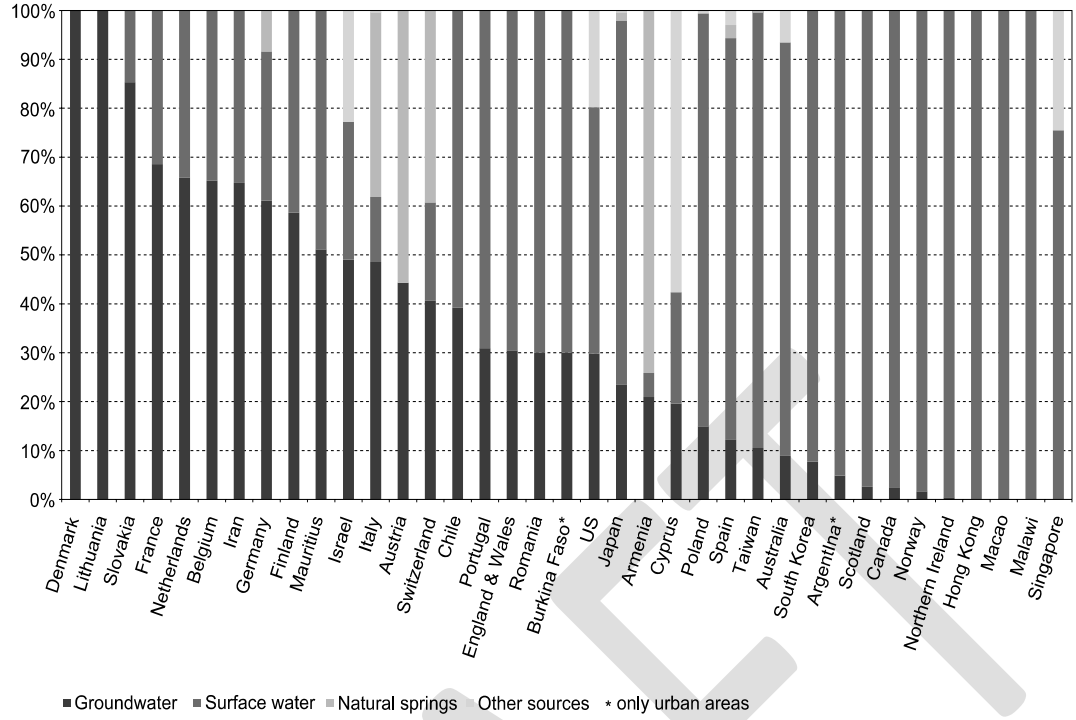

Figure 2: Sources of drinking water in various countries and major cities (data from Rose, 2015).

One of the key principles that the Danish government follows in the management and the utilisation of groundwater is sustainable groundwater supply and sustainable groundwater mapping, which in the country is regarded as the first step to a stable and sustainable water supply. However, mapping requires good data collection and secure data management. The Danish water consumers pay 0.04 euros (roughly 81 cent in South African currency) per cubic meter of water consumed, this money then funds the groundwater mapping and management programmes. Public entities have been appointed to ensure that the results of groundwater mapping are used to the best effect and interpreted within a wider context (Klee, 2013 in White Paper-Groundwater Mapping Sustainable Management, 2013). The Danish government has adopted a holistic approach in the management of its groundwater resources which is divided into four spheres:

a) Environmental authorities: Regulating and planning at national level

The Danish Environmental Protection Agency is responsible for drawing up and implementing environmental legislation, regulations and action plans at the national level. Also, the agency is responsible for keeping Parliament well informed about the state of the Danish environment.

The Counties are responsible for the water resource size and quality. Construction, operation and maintenance of water and wastewater facilities are the responsibility of the municipalities and are 100% financed by the consumers (White Paper-Groundwater Mapping Sustainable Management, 2013 and Klee, 2013).

b) The client: Supervising private sector contractor performance

The Danish water utilities frequently invite tenders for construction and renovation projects. To ensure project success, the water utilities need to have a high professional standard and extensive knowledge of contract preparation, project management and project follow-up. The municipalities are responsible for the planning and operation of the local water utilities, wastewater treatment plants and sewerage systems. Moreover, they stipulate the regulations governing connection to the sewerage system and wastewater disposal charges (Jorgensen *et al.*, 2017).

c) Water utilities: Water provision,

The overall objective of the Danish water utilities is the provision of a fully reliable, environmentally sound water supply at competitive prices. New forms of water utility organisation and ownership have developed in recent years, and the know-how and experience gained are now available to clients abroad (Jorgensen *et al.*, 2017).

d) Private and public sectors: Project implementation

In Denmark, the roles of the private and public sectors are very well defined, mainly constituting building and construction (Jorgensen *et al.,* 2017), within the water sector are implemented by Danish private sector consultancy firms and construction companies.

The Danish government has a list of key legislative and also follow its regional (European Union) initiatives that seek to protect and manage groundwater. These initiatives are listed in Table 2 below and their implications for groundwater management and use as indicated by Jorgensen *et al.*, (2017):

Table 2: Policy and Legislative frameworks for groundwater management and use in Denmark

Policy and legislative initiatives	Implications for groundwater management and use
Act on Water Supply 1926	Establishment of groundwater as a common good and licensing of groundwater abstraction as well as registration of abstraction wells; regulation on threats to groundwater; obligation on the abstraction to compensate third-party suffering.
Revision of the Act of Water Supply 1970	Compulsory water supply planning was introduced.
Establishment of the Ministry of the Environment 1971	Focus on discharges from industry and impacts on the local environment; a regional groundwater management strategy based on a platform of national legislation for the protection of the environment, planning of water supply systems.
Act on Environmental Protection 1974	Regulation of production, transport, storage and use of substances of potential risk for contaminating the environment (including groundwater); replaced local and disparate health regulations dating back to 1850s.
Act on Contaminated sites 1983	Mapping, investigating and remediation of old contaminated sites threatening the environment including groundwater.
Major revision of the Water Supply Act 1998	40% of the country is designated as particularly valuable for groundwater withdrawal and drinking water protection; intensive geological mapping and preparation of action plans for protection of these areas.
EU Landfill Directive 1999	Focus on industrial pollutants, identification of point sources, monitoring of groundwater pollution spreading, clean-up strategies and priority setting in remediation; also focus on prevention e.g separation of toxic and simple organic waste, protected landfills, and strategic location of waste sites.

EU Water Framework Directive 2000	A more integrated approach to water management, especially the impact of groundwater extraction on surface water resources and ecosystems.
National Action Plans on Aquatic Environment 2004	Focus on agricultural pollutants, sources thereof, monitoring and means of regulating diffuse pollution.
EU Groundwater Directive 2006	Criteria for assessment of the chemical status of groundwater; focus on measures to prevent or mitigate contamination of groundwater.
The first and second generation of Water Plans and Action Plans 2016	Quantitative focus, strengthened instruments to mitigate the impacts of groundwater abstraction on surface water bodies.
National Action Plan on Pesticides 2016	Focus on reduction of pesticide use, enhancing the use of less harmful pesticides, reassessment of already approved substances, and stricter procedures for the approval of new ones.

3.2. Groundwater Management and Use in Australia

In Australia groundwater has achieved the status of being one of the most important resources in the country, with over one million people from over 600 communities depending on groundwater for their daily activities (Ross, 2015). Most of the isolated communities around Australia rely on good groundwater availability and many features and landscapes such as wetlands and lakes are also directly linked to groundwater beneath (Stisen *et al.*, 2012). The Australian government has a unique way of addressing groundwater management and use, with the protection strategies being classified into three legislative groups:

1) Traditional groundwater management which its aim is to measure the availability, such as vulnerability maps, aquifer classification systems and wellhead protection plans;
2) A range of land-use planning measures which are there to help prevent contamination from occurring in inappropriate locations;
3) Environmental protection measures which are there to tackle modern waste management problems in progressive ways.

Table 3: Policy and Legislative frameworks for groundwater management and use in Australia

Policy and legislative initiatives	The implication for groundwater management and use
Guidelines for Groundwater Protection in Australia 1995	The guidelines provide a national framework for the protection of groundwater from contamination. It allows each State, Territory and the Commonwealth to develop policies and strategies which are tailored to their specific needs.
National Framework for Improved Groundwater Management 1996	This framework provided a comprehensive guide to states and territories on reforms in groundwater management. Among other things, it encouraged them to: • Define the concept of sustainable groundwater yield, in the context of principles of ecologically sustainable development, and develop groundwater management plans to facilitate intra-aquifer trading and reduce groundwater use to the level of the sustainable yield; • Integrate surface water and groundwater management, especially relating to pricing, allocations and trading; • Employ groundwater user charges to recover direct management costs, such as the costs of licensing; and indirect costs, such as the costs of formulating policy, where this was "realistic"; and make transparent any subsidies where recovering indirect costs were unrealistic; and • Increase public awareness of the value and vulnerability of groundwater.

Basin Salinity Management Strategy 2001	This strategy establishes valley-specific salinity targets, and began constructing a network of engineering works to intercept saline groundwater before it entered into and caused environmental and economic damage to rivers.
National Water Initiative (NWI) 2004 and 2006	The federal government and all state and territorial governments in Australia signed the National Water Initiatives with the aim to improve water governance, and the efficiency, productivity, and environmental sustainability of water use. Among other things, it focused on achieving transparent and statute-based water planning, nationally compatible water access entitlements, integrated management of surface water and groundwater, resolution of water over-allocation and over-use, effective water accounting, and open water markets.
National Action Plan for Salinity and Water Quality (2000–2008)	Provided for regional water quality targets, regional natural resource management plans, capacity-building and public communication programs, and regulatory reforms.
Water Act 2007	The Water Act provides for a legally binding Basin Plan, which is required to limit the use of groundwater and surface water in the Murray-Darling Basin to an "environmentally sustainable" level of extraction.
Operational policy no. 5.12-Hydrological reporting associated with groundwater well license 2009	The policy guides on when hydrogeological assessments and groundwater monitoring reports (collectively referred to as hydrogeological reports) will be required and the information that they should contain. It replaced the 'guidelines for hydrogeological reports and groundwater monitoring reports associated with a groundwater well licence.'

National Groundwater Strategic Framework (2016-2026)	The strategic framework seeks to optimise the contribution that groundwater makes to Australia's economic, environmental and social wellbeing through more efficient, effective and innovative groundwater management. The three priority objectives of this National Groundwater Strategic Framework are: • Sustainable extraction and optimal use—supporting the value of groundwater and improving understanding of groundwater resources to support optimal use • Providing investment confidence—providing confidence for investment through risk-based, consistent and efficient regulation of groundwater resources • Planning and managing now for the future—developing integrated water supply planning to enhance future water security.
Managing unlicensed groundwater use Policy 2019	The policy outlines approach for managing unlicensed groundwater use these activities include: • Irrigation of household gardens in urban areas • Household and garden use in rural areas • Stock watering bores under non-intensive conditions • Small dewatering projects • Occasional groundwater uses • Water taken under Commonwealth legislation. The Department of Water and Environmental Regulation will use this policy to manage unlicensed groundwater use through: • Regulation

	• Public awareness and education campaigns • Working with industry • Where necessary, provide financial incentives.

The Water Act 137 of 2007 was drafted by the Australian government to enable the Commonwealth in conjunction with the Basin States, to manage Basin water resources in the national interest and to also give into effect relevant international agreements that the Australian government agreed to. This legislation seeks to give into effect the management of water resources in ways that optimise economic, social and environmental outcomes. The principles that this Act follows include the return of environmentally sustainable levels of abstraction of water resources; protect, restore and provide for the ecological values and ecosystem services; and lastly to maximise net economic returns to the Australian community from the use and management of the Basin water resources. The Act covers the following issues concerning groundwater management and use:

Table 4: Water Act as a tool for groundwater management and use in Australia

Issues covered concerning groundwater management and use	Sections
Water for the Environment Special Account	Section 86(2)(f)(ii) replenish groundwater.
Investigations and Studies	Section 43(1)(d) the control and management of groundwater which may affect the quality or quantity of river water.
Monitoring	Section 44(b) the effect of groundwater on water and other natural resources.
Models developed by State Contracting Governments	Section 37 talks about each State Contracting Government being given the mandate to develop and maintain one or more groundwater models.
Special audit by Independent Audit Group	Section 17 (1) argues that the special audit data must be submitted by the relevant State

	Contracting Government, including, for example, data about areas under irrigation, storage capacities, crop production, irrigation technology and the conjunctive use of groundwater in the designated river valley.

3.3. Groundwater Management and Use in California, USA

In California groundwater is an important resource as almost 85% of all people living in the State depend on groundwater for some portion of their own water supply. Within this huge number of people relying mostly on groundwater for their own supply, a huge portion of communities within the State rely solely on groundwater for drinking, and these communities are in competition with the farmers (Leahy, 2015). When the groundwater resources in California were compared with surface water resources, it was found that until recently groundwater was unregulated by the California law. It was until in 2014 that the State through Sustainable Groundwater Management Act where we saw some regulations being put in place to ensure sustainable management and use of groundwater resources. Because the groundwater resources in California was now regarded as being overdraft, the Act then gave local agencies the tools and authority that they need to develop and implement plans that will bring their basin into balance.

This Act also gives the State Water Board a power to intervene in a case where local efforts are inadequate or local authorities request assistance (Kiparsky *et al*., 2017). The Sustainable Groundwater Management Act when analysed, transformed the legal regime in groundwater resource, it functions along the premises of sustainable groundwater resource management. This legislation on its own, defines sustainable groundwater management as the 'management and use of groundwater in a manner that can be maintained during the 50-year planning and implementation horizon without causing undesirable results (Kiparsky *et al.*, 2017). The undesirable results include the following:

a) Depletion of supply, indicated by chronic lowering of groundwater levels;
b) Reduction of groundwater storage;
c) Seawater intrusion

d) Degraded water quality
e) Land subsidence that substantially interferes with surface land uses; and
f) Adverse impacts on the beneficial uses of interconnected surface water due to depletion.

Table 5 below is the list of what the 2014 Sustainable Groundwater Management Act of California alludes to when it comes to the groundwater management and use in that particular State.

Table 5: Sustainable Groundwater Management Act of California

Issues covered	Implication for groundwater management and use
Groundwater Extraction Reporting for Probational Basins and Basins Without Groundwater Sustainability Agency	(a) This section applies to a person who does either of the following: (1) Extracts groundwater from a probationary basin 90 days or more after the board designates the basin as a probationary basin pursuant to Section 10735.2. (2) Extracts groundwater on or after July 1, 2017, in an area within a basin that is not within the management area of a groundwater sustainability agency and where the county does not assume responsibility to be the groundwater sustainability agency, as provided in subdivision (b) of Section 10724. (b) Except as provided in subdivision (c), a person subject to this section shall file a report of groundwater extraction by December 15 of each year for extractions made in the preceding water year. (c) Unless reporting is required pursuant to paragraph (2) of subdivision (c) of Section 10735.2, this section does not apply to any of the following: (1) An extraction by a de minimise extractor. (2) An extraction excluded from reporting pursuant to paragraph (1) of subdivision (c) of Section 10735.2.

	(3) An extraction reported pursuant to Part 5 (commencing with Section 4999). (4) An extraction that is included in annual reports filed with a court or the board by a water master appointed by a court or pursuant to statute to administer a final judgment determining rights to water. The reports shall identify the persons who have extracted water and give the general place of use and the quantity of water that has been extracted from each source. (d) Except as provided in Section 5209, the report shall be filed with the board. (e) The report may be filed by the person extracting water or on that person's behalf by an agency that person designates and that maintains a record of the water extracted. (f) Each report shall be accompanied by the fee imposed pursuant to Section 1529.5.
Sustainable Groundwater Management	To provide for the sustainable management of groundwater basins. (b) To enhance local management of groundwater consistent with rights to use or store groundwater and Section 2 of Article X of the California Constitution. It is the intent of the Legislature to preserve the security of water rights in the state to the greatest extent possible consistent with the sustainable management of groundwater. (c) To establish minimum standards for sustainable groundwater management. (d) To provide local groundwater agencies with the authority and the technical and financial assistance necessary to sustainably manage groundwater. (e) To avoid or minimize subsidence.

	(f) To improve data collection and understanding about groundwater. (g) To increase groundwater storage and remove impediments to recharge. (h) To manage groundwater basins through the actions of local governmental agencies to the greatest extent feasible, while minimizing state intervention to only when necessary to ensure that local agencies manage groundwater in a sustainable manner.
Basin Boundaries	(a) A local agency may request that the department revise the boundaries of a basin, including the establishment of new sub-basins. A local agency's request shall be supported by the following information: (1) Information demonstrating that the proposed adjusted basin can be the subject of sustainable groundwater management. (2) Technical information regarding the boundaries of, and conditions in, the proposed adjusted basin. (3) Information demonstrating that the entity proposing the basin boundary adjustment consulted with interested local agencies and public water systems in the affected basins before filing the proposal with the department. (4) Other information the department deems necessary to justify revision of the basin's boundary.
Establishing Groundwater Sustainable Agencies	Any local agency or combination of local agencies overlying a groundwater basin may elect to be a groundwater sustainability agency for that basin. (b) Before electing to be a groundwater sustainability agency, and after publication of notice pursuant to Section 6066 of the Government Code, the local agency or agencies shall hold a public hearing in the county or counties overlying the basin.

Powers and Authorities	(a) A groundwater sustainability agency may exercise any of the powers described in this chapter in implementing this part, in addition to, and not as a limitation on, any existing authority, if the groundwater sustainability agency adopts and submits to the department a groundwater sustainability plan or prescribed alternative documentation in accordance with Section 10733.6. (b) A groundwater sustainability agency has and may use the powers in this chapter to provide the maximum degree of local control and flexibility consistent with the sustainability goals of this part.
Groundwater Sustainability Plans	(a) A groundwater sustainability plan shall be developed and implemented for each medium- or high- priority basin by a groundwater sustainability agency to meet the sustainability foal established pursuant to this part. The groundwater sustainability plan may incorporate, extend, or be based on a plan adopted pursuant to Part 2.75 (commencing with Section 10750). (b) A groundwater sustainability plan may be any of the following: (1) A single plan covering the entire basin developed and implemented by one groundwater sustainability agency. (2) A single plan covering the entire basin developed and implemented by multiple groundwater sustainability agencies. (3) Subject to Section 10727.6, multiple plans implemented by multiple groundwater sustainability agencies and coordinated pursuant to a single coordination agreement that covers the entire basin.
Technical Assistance	(a) The department or a groundwater sustainability agency may provide technical assistance to entities that extract or use groundwater to promote water conservation and protect groundwater resources.

	(b) The department may provide technical assistance to any groundwater sustainability agency in response to that agency's request for assistance in the development and implementation of a groundwater sustainability plan. The department shall use its best efforts to provide the requested assistance. (c) The department shall prepare and publish a report by December 31, 2016, on its Internet Web site that presents the department's best estimate, based on available information, of water available for replenishment of groundwater in the state. (d) (1) By January 1, 2017, the department shall publish on its Internet Web site best management practices for the sustainable management of groundwater. (2) The department shall develop the best management practices through a public process involving one public meeting conducted at a location in northern California, one public meeting conducted at a location in the San Joaquin Valley, one public meeting conducted at a location in southern California, and one public meeting of the California Water Commission.
Financial Authority	A groundwater sustainability agency may impose fees, including, but not limited to, permit fees and fees on groundwater extraction or other regulated activity, to fund the costs of a groundwater sustainability program, including, but not limited to, preparation, adoption, and amendment of a groundwater sustainability plan, and investigations, inspections, compliance assistance, enforcement, and program administration, including a prudent reserve. A groundwater sustainability agency shall not impose a fee pursuant to this subdivision on a de minimise extractor unless the agency has regulated the users pursuant to this part.

Groundwater Sustainability Agency Enforcement Powers	(a) (1) A person who extracts groundwater in excess of the amount that person is authorized to extract under a rule, regulation, ordinance, or resolution adopted pursuant to Section 10725.2, shall be subject to a civil penalty not to exceed five hundred dollars ($500) per acre-foot extracted in excess of the amount that person is authorized to extract. Liability under this subdivision is in addition to any liability imposed under paragraph (2) and any fee imposed for the extraction. (2) A person who violates any rule, regulation, ordinance, or resolution adopted pursuant to Section 10725.2 shall be liable for a civil penalty not to exceed one thousand dollars ($1,000) plus one hundred dollars ($100) for each additional day on which the violation continues if the person fails to comply within 30 days after the local agency has notified the person of the violation. (b) (1) A groundwater sustainability agency may bring an action in the superior court to determine whether a violation occurred and to impose a civil penalty described in subdivision (a). (2) A groundwater sustainability agency may administratively impose a civil penalty described in subdivision (a) after providing notice and an opportunity for a hearing.
State Evaluation and Assessment	(a) The department shall periodically review the groundwater sustainability plans developed by groundwater sustainability agencies pursuant to this part to evaluate whether a plan conforms with Sections 10727.2 and 10727.4 and is likely to achieve the sustainability goal for the basin covered by the groundwater sustainability plan. (b) If a groundwater sustainability agency develops multiple groundwater sustainability plans for a basin, the department shall evaluate whether the plans conform with Sections 10727.2,

	10727.4, and 10727.6 and are together likely to achieve the sustainability goal for the basin covered by the groundwater sustainability plans. (c) The department shall evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin.
State Intervention	(a) "Condition of long-term overdraft" means the condition of a groundwater basin where the average annual amount of water extracted for a long-term period, generally 10 years or more, exceeds the long- term average annual supply of water to the basin, plus any temporary surplus. Overdraft during a period of drought is not sufficient to establish a condition of long-term overdraft if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods. (b) "Person" means any person, firm, association, organization, partnership, business, trust, corporation, limited liability company, or public agency, including any city, county, city and county, district, joint powers authority, state, or any agency or department of those entities. "Person" includes, to the extent authorized by federal or tribal law and subject to the limitations described in subdivisions (c) and (d) of Section 10720.3, the United States, a department, agency or instrumentality of the federal government, an Indian tribe, an authorized Indian tribal organization, or interstate body. (c) "Probationary basin" means a basin for which the board has issued a determination under Section 10735.2.

	(d) "Significant depletions of interconnected surface waters" means reductions in flow or levels of surface water that is hydrologically connected to the basin such that the reduced surface water flow or levels have a significant and unreasonable adverse impact on beneficial uses of the surface water.

4. Groundwater Governance Assessment Framework

Groundwater governance involves collective action to ensure socially-sustainable utilisation and effective protection of groundwater resources for the benefit of people and groundwater-dependent ecosystems (Foster *et al.*, 2009). Groundwater governance as defined in this project refers to forms of steering societies that go beyond government policy-making and include a wide variety of decision-making structures and processes at all levels of society. These involve a wide variety of non-government actors representing industries, scientists, environmental interests and other parties interested in groundwater (Foster and Garduno, 2013). The benchmarking of groundwater management and use between Australia, Denmark, California and South Africa is analysed using a framework based on the five issues defined in the Earth Systems Governance Project (Biermann *et al.*, 2009).

The Earth Systems governance framework enables a large number of governance issues to be grouped into five major classes: architecture, access and use, accountability adaptation and agency and some links between the five-issue classes are also established within the framework. Further details of this classification applied to groundwater are given in Table 4 and the remainder of this section.

4.1. Classification of earth system governance issues

Table 6: Classification of earth system governance issues

Architecture	Central principles, policies and institutions that guide sustainable groundwater use and protect groundwater quality, and interactions between them

Access and use	Institutions and procedures that determine who has access to groundwater, for what purposes and how groundwater is allocated
Accountability	Institutions and procedures that provide accountability for groundwater protection and use
Adaptation	How groundwater users, governments and third parties respond and adapt to changes and uncertainty in groundwater availability, use and governance
Agency	Private and public sector responsibilities for groundwater management

4.2. How South Africa compares with other countries

Table 7: Benchmarking South Africa with Australia, Denmark and California earth system governance issues

	Australia	Denmark	California	South Africa
Architecture	Native Water Initiative (NWI) Tradable property rights Water plans Drinking water standards	Water Supply Act of 1998, Drinking water protection	Sustainable Groundwater Management Act of 2014, Groundwater abstraction reporting, conservation, development and utilisation of state water resources	National Water Act, Drinking water standards, Water licensing
Allocation and access	Return over-allocated basins to sustainable use	Compulsory water supply planning	Reporting of diversion of diversion of surface water	Maintain good groundwater condition

			to underground storage	(quality and quantity)
Accountability	NWI consultation principle National Monitoring of NWI State monitoring of water plans	The Danish Environmental Protection Agency is responsible for drawing up and implementing environmental legislation, regulations and action plans at the national level. The overall objective of the Danish water utilities is the provision of a fully reliable, environmentally sound water supply at competitive prices.	State Water Boards, Groundwater sustainability agency, Department of Water Resources	Reports to CMAs and the National Department
Adaptation	Variables 'share' allocation Water markets	The first and second generation of Water Plans and Action Plans 2016	Groundwater sustainability plans	National Water Resource Strategy National Groundwater Strategy

Agency	Centralised governance	Focus on decentralised governance with each entity having its roles and responsibilities	Focus on decentralised governance with each water board or agency having its roles and responsibility	Focus on decentralised governance with CMAs and WUAs

In concluding the benchmarking of South Africa with international best practice, it is evident from the legislative framework supported by institutional arrangements that groundwater management and use have been given more focus and attention from the three case studies, which South Africa can learn from to strengthen its legal framework and institutions as the overall approach and structure has been realigned post 1994 to be in line with international models.

5. Groundwater Management and Use in the African Continent

Water is a precious natural resource, imperative for life, development and the environment. It can be a matter of life and death, depending on how it occurs and how it is managed. With this understanding of how vital water is, in 2009 the United Water Africa in collaboration with the Economic Commission for Africa (ECA), African Union (AU) and the African Development Bank (AfDB) published Africa water vision 2025 in which they acknowledge the natural and anthropogenic threats to water resources in Africa. This document was prepared in preparation for the second World Water Forum (WWF2), held in The Hague, the Netherlands in 2000, by African governments through consultative processes in 1999 and 2000 and presented at the WWF2. The Vision stresses the need to change attitudes towards water supply and usage, and proposes a framework for building on these achievements. As such, the Africa Water Vision for 2025 deals with water resources threats in the continent, and also prepare for future where the full potential of Africa's water resources can be readily unleashed to stimulate and sustain growth in the region's economic development and social well-being. The document identifies the need to ensure that water does not become a limiting factor in food and energy security as

well as for adequate water quality and quantity in sustaining the environment and life-supporting ecosystems whilst developing effective and reliable strategies for coping with climate variability and change, growing water scarcity, and the disappearance of water bodies as part of the challenges to be addressed in the Continent.

In 2015 the AU published a shared strategic framework for inclusive growth and sustainable development called "Agenda 2063: The Africa We Want". This strategic document seeks to:

a) Galvanise and unite in action all Africans and the Diaspora around the common vision of a peaceful, integrated and prosperous Africa.
b) Harness the continental endowments embodied in its people, history, cultures and natural resources, geo-political position to effect equitable and people-centred growth and development.
c) Build on and accelerate implementation of continental frameworks, and other similar initiatives.
d) Provide internal coherence and coordination to continental, regional and national frameworks and plans adopted by the AU, Regional Economic Communities (RECs) and Members states plans and strategies.
e) Offer policy space for individual, sectoral and collective actions to realise the continental vision.

The agenda 2063 has seven aspirations that the African Union seeks to achieve by 2063, namely they are: a) A prosperous Africa based on inclusive growth and sustainable development; b) An integrated continent, politically united based on the ideals of Pan Africanism and the vision of Africa's Renaissance; c) An Africa of good governance, democracy, respect for human rights, justice and the rule of law; d) A peaceful and secure Africa; e) An Africa with a strong cultural identity, common heritage, values and ethics; f) An Africa whose development is people-driven, relying on the potential of African people, especially its women and youth, and caring for children; and lastly, Africa as a strong, united, resilient and influential global player and partner (African Union, 2015).

With all these aspirations in mind, the African Union went on to have a list of goals under each aspiration. When it comes to water, the first aspiration (A prosperous Africa, based on inclusive

growth and sustainable development) has a goal on "Environmentally sustainable and climate resilient economies and communities" and one of the priority areas under this goal is water security. This will be achieved through improving the living standards in the continent, where nine out of ten people in the continent will have safe drinking water and sanitation by 2023. In terms of having a transformed, inclusive and sustainable economies the African Union envision that by 2023 at least 17% of terrestrial and inland water and 10% of coastal and marine areas would have been preserved and 30% of farmers, fisher folks and pastoralist will be practicing climate resilient production systems (African Union, 2015).

5.1. African Ministers Council on Water

The main aim of the African Ministers Council on Water (AMCOW) is a vision of an Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment. One of its missions is to provide political leadership, policy direction and advocacy in the provision, use and management of water resources for sustainable social and economic development and maintenance of African ecosystems. In the AMCOW strategy 2018-2030 has four strategic priorities and actions and they are:

a) Ensure water security
b) Ensure safely managed sanitation and hygiene
c) Promote good water governance and trans-boundary water cooperation
d) Strengthen AMCOW's governance and operational effectiveness

The AMCOW strategy 2018-2030 makes reference to groundwater management and use under strategic priority 3 (promote good water governance and trans-boundary water cooperation). This strategic priority acknowledges that good water governance, particularly as it relates to trans-boundary waters, is a critical first step toward harmonious and sustainable development, and towards water conflict avoidance, cooperation and water security. One of the key actions of the strategy is to support the creation of the enabling environment for regional cooperation on share water in all major rivers/lakes basins/groundwater aquifers. Moreover, the strategy also recognises the need to promote cooperative arrangements to implement Africa Water

Vision 2025 and targets under the United Nation's Sustainable Development Goals (SDG 6) in all river/lake basins/groundwater aquifers.

In extending the identification of groundwater as a priority intervention area through the 2018-2030 strategic plan, AMCOW further emphasized this assertion through the 2020-2024 Strategic Operational Plan and committed to support member states by rolling out the Africa's Path to Water Security (APAGrop) as a flagship groundwater intervention for the continent, primarily aimed at leveraging on science and reassert to influence groundwater policy and practice in Africa. Its goals are therefore as follows:

- To promote sustainable management and utilization of groundwater resources for water security and resilience;
- To promote appropriate technologies and practice in groundwater development and management; and
- To improve the policy and practice of groundwater in Africa for better lives and livelihoods.

Figure 3, below depicts agreements, declarations and decisions since 2000; these are critical in the management of all water resources in the African continent.

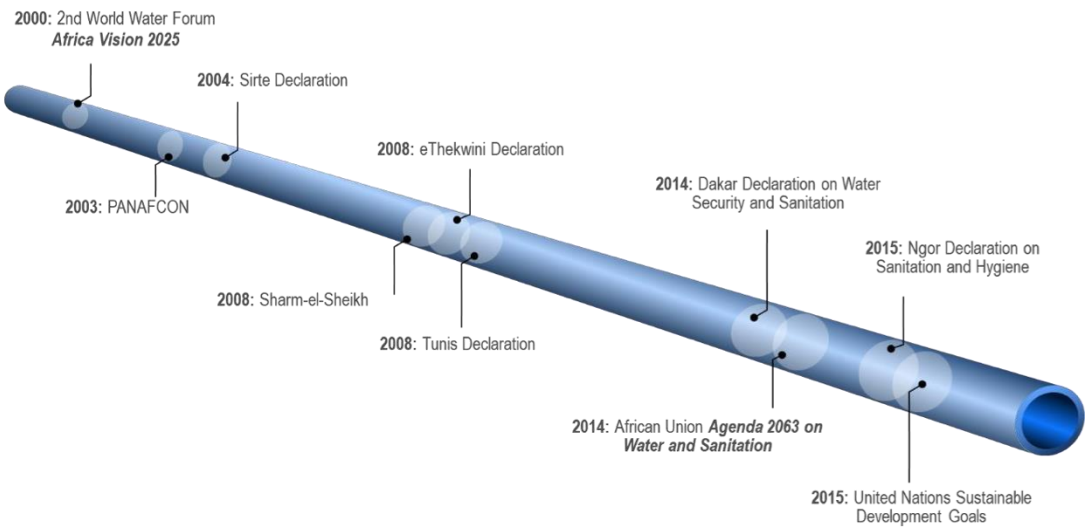

Figure 3: Key agreements, declarations and decisions since 2000

5.2. Southern African Development Community (SADC)

Groundwater management in the Southern African Development Community (SADC) is under the auspices of SADC-Groundwater Management Institute which has a mandate to:

1. Promote sustainable groundwater management and solutions to groundwater challenges in the SADC region through building capacity, providing training, advancing research, supporting infrastructure development, and enabling dialogue and exchange of groundwater information;
2. Conduct and support the SADC Member States in groundwater research, and serve as a focal interlocutor with national, regional and international groundwater initiatives (SADC, 2001).

In the SADC region water is at the centre of economic growth, sustainable development and poverty reduction, in one of the documented beneficial uses for groundwater in the region by Pieterson *et al.*, (2011) includes the following:

a) *Rural water supply*: Most of the rural communities in the SADC region rely on groundwater resources for their potable water. By 2012, it was estimated that about 60% of the Mozambican population which mostly are from rural areas rely on groundwater resources (Pavelic *et al*., 2012).
b) *Urban water supply*: By 2013 the City of Tshwane in South Africa was regarded as the city that obtains a significant portion of its water supply from boreholes and springs which blended with surface water within the bulk water distribution system (Dippenaar, 2013). On the other hand, Lusaka which is the capital of Zambia, gets almost 60% of its water requirements from groundwater resources (Nussbaumer *et al.*, 2016).
c) *Water security*: In terms of water security, groundwater contributes about 10% of Windhoek's water supply and artificial recharge strategies have been put in place to increase groundwater abstraction in this capital of Namibia (Christelies and Struckmeier, 2011; Tredoux *et al.*, 2009).
d) *Food security*: The SADC region has been regarded as one of the regions which are susceptible to food insecurity due to its climatic conditions and rising population. One of the interventions put in place by SADC is to introduce agricultural policies that seek to increase the income of the poorest groups. Angola has taken a step in ensuring that its

groundwater is used for irrigation in areas where rainfall is not sufficient for crops and where the rivers are unreliable (Pieterson *et al.*, 2010).

e) *Environmental services*: Groundwater also plays a pivotal role in servicing the ecosystem. Lake Sibiya in KwaZulu-Natal depends on its nearby aquifers. What is evident on the importance of groundwater on the environment is that the interaction of the surface and groundwater strongly influences the structure and function of the Okavango wetland ecosystem in northwest Botswana (McCarthy, 2006).

The SADC has put in place regional regulatory policy, strategies and plans that provide the enabling environment for the implementation of the SADC water sector programmes and plans (SADC, 2016). These regional regulatory policies, strategies and plans are listed in table 8 below:

Table 8: SADC regional regulatory policy, strategies and plans

SADC DOCUMENT	BRIEF SUMMARY
The SADC Declaration and Treaty	The SADC Treaty, which governs the Regional activities of SADC and its Member States, came into force on 30 September 1993.
The SADC Regional Indicative Strategic Development Plan (RISDP)	The RISDP outlines the key interventions necessary to deepen regional integration and reduce poverty on a sustainable basis over the period 2005 to 2020. The RISDP was formulated in March 2001 and was adopted and approved in August 2003. In order to ensure that the overarching objectives of poverty eradication and regional integration were more focused, the RISDP was revised in 2007 and again in April 2015 to review the period 2015 to 2020.
The SADC Revised Protocol on Shared Watercourses (2000)	The overall objective of the SADC Revised Protocol on Shared Watercourses, which came into effect in 2003, is to foster closer cooperation for judicious, sustainable and coordinated management, protection and utilisation of the 15 SADC shared watercourses, and advance the SADC agenda of regional integration, poverty alleviation and economic development.

The SADC Regional Water Policy (2005)	The SADC Regional Water Policy aims at providing a framework for sustainable, integrated and coordinated development, utilisation, protection and control of national and transboundary water resources in the SADC Region, for the promotion of socio- economic development and regional integration and the improvement in the quality of life of all people in the region.
The Southern African Vision for Water, Life and the Environment in the 21st Century (2000)	The SADC Vision for Water, Life and the Environment in the 21st Century is: Equitable and sustainable utilisation of water for social, environmental justice, and economic benefit for present and future generations.
The SADC Regional Water Strategy (2006)	The Regional Water Strategy (RWS) is based on the Regional Water Policy (RWP) and provides a framework for the implementation of the RWP. Whilst the RWP deals with the "What" on Regional water issues, the RWS deals with the "How", "Who" and "When" in the implementation of the RWP.
The SADC Regional Awareness and Communication Strategy for the Water Sector (2009)	The ultimate goal of the SADC regional awareness and communication strategy for the water sector is to improve awareness and understanding on water issues and initiatives in the SADC region, contributing to poverty eradication and regional integration.
The SADC Regional Strategic Action Plans: I, II & III	The main objective of the RSAP I (1999 to 2004) was to create an enabling environment for joint management of Regional water resources. The major change between RSAP I and RSAPII (2005-2010) was the emphasis put on infrastructure development. The goal of the RSAP III (2011-2015) was to strengthen the enabling environment for Regional water resources governance, management and development through the application of integrated water resources management at the regional, river basin, Member States and community levels.

The SADC Guidelines for Strengthening River Basin Organisations (2010)	Published in 2010, the SADC Guidelines for Strengthening River Basin Organisations covers four areas: establishment and development, environmental management, funding and financing and stakeholder participation.
Climate Change Adaptation in SADC: a Strategy for the Water Sector (2011)	The SADC climate change adaptation strategy for the water sector was launched in November 2011. The overall goal of the strategy is to improve climate resilience in SADC.
The SADC Regional Infrastructure Development Master Plan (RIDMP) (2012)	The primary objective of the SADC Regional Infrastructure Development Master Plan (RIDMP) is to define the minimum but ultimate regional infrastructure development requirements and conditions to facilitate the implementation and realization of the key infrastructure in the water, energy, transport, tourism, meteorology and telecommunication sectors that will move forward the SADC agenda and enable the SADC region to realize its goal by year 2027: the attainment of an integrated regional economy on the basis of balance, equity and mutual benefit for all Member States.

6. Groundwater Management and Use in South Africa

South Africa's groundwater resources have not received the same level of attention, either from management or users as surface water prior to 1994 as already stipulated above. As the country transitioned to the democratic era, the policy and legislation reforms at the time were sought to address this negligent of this resource thus the formulation of the National Water Policy in 1997 which had different principles that addressed groundwater management and use, then in 1997 and 1998, the promulgation of the Water Services Act and National Water Act provided a legal framework for the management and use of groundwater resources (Braune *et al.*, 2014; Closas & Molle, 2016; Riemann *et al.*, 2011). It is against this background that this literature went to investigate the existing legal and policy framework on groundwater management and use, which also includes strategies that seek to guide on how groundwater is managed and used in South Africa. With this in mind, the aim was to identify all the issues covered by our legal,

policy and strategic frameworks and their implication for groundwater management and use, this will also help with the identification of the loopholes that may arise but most importantly provide clarity on some of the loopholes that were previously identified.

6.1. Current Legal and policy framework on groundwater management and use

Policies and other legal framework play a critical role in ensuring effective governance of groundwater resources. Contemporary laws and policy framework take an integrative approach to surface and groundwater resources, where clear rights and obligations are defined, with management tools being put in place to ensure the protection of quality and quantity of groundwater resources and also to lobby stakeholders and institutions that will be in charge of the implementation of such legal and policy frameworks. The contemporary legal and policy framework regulate the conditions for access to groundwater, the protection of aquifers against depletion and pollution, the use of monitoring and planning tools, the way private and public interests have to be balanced and the involvement of stakeholders in decision-making and management processes (Albert *et al.*, 2011; Mechlem, 2016; Robert *et al.*, 2012).

6.1.1. White Paper on National Water Policy (1997)

The 1997 White Paper on National Water Policy provides a direction in the management of both quality and quantity water resources in the country. The policy with its 28 principles gave rise to the National Water Act of 1998 (NWA), these principles cover a wide range of resource management areas ranging from rights and access to groundwater (Principles 2-4, 14 and 25), the management of groundwater (Principles 5-7, 12, 13, 15-18, 20, 23 and 27). Beyond the principles, the policy also responds to several groundwater management and use issues as mentioned below in Table 9:

Table 9: Issues covered by the White Paper on National Water Policy 1997

Issues covered	Sections
Groundwater allocation	6.2.4
Groundwater protection	6.3.3
Climate change impact on groundwater resources and opportunities for adaptation	6.8.1

Conjunctive use and management of surface and groundwater	6.4
Better Utilisation	6.4.2
Groundwater monitoring	6.8.2
Water pricing	6.5.3
Transboundary water management	Principle 11
Institutions for water management	7.2
Stakeholder participation	6.3.3 and 7.2.4

6.1.2. National Water Act (1998)

Since the dawn of democracy, South Africa's groundwater is recognised as a common asset whose trusteeship is vested in the state. The NWA recognised groundwater as public water and abolished the riparian principle of landowner owning the groundwater below its property. Groundwater is now seen as part of the water cycle, and therefore as connected to other water resources. This Act with its vision of IWRM states that water is an indivisible national resource (rivers, streams, dams and groundwater) for which national government is the custodian. It contains rules about how the water resource is protected, used, developed, conserved, managed and controlled in an integrated manner.

It was for the first time that groundwater had to be managed according to the instruments for national water resource management, including several key instruments and concepts being introduced (Collin, 2014; Herbertson *et al.*, 2001; NPC, 2019; Pietersen and Beekman 2010). As groundwater is recognised as a cornerstone water resources management, three pillars take centre stage namely the social equity, economic efficiencies and environmental sustainability. The fundamental principles and objectives of South Africa's water law with implications for groundwater are that:

- All water resources are common to all (water considered as a public asset) and are subject to national control (trusteeship vested in the state)
- All water has a consistent status in law, irrespective of where (and wherein the water cycle; includes groundwater) it occurs

- Groundwater is an integral part of the water resource and must be managed as such (supporting the 7 below principles of IWRM: groundwater should not be seen in isolation) (Pietersen *et al*., 2011).

The NWA (1998) provides a legal framework to guide and give into effect the management and use of groundwater. Table 10 provide a detail split of issues covered by and section in the NWA.

Table 10: Groundwater issues covered by NWA

Issues covered	Sections
Controlling groundwater use	Schedule 1
Regulating the construction of wells and boreholes	Chapter 4, Section 29(e).
Controlling groundwater pollution	Section 29(1)(d).
Private sector participation in groundwater exploration and development	Section 116(1)(i).
Organisational arrangements and responsibilities for groundwater management protection	Chapter 6 (general powers and duties of the Minister and Director-General); 7 (establishment and organisational arrangements of Catchment Management Agencies); 8 (Water user associations); 9 (advisory committees); 10 (International water institutions) and Schedule 3 and 6.

6.1.3. Policy and Strategy for Groundwater Quality Management in South Africa

Since 1994, there was no policy dedicated strictly to groundwater as the 1997 White Paper on National Water Policy provided broad principles. This provided a rationale for the Department of Water Affairs and Forestry (DWAF) to initiate the development of policy and strategy for the management of groundwater quality in South Africa (2000). This policy provided a practical way of managing groundwater resources and it takes its cue from the principles from the 1997 policy and it integrates the management of the quality of surface and groundwater thus helping to ensure efficient management of both resources.

Through this policy the DWAF sought to achieve its mission through effecting three policy goals, namely:

a) To implement source-directed controls to prevent and minimise, at source, the impact of development on groundwater quality by imposing regulatory controls and by providing incentives (mainly Chapter 4 of the NWA);
b) To implement resource-directed measures to manage such impacts as do inevitably occur in such a manner to protect the reserve and ensure suitability for beneficial purposes as recognised by NWA, Chapter 3;
c) To remedy groundwater quality where practicable to protect the reserve and ensure at least fitness for the purpose served by the remediation as outlined in Chapter 3 of the NWA.

Moreover, this policy provides the framework within which detailed management procedures can be developed and implemented thus the following aspects are addressed in the policy:

Table 11: Groundwater issues covered by Policy and Strategy for Groundwater

Issues Addressed	Sections
Broad functional strategies	Section 4,5and 6 of the policy.
Institutional arrangements for groundwater quality management	Section 7 of the policy.
Requirements for enabling the implementation of the policy/strategy	Section 8 of the policy.

6.1.4. Groundwater Management Strategy (2002)

The Groundwater Strategy recognises the need for a paradigm shift so that groundwater is given recognition as a vital, strategic resource, which should form an integral part of water resource management. Twenty-nine strategies have been developed to ensure the optimal development and management of groundwater resources in South Africa. The purpose was present a suite of strategies with a wide scope including; management; protection and use;

institutional arrangements; human resources and capacity building, for inclusion in the National Water Resource Strategy v1(2004).

6.1.5. NWRS1 (2004)

The First Edition of the National Water Resource Strategy (NWRS) was the first blueprint strategy that came in response to what the NWA prescribed. This strategy describes how the water resources of South Africa will be protected, used, developed, conserved, managed and controlled per the requirements of the policy and law. The central objective of managing water resources is to ensure that water is used to support equitable and sustainable social and economic transformation and development. Water is, of course, central to all economic activity. The NWRS1 provides a platform for the essential collaboration and co-operation among all departments in all spheres of government involved in economic development. It is an important input to the evolving National Spatial Development Framework, helping to provide a better understanding of the contribution that water can make to development in all departments' areas of activity. A list of issues covered by the NWRS1 and their groundwater management and use implications are provided in Table 12 below:

Table 12: Groundwater issues covered by NWRS1

Issues covered	The implication for groundwater management and use
Groundwater use monitoring	The mainframe-based National Groundwater Database has been replaced with a server-based system as a bridging solution until the web-enabled National Groundwater Archive becomes operational. The Water Use Authorisation and Registration Management System (WARMS) is a comprehensive system designed to do the following - • Manage the process of registering water use by storing the information needed to uniquely identify a water user, and characterise the location, nature and extent of the use.

	• Manage the authorisation of water use by incorporating the workflow requirements for the licensing process from application, through evaluation, issue or refusal, to review. The information captured will include details of the evaluation of the application, any appeals against licensing decisions, licence conditions, licence and review periods, and any waivers granted on water use charges. • Invoice water users based on established tariff structures, issue receipts and statements, account for revenue received and track outstanding water use charges. The financial component of WARMS is a secure system based on accepted accounting principles and includes an audit trail for every data item. Data security and stability is ensured by continuous data replication and updating between the systems at the Department's national and regional offices. • Establish links with other national databases, such as the National Deeds Register, to facilitate validation of data and information. • Produce reports on all of the above dimensions.
Groundwater monitoring guidelines	Guidelines for the expansion of the national monitoring network from its present 150 points to the required 460 points will be available during 2004 and the planned expansion is expected to be completed by 2006. Implementation will be prioritised to accord with the programmes for compulsory licensing and provision of water services from groundwater sources.
Classification of groundwater resources	Water resources, which includes groundwater resources in South Africa, will, over time, be classified using similar criteria and approaches.

Groundwater Reserve	Because of the contribution of groundwater to surface water flow in certain circumstances, the volume of groundwater that can be abstracted without impacting the ability of groundwater to sustain or contribute to the surface water, Reserve has to be determined. This is done by determining recharge to a particular groundwater resource, assessing the groundwater contribution to the baseflow of a surface water resource and calculating the basic human needs to be met from groundwater resources. It is also necessary to control the amount of water abstracted to protect the structural integrity of the aquifer and to protect terrestrial ecosystems dependent on groundwater resources.
Resource quality objectives for groundwater resources	Resource quality objectives for groundwater resources are considered crucial for the effective protection of groundwater. Numeric or descriptive statements for a groundwater resource will be set to guide the use and management thereof. Typically, these may relate to – • groundwater levels or gradients (time and locality specific); • groundwater abstraction rates; • groundwater quality; • spring flow; and • targets for the health of terrestrial ecosystems that are dependent on groundwater. Resource quality objectives will be considered for licence for the use of a particular groundwater resource.

6.1.6. Framework for a National Groundwater Strategy (2007)

Before the development of the Groundwater Strategy in 2010, the Department of Water Affairs and Forestry in 2007 saw the need to come up with the framework for a national groundwater strategy. This framework was to guide and provide support for the formal process of

developing and implementing the Groundwater Strategy. This framework sought to cement groundwater as a resource that should be given its rightful status alongside surface water, thus helping to meet the growing water demand as a recognised strategic resource within an integrated water resource management approach.

The framework aimed at ensuring that the knowledge and use of groundwater are increased along with the capacity to ensure sustainable management. With this in mind, the framework lays a foundation on how pro-active groundwater management programmes will be developed and implemented at required water resource management levels, focusing on both quality and quantity aspects. On this framework, there are fourteen themes covered that form the basic tenet of a National Groundwater Strategy. These themes are Process to facilitate the participation of stakeholders; Visioning; Supporting implementation of IWRM-ensuring the visibility and status of groundwater; Changing mind-sets; Documenting success in the use of groundwater; understanding the groundwater-surface interaction; Bringing in investment and resources; Building up resource information-improving knowledge on availability and use; Resource protection-a focus on quantity, quality and resource management; Monitoring the resource and impacts of management; Information sharing; Strategies and guidelines to create enabling environment; Building capacity in hydrogeology; Strengthening leadership in the groundwater sector Groundwater Strategy 2010. It is these themes that have turned into activities that formed the processes of developing the National Groundwater Strategy.

6.1.7. Groundwater Strategy (2010)

After the development of the Framework for a National Groundwater Strategy, there was a 3-year robust consultative process with different stakeholders and experts within groundwater. The result of that was the Development of the Groundwater Strategy 2010 whose aim was to address the shortfalls of the National Water Resource Strategy 1, but also to inform to the National Water Resource Strategy 2 which was due in 2011 but later published in 2013. The Groundwater Strategy had several issues to cover, and they are listed in Table 13 below, with their implication for groundwater management and use.

Table 13: Groundwater issues covered by the Groundwater Strategy 2010

Issues covered	The implication for groundwater management and use
Policy, legislation and regulation	All groundwater water use license applications must be resolved within six months All larger groundwater users must be registered and possess water use licenses• Existing groundwater use must be verified within a reasonable period• Borehole drillers must be registered with DWA and must submit drilling data from all boreholes drilled.
Water resources planning	Groundwater resource assessments must be conducted to a level comparable with other water resource assessments (e.g. assessment of surface water potential): • Implement groundwater development programmes for domestic and productive water use to support national imperatives; • Figures on groundwater availability and use must be updated as new data becomes available; • Establish guidelines for the groundwater content of Internal Strategic Perspectives and emerging catchment management strategies; • Develop and implement best practise guidelines on groundwater management and protection for the municipal, agricultural, energy and forestry sectors .
Human capacity	DWA should develop an adequate capacity to fulfil its groundwater functions • DWA to develop and implement a national capacity building strategy; • DWA to mobilise private sector support where necessary to capacitate regional offices; • Implement practical, in-service training courses on priority aspects (e.g. licensing process, the Reserve, groundwater monitoring, etc.) for DWA officials.

Sustainable groundwater management	DWA must ensure the implementation of existing strategies, regulations and guidelines on groundwater management such as the Artificial Recharge strategy and others. DWA must establish a Groundwater Resource Management section, which will ensure support to water services institutions in the operation, maintenance and management of groundwater supply schemes. Functions must include the evaluation of artificial recharge and conjunctive use schemes.
Institutional capacity	DWA should capacitate and provide adequate resources to the DWA Regional Offices to fulfil their mandatory water resource management functions: • Improve cooperation and coordination within DWA, and between government departments and the private sector to leverage available capacity and resources; • Incorporate the All Town Studies Reconciliation Strategies into the IDPs and WSDPs; • Provide strategic support to water services institutions to develop business plans (i.e. WSDPs) for groundwater development, management and monitoring as well as for the operation and maintenance of groundwater infrastructure; • The roles and responsibilities for groundwater development and management, including monitoring of groundwater abstraction and quality, as well as the maintenance and operation of groundwater infrastructure across sectors, should be improved and streamlined, and responsibilities clearly defined.
Information management	DWA to announce the National Groundwater Archive (NGA) to the Public Domain, including Catchment Management Agencies (CMAs), Water Resources and other external stakeholders, as well as finalize the adoption of measures to incorporate privately held datasets, including the registration of drillers.

	Develop and implement an integrated groundwater information system to support water services provision at the municipal level
Groundwater research	DWA and the Water Research Commission (WRC) must continue to support groundwater research capacity at tertiary institutions, and prioritise research projects which directly address strategic national objectives, including issues identified as bottlenecks in groundwater management or delivery: • The dissemination and implementation of research products must be improved; • The WRC should regularly assess the impact of research investment in groundwater; • Emphasis should be placed on the strategic leveraging of resources between the WRC, DWA, NRF and the alignment of strategic objectives for groundwater management between the WRC and DWA e.g. the development and roll-out of strategies supported by implementation programmes;
Communication and awareness	Develop a professional marketing and communication plan focussing on successful groundwater use and management.

6.1.8. The NWRS 2 (2013)

The National Water Resource Strategy 2nd edition is one of the most comprehensive strategies every produced in the country and as such it responds to the priorities set by the Government in the National Development Plan and the National Water Act for sustainable development. The approach of the NWRS2 is around the actual management of water resources and the utilisation of groundwater, desalination, water reuse, rainwater harvesting and treated acid mine drainage. However, this is not a move away from the traditional engineering solutions of infrastructure development, that were ought to be abandoned in the early 1990s (Kelbe & Rawlins, 2016; Meissner, 2017).

It is this strategy that recognises groundwater as an important resource that is currently undervalued and under-used resource. Therefore, efforts were made to ensure that this undervalued resource becomes an important resource that will address the needs of developing

the country with water being at the centre of such development. Therefore, a list of issues that the NWRS2 covers and their implication for groundwater management are listed in Table 14 below:

Table 14: Groundwater issues covered by NWRS2

Issues covered	The implication for groundwater management and use
Efficiency	This implies that the value chain from the river, groundwater to wastewater should be considered in its entirety when making water resource management decisions.
Groundwater development and use (artificial recharge)	Artificial recharge of groundwater is encouraged to promote the use of groundwater on a larger scale.
Protect riparian and wetland buffers and critical groundwater recharge areas	Buffers and critical groundwater recharge areas are recognised as the critical ecological infrastructure supporting water security and are kept intact, maintained and restored to support water quantity and quality.
Compulsory licensing	Achieve a fair allocation of water from a water resource including surface and groundwater
Infrastructure development, operation and maintenance (increasing water supply)	DWA will consider all appropriate sources of water for increasing water supply, including groundwater and alternative water supply sources. The use of these will be tested against the climate change scenarios.
Water conservation and water demand management	This must be implemented by all water sector institutions and water users and should include the optimisation of dam and groundwater operation, as well as the reduction of physical water losses and the introduction of water-efficient appliances, processes and crops.
The use of groundwater	Accessible groundwater should always be utilised, even where surface water is available, to reduce the demand on surface supplies.

6.1.9. National Groundwater Strategy (2016)

With all the developments and the legal framework put in place to ensure sustainable use and management of groundwater resources, many issues were still left uncovered. Many organisations and experts in the groundwater management and use field were of the view that the legal provisions put in place focus too much on the management side of groundwater resources and neglect the utilisation of such resources. The other challenge that was identified was on institutional arrangements, with a need to re-establish a Geohydrology Directorate within the Department of Water and Sanitation (DWS) after it was abolished in 2003 being highlighted. This follows the integration of specialists in groundwater into various water management functions like Planning and Water Quality Management over the years. The National Groundwater Strategy 2016 took its cue from the National Water Resource Strategy 2 which its mandate is to respond to South Africa's vision for 2030, as articulated in the National Development Plan (NDP) and the National Government Outcomes outlined in the National Government's Programme of Action for 2010-2014.

These priorities are key drivers for change and as such, are the national strategic imperatives that shape NWRS2 and the NGS. The high-level direction that the NGS 2016 takes includes:

a) Addressing past imbalances (access to water services, access to water resources, access to benefits from water resource use) will be a continued focus;
b) Groundwater's role will be increasing; South Africa is experiencing water-stress and surface water resources are already limited in many catchments;
c) Climate change will be an increasingly important driver of water availability and water requirements;
d) Groundwater must, therefore, be seen, throughout the country, as a high-priority conjunctive-use source option or, in the more arid regions, as a sole water source;
e) Groundwater, compared to available surface water resources, still has significant potential for development (NGS, 2016)

Apart from this, the National Groundwater Strategy 2016 covers a lot of issues that may have been neglected before. Table 15 below outlines a list of issues covered and their implication to groundwater management:

Table 15: Groundwater issues covered by the NGS 2016

Themes covered	Implications for groundwater management and use
Stakeholder-driven development and implementation	To continuously improve stakeholder understanding and collective agreements and also work within an expanding framework of local level participative management and good groundwater governance.
National groundwater leadership	To develop and maintain national groundwater champion that must hold overall groundwater governance framework together and facilitate and support its roll-out, smooth functioning and growth.
Responsive groundwater regulatory framework	Anchor the shared understanding of groundwater governance inappropriate policy and regulations that will enhance sustainable and efficient use of groundwater resources.
Groundwater resource protection	Develop and maintain approaches for pro-active protection of groundwater resources and aquifer-dependent ecosystems to secure a sustainable supply of water for human survival and socio-economic development, while maintaining essential groundwater environmental services.
Sustainable groundwater resource utilisation	Translate practical understanding of groundwater resources into appropriate guidance material to fully capacitate those responsible at all levels for sustainable groundwater resource utilization, covering planning, development, management and protection.
Appropriate institutional development	Develop, facilitate, capacitate and support appropriate institutions that will allow effective local-level participative management of groundwater resources.
Redirecting finances	Redirect incentive policies and public expenditures impacting groundwater by and within different sectors to achieve a combined, much stronger focus on sustainable and efficient groundwater management.

Groundwater resource planning and development	Achieve integrated groundwater resource planning at national, regional and local levels that wilfully and sustainably establish the unique potential of groundwater for socio-economic development.
Information management	Grow and maintain the groundwater resource knowledge base, focusing on the resource itself, its socio-economic role and its appropriate management. Develop and maintain effective and efficient information and information systems, as a shared national objective and an integral part of water management strategies, in support of groundwater development and management at all levels.
Regional and international partnerships	Actively participate in and grow appropriate regional and international partnerships towards groundwater resource understanding and optimal utilization, including trans-boundary resource management.
Water sector skills and capacity	Develop and maintain skills and capacity for the sustainable development and management of groundwater resources at all management levels and with the participation of all stakeholders as part of a long-term, on-going process.
Local action	Manage and maintain actions on all strategy fronts in a concerted effort from the government at different levels, from municipalities and utilities, the private sector, civil society, educational institutes, media and professional associations to achieve the essential local level actions for sustainably managing shared groundwater resources.

6.1.10. National Water Resource Strategy 3 (Draft 2.4, 2020)

The National Water Resource Strategy 3rd edition builds on the National Water Resources Strategy editions 1 and 2, and the revision of the strategy, as prescribed in the NWA, has been undertaken with the purpose being to:

- Facilitate the proper management of the nation's water resources;

- Provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole;
- Provide a framework within which water will be managed at regional or catchment level, in defined water management areas;
- Provide information about all aspects of water resource management;
- Identify water-related development opportunities and constraints.

The purpose of the third edition of the National Water Resource Strategy (NWRS-3) is to ensure the protection and management of water resources to enable equitable and sustainable access to water and sanitation services in support of socio-economic growth and development for the well-being of current and future generations in South Africa.

The NWRS-3 is a strategy for all sectors and stakeholders who use and impact upon South Africa's water resources and it responds to the NWA by outlining strategic objectives and actions which are then carried forward for implementation in the National Water and Sanitation Master Plan (NW&SMP).

Table 16: Groundwater issues covered by NWRS3

Issues covered	Implications for groundwater management
Water resource planning, infrastructure development and management	Groundwater, water reuse, desalination, treated acid mine drainage, rainwater harvesting and water conservation and water demand management interventions must be, together with surface water resources, recognised and utilised as integral components of water resource Reconciliation Strategies.

To ensure reliable current and future water supply inclusive of the effect of climate change	• Achieve integrated water resource planning at national, regional and local levels that will fully and sustainably establish the unique potential of groundwater for socio-economic development. • Translate practical understanding of groundwater resources into appropriate guidance material to fully capacitate those responsible at all levels for sustainable groundwater resource utilization, covering planning, development, management and protection. • Develop, update and maintain reconciliation planning studies to achieve optimal water mix (surface water, groundwater, re-use and desalination, and incorporate climate change into studies) • Develop a guideline for the protection, recharge, use and monitoring of groundwater. • Increase groundwater use (including artificial recharge through the identification of groundwater stressed catchments for the removal of alien vegetation), re-use and saving of water (i.e. low flush toilets in reticulated settlements). • Identify groundwater's crucial role in drought preparedness and emergency response as part of drought risk management. • Redirect incentive policies and public expenditures impacting groundwater by and within different sectors to achieve a combined, much stronger focus on sustainable and efficient groundwater management.
To maintain a long-term capital investment plan for the	Redirect incentive policies and public expenditures impacting groundwater by and within different sectors to

development of water resources infrastructure	achieve a combined, much stronger focus on sustainable and efficient groundwater management.
To redress race and gender imbalances	Identify areas where small dams or groundwater development can provide water for small scale black farmers
Enable integrated planning of water supply and sanitation services	Promote an integrated approach between Regional Bulk Systems and the development of Groundwater as a valid source for conjunctive use.
Compliance monitoring and enforcement	Hydraulic fracturing is not yet a compliance monitoring and evaluation problem but is said to pose a threat to groundwater and to the environment which has sparked calls for strict regulation, and due to the highly technical nature of hydraulic fracturing such regulatory skills will need to be developed internally or sourced for government including DWS.
Facilitate financially sustainable and well governed water and sanitation institutions	Anchor a shared understanding of groundwater governance in appropriate policy and regulations that will enhance sustainable and efficient use of groundwater resources.

6.1.11. Other Sectoral Acts and Policies on Groundwater Management

The groundwater management is also covered by other legislation which has an impact in the water sector, therefore Table 17 below lists Acts and Policies with their implications to groundwater management.

Table 17: Groundwater issues covered by other sectoral legislation and policies in SA

Other sectoral Acts/Policies	The implication for groundwater management
The White Paper on Spatial Planning & Land Use Management: Wise Land Use 2001	Considers “best use” for a given area of land and prohibits activities on land that may be harmful to the broader environment thus contributing to groundwater protection.

National Strategy on Sustainable Development (NSSD) 2010	Promotes integrated planning and should consider water as part of the planning process. Prioritises sustaining ecosystems and using natural resources such as water efficiently. Responds to environmental challenges which include climate change and dealing with its consequences such as droughts and floods.
Mineral and Petroleum Resources Development Act 2002	Requires environmental management plans that require minimisation of polluting activities that impact on groundwater. The plans must be supported by detailed groundwater investigations.
National Environment Management: Air Quality Act of 2004	Regulates greenhouse gases and its potential impacts on the water environment.
National Environmental Management: Waste Act 2008	Requires reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development. Requires remediation of land that may harm the environment.
National Environmental Management Act (1998)	lays out a new obligation for the mining and other industries in terms of the monitoring and remediation of pollution of water resources.

7. Municipal By-laws in South Africa on groundwater management and use

The municipal by-laws by their nature are laws or legislation made by municipal council, unlike laws made by the national or provincial government; the by-laws seek to regulate the affairs and services in the jurisdiction of a certain municipality. As such, this section of the report, seeks to look at the current groundwater by-laws on major municipalities in the country. In 2019, the Water Research Commission published an Urban Groundwater Development and

Management in which they assert that groundwater use by urban users' needs to shift from the lack of active management and indirect use to active management leading to potential for bulk water supply from urban groundwater resources.

This study further alludes that there are eight metropolitan municipalities that are currently using groundwater resources or managing groundwater resources to varying degrees, these municipalities includes the City of Johannesburg, Ekurhuleni, City of Tshwane, eThekwini Municipality, City of Cape Town, Nelson Mandela Bay, Mangaung and Buffalo City (WRC, 2019). Some of these municipalities are planning to expand their groundwater resource development as part of their future reconciliation plans. Below the report will be a discussing some of the by-laws that some of the biggest municipalities in South Africa have on groundwater management.

7.1. City of Johannesburg

City of Johannesburg's Metropolitan Municipality (CoJ MM) get its water from Johannesburg Water which acts as a water service provider to the municipality. With 95% of all the City's households having piped water, most of the bulk water supply is bought from Rand Water and imported from the Vaal Water Supply System (VWSS), supported by a number of storage and inter-basin transfer schemes from the Upper Vaal Catchment and an international transfer from the Lesotho Highlands Project (CoJ, 2011; CoJ 217). The remaining 5% is water that is acquired from private boreholes and tankers (Pietersen *et al.*, 2011).

The municipality has by-laws put in place to measure the dolomite groundwater levels and control of dolomite abstractions:

a) The CoJ shall establish, maintain and actively monitor, a dolomite groundwater level monitoring network of adequate coverage in CoJ;
b) The CoJ can require a private developer to install a monitoring borehole on site, with a servitude established in favour of the CoJ MM;
c) The by-laws enable the CoJ to instruct parties causing drawdown of dolomites to cease abstraction "as is appropriate";

d) Written consent from the Dolomite Risk Management Section is required prior to any groundwater abstraction in dolomite, and boreholes abstracting from dolomite prior to the promulgation of the by-laws must register within 12 months of promulgation, and their licenses (presumably with DWS), may be revoked in the interest of safety concerns.

7.2. Ekurhuleni Metropolitan Municipality

The Ekurhuleni Metropolitan Municipality (EMM) gets its bulk water from Rand Water just like the city of Johannesburg. Rand Water is then also responsible for the planning and monitoring of the utilised water sources. Rand Water mainly sources water from the Vaal River Supply System (VWSS) (Piketh *et al.,* 2013; EMM, 2015b). With regards to the groundwater management and use, the municipality has by-laws that seek to put regulatory framework with this regard. The Ekurhuleni Metropolitan Municipality by-laws 2001 stipulates that:

a) The owner of a borehole, well or wellpoint existing prior to the promulgation of the by-laws, has 90 days to notify EMM of its existence and potential/actual yield;
b) All new boreholes must be approved by the Council with conditions that their locations are clearly marked, unsuccessful boreholes are sealed, and geological information, borehole depth, discharge capacity and standing water levels are recorded;
c) No existing boreholes may be replaced or deepened without Council's consent,
d) The Council has authority to enter the property to monitor private boreholes and impose a maximum abstraction limit;
e) Lastly, the by-laws also have provisions for prevention of water body pollution, however, it references only streams, reservoirs and aqueducts, and does not include protection of aquifers or boreholes.

7.3. City of Tshwane Metropolitan Municipality

It is important to note that, the City of Tshwane (CoT) acts as a water service authority (WSA) for the Tshwane Metropolitan Municipality. Majority of the water scheme of the municipality is acquired from Rand Water with a staggering of 71%. The water is sourced from the Vaal Dam, and Roodeplaat Dam (10%) operated by Magalies Water. The rest is supplied by Rietvlei Dam which is owned by the municipality and groundwater sources (the Fountains Springs, the

Rietvlei and Grootfontein Springs, and the Valhalla and Rietvlei boreholes; 13.1% overall) (DWAF, 2010c). Access to water is good in Tshwane compared to other MMs, with only 3.4% of the population not having access to piped water (TMM, 2014). In addition to supplying the WSS, groundwater is also used in rural areas at the central north part of the Tshwane, (TMM, 2014).

The Tshwane municipality has put various measures to ensure sustainable management and use of groundwater resources which are included in the by-laws published in 2003, and these measures includes:

a) By public notice, request notification of all existing or planned boreholes;
b) Require owners / occupiers of premises to conduct an Environmental Impact Assessment (EIA) before sinking a borehole;
c) Require owners / occupiers of premises with boreholes to obtain approval from the MM for use of borehole for potable supply;
d) Impose conditions for potable use of borehole water. Furthermore, provisions have been made against wasting of water, pollution of the WSS, and to require the owner / occupier of premises with boreholes to provide and maintain a meter measuring the total quantity of water abstracted and discharged as industrial effluent into the sewers.
e) The by-laws grant Tshwane Municipality sufficient control over borehole users to manage groundwater overexploitation and mitigate adverse effects on local ecosystems and other water users in terms of water quantity, however, what is currently lacking are provisions against contamination of the groundwater.

7.4. eThekwini metropolitan Municipality

The eThekwini Metropolitan Municipality water infrastructure is managed by Umgeni Water which acts as a water service provider to the municipality. The water that the municipality currently receive is entirely supplied from surface water; there are instances where private boreholes are drilled for the purpose of private use (Le Maitre *et al*., 2017; DWA, 2009). The eThekwini Municipality does have measures put in place for groundwater resources. The eThekwini 2017b by-laws state that:

a) By public notice, request notification of all existing or planned boreholes, as well as, if water abstracted from a borehole is discharged into the Council's sewerage system, to install a meter in the pipe leading from a borehole to its discharge point

It is important to note that, so far the municipality does not have any provisions to protect boreholes or groundwater from pollution, to meter the total groundwater abstraction, to sustain sufficient high/low groundwater levels to provide minimum water requirements for the ecosystems and prevent (basement) flooding (WRC, 2019).

7.5. City of Cape Town Metropolitan Municipality

The Western Cape Water Supply System is the main water supplier to the City of Cape Town. The system consist of six dams, in which five of them are in the Berg River Catchment (Berg River, Voëlvlei, Wemmershoek, Upper and Lower Steenbras Dams) and one of which is in the neighbouring Breede River Catchment (Theewaterskloof Dam) and transfers water into the Berg Catchment. In 2014/15, the City of Cape Town accounted for 61% of the water requirements on the Western Cape Water Supply System, agriculture 31%, and the remainder made up by smaller towns (Stellenbosch, West Coast District Municipality) (DWS, 2015).

In 2010 the City of Cape Town passed the water by-laws in order to control and regulate water services within its area of jurisdiction, as such there were number of measures put in place to ensure that boreholes are protected and they are as follows:

1. Wells, boreholes, wellpoints and excavations

i) Every owner of premises must ensure that any well, borehole, well-point or other excavation located on his or her premises—

- Is adequately safeguarded from creating a health nuisance;
- Is not filled in a way or with material that may cause an adjacent well, borehole or underground source of water to become polluted or contaminated; and
- No interconnection is made between a water installation supplied from the main and any other source of water supply.

b) Notice of the sinking or digging of boreholes, wells and wellpoints

i) No one may sink or dig, or cause or permit to be sunk or dug, a well, wellpoint or borehole, unless the Director is provided with at least 14 days' written notice of his or her intention to do so;

ii) If water obtained from a borehole or other source of supply on any premises is used for a purpose which gives rise to the discharge of such water or a portion thereof into the sewerage system of the City, the owner must install a meter to the specification of the City in the pipe leading from such borehole or other source of supply to the point or points where it is so used;

iii) The Director may, by written notice, require the owner of any premises within any area of the City upon which a borehole exists or, if the owner is not in occupation of such premises, the occupier to notify him or her of the existence of a borehole on such premises, and provide it with such information about the borehole as he or she may require;

iv) The Director may require that a study be undertaken at the cost of the owner in order to assess any impact the proposed well, well-point or borehole may have on the wellbeing of the community.

7.6. Nelson Mandela Bay Metropolitan Municipality

The Nelson Mandela Bay Metropolitan Municipality (NMBMM) and surrounding small towns, irrigation users are supplied by the Algoa Water Supply System (AWSS), which includes dams in several basins, and a transfer from the Orange River. Since 2009 till date the municipality has been struggling to meet its constitutional obligation of supplying reliable water services to its community because of the drought in the region, as such number of interventions have been put in place to curb the effects of the droughts and those interventions includes surface water schemes, groundwater use, use of treated effluent, and desalination and these interventions were fast-tracked (DWA, 2011). It is important to note that the Nelson Mandela Bay Metropolitan Municipality despite the interventions put in place, it has not won the battle against drought, the region continues to feel the pinch of this drought with communities depending on the municipality for potable water supply remain in limbo about where to get water for their potable use.

Groundwater resources in the Nelson Mandela Bay are managed under the Water and Sanitation Services By-law of 2010. The measures put in place would enable the municipality to manage private (potentially competing) use of groundwater resources, as the municipality has the ability to impose conditions on use (in addition to the conditions that would be in a Water Use Licence from DWS, according to the NWA). However, there are no measures to protect groundwater resource quality, where that groundwater is not part of municipal water services infrastructure. The NMBM by-laws refer to preventing pollution of a water supply system (WRC, 2019).

7.7. Mangaung Metropolitan Municipality

The Mangaung Metropolitan Municipality get its water from Bloem Water which on its own is getting water from the Greater Bloemfontein Water Supply System (GBWSS), which includes the following sources: 1) the Welbedacht Dam and Knellpoort off-channel storage dam on the Caledon River, and 2) the Maselspoort Scheme on the Modder River, which includes the Rustfontein and Mockes Dams, which receive water transferred from the Caledon River via the Novo Transfer Pump Station at Knellpoort Dam. In Mangaung Municipality the management of groundwater is under the By-laws relating to Water Services of 2013. Within these by-laws the issue of groundwater pollution is not catered for, the only the dangerous wells, boreholes and excavations; and the notice of the sinking or digging of boreholes or wells are discussed in the by-laws.

7.8. Buffalo City Metropolitan Municipality

The Buffalo City municipality is supplied by Amatole Bulk Water Supply Scheme. Other coastal cities within the region which are not serviced by Amatole Bulk Water Supply Scheme depend largely on groundwater supply with over 6800 households using groundwater as their water source, (FutureWorks, 2014). The Water Research Commission argues that groundwater potential in Buffalo City is not good, resulting in low borehole yields (generally below 2l/s and high salinity waters). The Buffalo City Municipality in 2011 promulgated Water Services By-law as a means to ensure that there is a sustainable use of water resources. The 2011 water services by-law prevents individuals engaged in commercial, trade or industrial activities from polluting groundwater resources with regards specifically to boreholes the municipality has the following:

a) The protection of borehole sources
b) The municipality may by public notice require the owner to notify it on the existence of any boreholes and also the owner or occupier of any premises who intends to sink a borehole or utilise a spring for water supply for domestic purposes on their premises to notify the municipality on the prescribed form of such intention before work can be started
c) The quantity of water abstracted from boreholes must be measured.

7.9. Chris Hani District Municipality

The Chris Hani District Municipality is a Water Services Authority (WSA) in all local municipalities within the district, in terms of powers and functions developed by Municipal Structures Act, 117 of 1998. CHDM is a legislated Water Services Authority and Water Services Provider (WSP) for its entire area of jurisdiction; after completed an assessment of alternative mechanism, as required by Section 78 of the Municipal Systems Act. However, Water services infrastructure in Chris Hani District is now being operated by the individual local municipalities in their capacity as Water Services Providers. It is made up of the following eight local municipalities: Inxuba Yethemba, Enoch Mgijima, Intsika Yethu, Emalahleni, Engcobo and Sakhisizwe. The local municipalities comprise of the following:

a) Enoch Mgijima local municipality comprises of Queenstown, Whittlesea, Tarkastad, Hofmeyr, Molteno, Sterkstroom and numerous peri-urban and rural settlements. This is the home of the district's administrative centre.
b) Sakhisizwe local municipality comprises of Cala and Elliot, and numerous peri-urban and rural settlements.
c) Emalahleni local municipality comprising of Lady Frere, Dordrecht and Indwe, and numerous periurban and rural settlements.
d) Intsika Yethu local municipality comprises of Cofimvaba and Tsomo, and numerous peri-urban and rural settlements.
e) Inxuba Yethemba local municipality comprises of Cradock and Middleburg, and numerous peri-urban and rural settlements.
f) Engcobo local municipality comprises of Ngcobo and numerous peri-urban and rural settlements.

g) Chris Hani District Municipality covers an area of 36 561 square kilometres. Enoch Mgijima is the largest single municipality in the district, followed by Inxuba Yethemba. Sakhisizwe and Engcobo are the smallest

For the purpose of the report, below we provide a snapshot of local municipalities and their towns within the Chris Hani District Municipality that use groundwater resources for their own water supply.

Local Municipality	Towns that use boreholes	
Inxuba Yethemba	Middelburg	Middelburg abstracts groundwater through 14 boreholes in the 5 "borehole fields" of Matjieskloof, Die Vleie, Uitsig, Midros and Zonnenbloem. Most of the boreholes are equipped with electrically-driven submersible pumps. The water is pumped directly to three clear water reservoirs (total capacity of 13.5 Mℓ) before reticulation through the distribution systems of Middelburg, Midros, Kwanonzame / Lusaka and the Transnet-settlement at Rosmead, 10km east of Middelburg.
Enoch Mgijima	Hofmeyr	Water for Hofmeyr, Twinsville and Luxolweni is obtained from 5 boreholes equipped with electrically driven 'mono' pumps. Daily demand from these boreholes is approximately 360kℓ.
	Tarkastad	Water for Tarkastad, Ivanhue and Zola is obtained from seven boreholes equipped with electrically driven 'mono' pumps. The total potential supply from these boreholes is 10.58ℓ/s although current town demand is estimated at 14 ℓ/s. Four additional boreholes have been drilled and a proposal is being considered by the DM to equip two of these
	Sterkstroom	Water for Sterkstroom primarily comes from 2 springs on the Carnarvon Estates, 17km east of the town. Water is gravitated through 23km of gravity main, via break pressure tanks at Penhoek and Hex River, to the 1,100 kℓ Sterkstroom bulk reservoir.

In 2020 the Chris Hani District Municipality developed their Water and Sanitation Bylaw, which in the context of groundwater management they only look at the notification of boreholes and measures include:

a) No person may sink a borehole on premises situated in a dolomite area, and a person must, before he or she sinks a borehole, determines if the premises on which the borehole is to be sunk is situated within a dolomite area.
b) The Municipality may require the owner or occupier of any premises who intends to sink a borehole to undertake an environmental impact assessment for such intended borehole before sinking the borehole.
c) Boreholes are subject to the requirements of the National Water Act, 1998 (Act No. 36 of 1998).
d) The Municipality may by public notice require owners or occupiers who have existing boreholes used for water services, to obtain approval from it for the use of a borehole for potable water supply services in accordance with sections 6, 7 and 22 of the Act.
e) The Municipality may, in the notices -
    i. Impose conditions in respect of the use of a borehole for potable water services.
    ii. Impose a fixed charge in respect of the use of a borehole.
    iii. Impose a bulk meter installation for each borehole.

It is important to note that the Chris Hani District Municipality is currently busy developing their water security plan to guide sustainable ground and surface water management towards meeting the growth and development needs and promote efficient water utilisation. The plan seeks to take the district into the future with attention to the needs, the protection and sustainable development of the water resources. Their approach to this water security plan has been structured in two phases:

a) Developing a ground and surface water monitoring system

    Development of the plan began with groundwater monitoring training for pump operators throughout the district and issuing of borehole questionnaires. The broad objective of the plan includes the following:

    i. To install meters on all rural water abstractions
    ii. To install borehole monitoring equipment i.e. Piezometer Tube, Dip Meter, Flow meter, Water Meter and Diver

iii. Education and Awareness campaigns on borehole management in conjunction with water conservation and demand management
iv. To reduce bursts and water leaks
v. To ensure clean audit of the water business on a yearly basis
vi. To reduce unrestricted average domestic water consumption (wastage)

b) Developing of Alternative Water Resources

An alternative water resources such as direct, indirect water reuse and aquifer recharge could be evaluated holistically in order to develop optimum solutions to augment and manage water supply from a combination of water sources that can be developed and managed to provide a sustainable secure water supply to communities, industry, agriculture and the environment.

7.10. Vhembe District Municipality

Vhembe District is a Water Service Authority and Provider, it consists of four local municipalities, namely: Thulamela, Makhado, Musina, and Mutale. The district purchase bulk raw water from the department of Water Affairs, then process or clean the water for reticulation. The goal of Vhembe District Municipality WSA is to supply every household with an adequate and reliable water supply and to manage the water supply services in an affordable, equitable and sustainable manner. There are 39 water supply schemes in the Vhembe District Municipality and out of those 39 water supply schemes, 35 of them use groundwater in one way or another. The Vhembe District Municipality by-laws 2014 on groundwater stipulates that:

a) The owner of any premises within the area of jurisdiction of the Water Service Authority upon which a borehole exists or, if the owner is not in occupation of such premises, the occupier thereof, to notify it on the prescribed form of the existence of a borehole on such premises, and provide it with such information in respect thereof as it may require; and
b) The owner or occupier of any premises who intends to sink a borehole on such premises to notify it on the prescribed form of such intention prior to the commencement thereof.
c) Obtain approval from it for the use of a borehole for water services in accordance with sections 6,7 and 22 of the Act;

d) Impose conditions in respect of the use of a borehole for water services; and
e) Impose a fixed charge in respect of use of such a borehole.

8. Observations

The bylaws assessed reflect a one-sided focus on the supply aspect of groundwater, through boreholes and seem to neglect groundwater resources development processes and procedures in relation VIP management for sanitation. On borehole management, there is no mention of prohibition of drilling in certain areas as well, which is crucial in resource protection. When looking at the groundwater monitoring and assessment perspective, the bylaws appear to be weak on the monitoring of use of groundwater, particularly through professional assessments, and the related reporting.

9. Implementation experiences

9.1. Understanding of groundwater management purpose

The responses to the question of an understanding of the purpose of groundwater management indicated that it is monitoring of groundwater to ensure safeguarding or protection of resource through implementation of suitable management practices to achieve a balanced exploitation in terms of quantity and quality. This 'balanced exploitation' has to ensure equity, efficiency and sustainability in order to maintain both quality and quantity. Moreover, to reach and maintain a long-term balance between groundwater utilisation (for e.g. domestic purposes, socio-economic development, etc.) and protection (for environment, and groundwater supported ecosystems) in an integrated manner in order to ensure sustainability of the resource.

There is agreement general consensus that there is no management of groundwater resources without proper assessment in terms of utilisation (before development activities), coordinate monitoring of the usage (quantity in terms of abstraction, quantity in terms of levels and quality in terms of chemistry). While other DWS officials understand the purpose of groundwater management in two dichotomies, one in terms of management and the other in terms of governance. For the management side, it is understood as what the actors do within the governance framework; activities related to the development and protection of groundwater to

implement the policies and plans which have been established. The hydrogeological conditions and distribution of human activities will determine where these management activities are required.

In terms of governance side, it is understood as entailing an enabling framework that establishes who formulates policies and strategies and is responsible for their execution (the actors) and how different stakeholders interact (the legal and institutional framework). Decisions made by the actors regarding what to do in pursuit of societal goals are driven by information, knowledge and science, and result in policies and plans which define why activities are needed and when they should be undertaken or completed.

This understanding of the purpose of groundwater management and use by DWS officials clearly highlights their constant engagement with contemporary academic outputs on the subject matter. In addition to their understanding of the purpose of groundwater management and use, the DWS officials went on to highlights also the importance of groundwater as an important freshwater resource for both socio-economic and environmental systems and forms a critical buffer during periods of drought. It also provides base-flow to rivers or streams, support aquatic ecosystems as well as riparian and terrestrial vegetation, maintain a geotechnical balance and prevent earth subsidence. From this information, one gets a clear indication that the importance of groundwater within DWS takes into cognisance both social and environmental factors. Thus, this makes the protection of groundwater supplies through management, pollution control and remediation critical. This clearly indicates that the understanding of the purpose of groundwater management by DWS officials is informed by their daily experiences and the application of legislation, policies and other supporting instruments on their day-to-day activities.

9.2. Legislative or policy framework provision including supporting instruments (strategies, protocols, regulations, guidelines, etc) used by DWS officials to ensure effective groundwater management and use

Department of Water and Sanitation's Legislation, Policies and other instruments used for groundwater management and use referred to by DWS in the interview
• S24 and S27 of the Constitution of RSA, 1996 • National Water Policy, 1997 – declares that all water irrespective of where it occurs in the hydrological cycle is public water, and that the national government will act as a public trustee. Though groundwater is not always explicitly mentioned in the policy, it assumes the same status as surface water. Recharge zone protection, conjunctive use of surface water and groundwater, trans-boundary groundwater management and local groundwater management institutional arrangements are also not explicitly mentioned. • Water Services Act, 1997 - roles and responsibilities in terms of water resource management and specifically groundwater are not explicitly stated but can be generally inferred. • Chapter 3 of the National Water Act of 1998: Protection of Water Resources • Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme, 1997 • National Water Act, 1998 – Chapters 2, 3, 4, 10, 11, 12, 13, 14 and Schedule 1. *However, Lazarus (1998) provided legal scenarios to inform the drafting team of provisions to be included in the legislation and was done in the* ***absence*** *of a fully developed, coherent* ***groundwater policy****.* • National Environmental Management Act, 1998 – provide for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment. • Minimum requirements for water monitoring at waste management facilities, dated 1998; • Government Notice GN.704 Regulations on use of Water for Mining and related activities aimed at the protection of Water Resources (GN. 704) dated 4 June 1999;

- Policy and Strategy for Groundwater Quality Protection and Management in South Africa, 2000 - includes functional approaches on resource directed measures and source-directed controls specifically focusing on groundwater.
- Water Quality Management Policy with regard to the Management of and Control over cemeteries as a source of water pollution, sanctioned and signed by Minister Ronnie Kasrils on 25 July 2001;
- Mineral and Petroleum Resources Development Act, 2002 – requires environmental management plans that requires minimisation of polluting activities that impacts on groundwater and these plans must be supported by detailed groundwater investigations.
- Strategic Framework for Water Services, 2003 – allow for an integrated planning approach between the development of water services and water resources, with catchment management strategies taking into account other local plans.
- A Protocol to Manage the Potential of Groundwater Contamination from On Site Sanitation, 2003
- Guidelines for Groundwater Resources Management in Water Management Areas, South Africa: Integrated Water Resource Management Strategies, Guidelines and Pilot Implementation in Three Water Management Areas, South Africa, 2004
- A Framework for Groundwater Management of Community Water Supply, 2004 (NORAD Toolkit)
- Artificial Recharge Strategy, 2007 – management actions are defined for each thematic area with responsibility and priority of action.
- A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa, 2008
- Operational Guideline to assist in the Compilation of an Integrated Water and Waste Management Plan, 2008
- National Environmental Management: Waste Act, 2008 – requires reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development; including remediation of land that may have a negative impact on the environment.
- Regulations 810 (Government Gazette 33541) in September 2010:
- Regulations for the establishment of a water resource classification system

- Geoscience Amendment Act, 2010 – mandate the Council for Geoscience to compile and develop a comprehensive and integrated collection of knowledge and information of geology, geochemistry, geophysics, engineering geology, economic geology, geochronology, palaeontology, **geohydrological aquifer systems**, geotechnical investigations, marine geology [and], geomagnetism, seismology, geohazards, environmental geology and other related disciplines.
- Groundwater Resource Directed Measures (2011 edition). This is a methodology based on the Regulations 810
- Spatial Planning and Land Use Management Act, 2013 - no provision for groundwater source protection zones (SPZs) in urban areas. Seyler et. al. (2019) proposes a new policy required to standardise the implementation of source protection zones (SPZs) to include definition of an SPZ, procedure for determining which sources have SPZs identified, acceptable identification methods and the procedure for update of the SPZ
- National Water Resources Strategy, 2013 – set out a national framework for managing water resources and subdivide the country into Water Management Areas (WMAs).
  - Chapter 4 focus water resources planning, infrastructure development and management, thus groundwater specific proposals are highlighted including implementation of the National Groundwater Strategy.
  - Chapter 5 focus on Water Resource Protection
- Guidelines on Protecting Groundwater from Contamination Published by DWAF Directorate: Information Programmes, dated March 2014
- National Sanitation Policy, 2016 – highlights the employment of appropriate sanitation technologies that minimise natural resource use and negative impacts.
- National Groundwater Strategy, 2016– provides a groundwater governance framework, broken down into a number of strategy themes and strategic actions in which every stakeholder can now recognise the overall needs as well as their own objectives and their areas of influence for action. It highlights that there are serious warning that indicate that groundwater use is presently on an unsustainable path, with water services to communities under threat. It also highlights that proper valuing of this previously neglected resource as foundation for an appropriate investment into its protection, conservation and sustainable use. Aspects for consideration include:

  - Enabling agricultural development for food security as well as job security through groundwater's untapped role in smallholder irrigation;
  - Systematic planning and implementation for groundwater to play its critical role in drought emergencies; and
  - Fully visualizing and developing the role of women in local groundwater resource development and management.
  - Shale gas development and groundwater resource protection.
- Integrated Water Quality Management Strategy, 2017 - sets out strategic actions which are required to be undertaken in order to realise the vision and goals for water quality in South Africa. It also highlights the importance of integrated, coordinated planning to ensure effective use of resources in managing water quality.
- South African Water Quality Guidelines;
- Best Practice Guidelines;
- Groundwater Sampling Protocol and Manuals
- SABS Standards on groundwater development activities (including assessment, drilling, and development)
- GRA II assessment methodologies
- Procedure to develop and implement Resource Quality Objectives.
- *Regulations*
  - *WULA process*
  - *Gas*
- Municipal by-laws

9.3. Hindrances and challenges that DWS officials encounter/ed when implementing the current groundwater management and use policies, legislation and supporting instrument

In terms of hindrances that DWS officials are encountering when implementing current groundwater management and use policies, legislation and other supporting instruments has been the following issues:

Policy and legal framework: there is an issue of out-dated regulations (e.g. Government Notice GN.704 Regulations) which some of them are still in the process of being revised. This even goes beyond to the policy level where, Water Quality Management Policy with regards to section that talks to the management and control over cemeteries is according to DWS officials is out-dated. This then creates a problem with taking an informed decision for Water Use License Application lodged to the Department. Moreover, the Regulation 810 in Government Gazette No.33541 dated 17 September 2010 and the procedure to develop and implement Resource Quality Objectives both deal more with surface water and with limited focus on groundwater.

In relation to what is happening contemporary, the Department is facing a huge challenge of how it will respond to the application for a proposed cemetery site for the Covid-19 surge or any other pandemic or natural disaster that has the same or even higher mortality rate. A regulatory response to ensure that water resources are protected from a water quality perspective when facing such conundrum remains problematic.

There is a mismatch between the municipal by-laws and the national regulations. Within municipalities, decisions on boreholes and usage can be made; however, what is missing is the role of the actual regulator, i.e. DWS, in this process. This is a large regulatory gap that needs to be addressed. The Department as a sector leader need to provide leadership in having a synergised regulatory framework from national to provincial and local level of governance. What the report also shows is that the City of Tshwane Metropolitan in its by-laws requires environmental impact assessment prior to drilling of boreholes. DWS should consider something similar, which could be translated to other municipalities in the country. Instead, the DWS regulatory environment appears to only commence once a water resource has been found and borehole registration / licensing for abstractions are submitted – by then, it is already too late: by then, investments are already made for an anticipated yield from the aquifer, but but what happens if the volume to be abstracted leads to non-compliance with the Groundwater Reserve in a catchment where abstraction is applied for?

Groundwater assessment and monitoring: As much as the importance of groundwater was elevated when the NWA was enacted, and more recently the adoption of the National

Groundwater Strategy 2016, DWS officials however, are of the view that there is still undervaluing of the importance of groundwater resources. This is evident in their line of work when they are faced by the shortage of relevant data and information, with skewed spatial distribution of groundwater monitoring stations (geo-sites) and especially at the local municipalities.

DWS officials further asserted that there is an inefficient technical tool in terms of the assessment of the resource from groundwater perspective for the purpose of protection and that the enforcement of regulations, compliance to conditions in the Water User Licence (WUL), and funding of developments, operations and maintenance of groundwater structures remains elusive.

There are some activities within the DWS that are going on under the auspices of groundwater management (protection) through authorisation process, even though there are no regulations to address abstraction activities outside authorisations. The existing regulations focus on the use of water, they are silent on the issue of controlling the access to groundwater through drilling regulations. This then defeats the endeavour towards sustainable groundwater management in South Africa. The same can be said about the lack of provision of hydrogeological data to inform DWS database and decision making to achieve sustainable development and utilisation of groundwater resources.

Institutional arrangements: The other key aspects in groundwater management lie on the Groundwater Governance Structures and clear roles and responsibilities within each institution, currently there is an indistinct roles and responsibilities on various task performed between DWS National and DWS Regional office. There is a minimal or no coordination between groundwater sections within the department of Water and Sanitation. Even with the adoption of the National Groundwater Strategy 2016, there is a lack of regulations that seek to convert some of the best principles and standards into enforceable tools such as regulating drilling and abstraction of groundwater.

9.4. Policies and legislative positions that DWS officials would like to be changed to make their work more efficient (was the recommendation submitted in the current legislative review)

According to DWS officials, the current reliable yield of surface water at an acceptable assurance of supply is approximately 10 200 million m³/a nationally. The combined storage capacity of large dams is in the order of 31 000 million m³. The total nationally accessible groundwater potential is about 4 500 million m³/a of which between 2 000 and 3 000 million m³/a is currently being utilised. The vitally important social, economic and environmental roles of groundwater towards the achievement of the country's development goals are still largely unrecognised and undervalued. Even where groundwater has made 60-70% up of the sources towards the politically important domestic water supply thrust, this is still seldom captured in-country statistics which persist in reporting in bulk water supply terms (e.g. groundwater making up 29% of country water supply). This results in neglecting the potential use of groundwater as a valuable alternative to surface water and also the protection of existing groundwater sources. *Despite the increasing scarcity of surface water as bulk water supply, there is no policy to give preference to the use of local water sources*.

The choice of the water supply system remains biased towards surface water, irrespective of the characteristics of a given area and nature of groundwater occurrence. Despite the international recognition that as a country, we have very good and progressive water resources policies and strategies and a groundwater programme, more attention should be given to groundwater development and protection. This includes updating.

Government Notice GN.704 Regulations and the Water Quality Management policy under the management and control over cemeteries need to take into account the lessons learnt during the Covid-19 period where the chances of having a spike in the application of the new cemetery sites in response to disasters of this nature. A regular review and update (where necessary) of existing Reserves, Resource Quality Objectives (RQOs) is needed to make DWS officials work more efficient because they believe that methodologies and technical tools get enhanced when more research is undertaken and information is being continuously generated, thus they believe that this will result in more effective groundwater protection measures.

The application of user pay principle should be given into effect especially in the groundwater space, so to ensure cost recovery for services rendered, and such capital that is generated can be channelled towards operating and maintaining infrastructure. For some officials, they feel that the appointment of professional hydrogeologists at our local municipalities that depend largely on groundwater should be a priority because they will ensure compliance with policies, legislations and other supporting instruments. The regulation on the professionalism of Geohydrological Profession is paramount.

There is a need for a policy that will pronounce the need for the regulations of activities that are critical in groundwater management and use. Such activities include but not limited to:

a) Control drilling activities in South Africa. The Directorate: Surface and Groundwater Information got a Legal Opinion from the Chief Directorate: Legal Services on the sections of the National Water Act that support the need to develop regulations that control the drilling of boreholes. In addition, an engagement with the Hydrogeology industry experts has occurred during the Groundwater Division Conference: Borehole regulation topic was one of the keynote addresses and the industry is in support to the idea to develop the drilling regulations.

b) Regulation of information related to groundwater / hydrogeological development. The is a need for the Department of Water and Sanitation to get all data captured by the stakeholders/ DWS on the DWS systems (both Historical, Current and new data). This is supported by the legal Opinion which stipulated that “section 143(a) and (b) of the Act also find relevance as a basis for the development of regulations to regulate groundwater data to be provided to DWS National Systems (NGS) in South Africa.

c) The need to develop standards on the minimum requirements for the tender related to (a) groundwater assessment, (b) borehole drilling (c) civil work related to groundwater scheme: many challenges faced in South Africa today are a result of the lack of these tools where municipalities use (eg drilling tender) for all the three above and end up with activities billed that are not part of the Request For Quotation (RFQ): leading to unauthorised expenditure (example is the well-known Giyani Groundwater Project).

9.5. Lessons suggested by the DWS officials on current international trends including trans-boundary on groundwater management and use

The DWS officials agree that as much as we as a country have come a long way in terms of reforming the management and use of groundwater resources, a lot can still be learnt from other countries, including the incorporation of data-science when it comes to the management and modelling of future models in relation to groundwater use, pollution and sustainability. The international groundwater management practices that could be of value to South Africa include but not limited to:

a) Dire Dawa, Ethiopia

i. Proper management of liquid and solid waste systems within the City,
ii. Establishing of protection (buffer) zones around the well-fields,
iii. Locating industries producing harmful products and by-products far from well-field protection zones,
iv. Prohibition of chemical fertilizers within the protection zones,
v. Drilling new boreholes and decommissioning contaminated ones,
vi. Blending of water from two (2) boreholes to reduce the Nitrates (only if groundwater has naturally high concentration of Nitrates) to an acceptable level,
vii. Use of Nitrate water for other household purposes except for drinking and cooking,
viii. Groundwater monitoring for seasonal abstractions, water level, streamflow, and water table mapping. This would also strengthen the Water Resource Management Plan, and
ix. Issuance of permits and certificates for the development of boreholes. Additional service fees for permits pertaining to waterworks construction, water use, and discharging waste.

b) Namibia

i. Augmentation by means of a water bank through managed aquifer recharge of the Windhoek Fractured aquifer;
ii. Managed recharge of the Windhoek aquifer (using surplus water from the Central Area dams to increase underground reserves),

iii. Karst aquifers used only for emergency supply, and

iv. A pipeline link from the Okavango River to supply the Central Areas when required.

c) Mozambique:

i. Groundwater fits in under broader policies and legislations dealing with the management of water, as a natural resource.

d) Kingdom of Eswatini:

i. Part VI of the Water Act is dedicated to groundwater and deals with the development and protection of groundwater.

e) **Australia, Great Artesian Basin**

i. Conjunctive use of surface water, groundwater, and artificial recharge are used to manage the aquifers. The artificial recharge scheme is supplied with water from rivers, artificial channels, recharge pits, and tidal barrages,

- Aquifer Storage and Recovery (ASR) is a common practice of managing aquifers by re-injecting water into aquifers for industrial, agricultural and municipal use for future recovery and use, and
- Water re-use in the Alice Project recycles and stores approximately 600 Ml annually of treated wastewater in an aquifer. The water is further re-used for the, Arid Zone Research Institute Horticulture" projects.

ii. Community consultations used as a means to reduce groundwater over-abstraction in the limestone aquifers,

iii. Desalination is an option for many cities due to saline groundwater,

f) Netherlands:

i. Water management in the Netherlands is closely linked to spatial planning, suggesting the land use functions of areas and sub-areas (urban areas, different types of agricultural areas, aquatic and terrestrial nature) are a start of defining the desired regime of groundwater and surface water levels,

ii. Approximately 10% of horticulture farmers are using brackish groundwater to irrigate crops due to surface water and rainwater not being a sufficient source of water for this purpose.

iii. Since 2006, the European Water Framework Directive prohibits the use of salty water hence the need to find alternative solutions. Other relevant directives are for Nitrates, urban wastewater treatment, plant protection products, biocides, integrated pollution prevention control, and landfills,

iv. The Groundwater Act of Netherland stipulates that no one has the ownership to groundwater and a license or permit is a prerequisite for any groundwater extraction,

v. Every license holder should pay a levy by virtue of the Groundwater Act,

vi. There is a groundwater management policy that caters for groundwater managers i.e. provinces, that require groundwater management plans in advance for any groundwater-related activity to ensure good groundwater management,

vii. Acts protecting groundwater pollution are The Environmental Management Act, The Pollution of Surface Waters Act, The Fertilisers Act, and the memorandum on the use of animal fertilizers.

g) Denmark

i. Groundwater management – ownership of groundwater and the management there of; Local operational system; private water utilities

ii. Mapping of groundwater resources – sustainable development

iii. Information driven management

iv. Local municipality support

v. Driller Regulations

vi. Detail groundwater protection policies

vii. Management plans per wellfield /aquifer

viii. Stakeholder participation on groundwater management

h) **RAMOTSWA Transboundary Aquifer Project and the Stampriet Transboundary Aquifer System Project under the framework 'Governance of Groundwater Resources in Transboundary Aquifers' (GGRETA)** which both contributed

significantly to the advancement of trans-boundary groundwater management in two distinct geographies in the SADC region. At least six lessons can be drawn from the two projects:

i. There are different ways to formulate trans-boundary aquifer projects and there are certain elements that may be critical regardless of context. These are:
    - A Trans-boundary Diagnostic Analysis (TDA), critical to create an initial knowledge platform for cooperation,
    - Dialogues, critical to essential engagement with and among stakeholders,
    - River Basin Organisations (RBO) linkages, critical to sustainability and ownership.

ii. Furthermore, at least two other elements may be helpful regardless of context:
    - information management, important to host and disseminate data and knowledge related to a shared resource, necessitating the development of monitoring and data sharing protocols among sharing countries,
    - a Strategic Action Plan (SAP), important to elaborating common ways forward in the joint management of a shared system.

iii. There are limits to sole focus on groundwater despite the growing recognition for the need to focus on shared aquifers, isolated focus on shared aquifers. The need for conjunctive water management is explained by fairly ubiquitous realities in which rivers flow over aquifer outcrops and water from different sources interact. Ultimately, it may be best to emphasize incorporation of aquifers into existing water management frameworks rather than treating aquifer management as a distinct new endeavour.

iv. Trans-boundary River Basin Organisations (RBOs) provide a useful resource for institutionalising and sustaining trans-boundary aquifer management

v. The lack of high-quality data may be a critical project constraint; this calls for more upstream emphasis on monitoring. Clearly, it is important to be strategic and targeted in the installation of monitoring equipment.

vi. Consider which areas require cooperation and which do not. While many actions and issues on a shared aquifer may benefit from cross-country

coordination, there may also be many that do not. Indeed, actions in many parts of a trans-boundary aquifer may not have trans-boundary impacts.

i) Multi-Country Consultation Mechanisms among **countries sharing trans-boundary aquifers** to ensure co-governance of the resource (including collaborative monitoring and information sharing such as:

- North Western Sahara Aquifer System (NWSAS – shared between Algeria, Libya and Tunisia) Multi-Country Consultation Mechanism (MCCM), nested within the Sahara and Sahel Observatory (OSS) structure since 2003. The objective of the Consultation Mechanism is to coordinate, promote and facilitate the rational management of the NWSAS water resources.

***Websites and References*:**

- North-Western Sahara Aquifer System Project, available at http://nwsas.iwlearn.org/.
- Sahara and Sahel Observatory, available at http://www.oss-online.org/
- The North-Western Sahara Aquifer System (Algeria, Tunisia, Libya): Concerted Management of a Transboundary Water Basin, OSS Synthesis Collection No. 1, 2008, available at http://www.oss-online.org/pdf/synth-sass_En.pdf.
- Establishment of a Consultation Mechanism for the Northwestern Sahara Aquifer System (SASS) [2002], in GROUNDWATER IN INTERNATIONAL LAW: COMPILATION OF TREATIES AND OTHER LEGAL INSTRUMENTS (Stefano Burchi, Kerstin Mechlem eds. 2005, FAO/UNESCO), part II(2), available at http://www.fao.org/docrep/008/y5739e/y5739e00.htm.

j) The other international trend that South Africa is part of and can learn extensively from is the ORASECOM (River Basin Organization by Botswana, Lesotho, Namibia and South Africa) however, is already advanced in this process, and lessons learnt from its process can be applicable elsewhere.

9.6. Further proposals on how this lesson learning process can be enhanced

The DWS officials agree that there should be a development of collaborative monitoring and information sharing protocols can be developed, agreed on, and adhered to. The sole use and/or conjunctive use of groundwater should be elevated to the same status as surface water for stakeholders/decision-makers to take it seriously and integrate it into the management of water resources. In terms of the South Africa-Denmark (SA –DK) Strategic Sector Corporate is now in the 2 Phase. There is a need to implement the guidelines, data initiative, mapping and assessment approach in South Africa. DWS needs to align all groundwater activities in South Africa with the needs of the international bodies such as River Basins Organisations (LIMCOM, ORASECOM)

9.7. Additional information that the DWS officials feel would add value to this report that was not captured

There is a general consensus that there is a need to have a closer look at the Municipal by-laws, to check whether they incorporate or include groundwater management practices and protection of the groundwater resources. There is also a need to get answers on why current groundwater legislation, regulations, guidelines and policy positions are neither enforced nor soundly implemented on the ground.

10. Findings and Lessons learnt

The definition of groundwater management is not static, it depends on who defines it and for what purpose. The internationally recognised Food and Agriculture Organisation defines groundwater management as “the set actions to implement decisions that derive from the process of governance”. In terms of defining groundwater management with the interpretation of the National Water Act understanding of the term, South African government through the legislation defines ‘groundwater management’ as the process ‘to ensure the sustainable use of water through the protection of the quality [and quantity] of water resources for the benefit of all water users’. This definition when dissected outlines actions needed to achieve such management as outlined by the FAO definition. What is coming out from the report is that even the DWS officials understand and define groundwater management within the context

governance process and they even go in detail to outline mechanisms that one needs to take into cognisance in order to achieve the proper management of groundwater resources.

The report came as a result of the WRC 2015 report in which they found that there is too much attention paid in the management of the groundwater resources with little on the use part. This report has shown that WRC failed to dissect groundwater management which in principle involves the 'use' aspect in its definition. The WRC report focused on the dichotomisation of the 'management' and 'use' and Fourie (2020) dispute this notion by arguing that the 'use' part forms part of the twelve principles of groundwater management, thus they cannot be separated from each other. Even in the National Water Act when one interprets the preamble, one could come to a conclusion that the legislation defines or describes water resource management or integrated water resource management as the process to ensure 'to ensure the sustainable use of water through the protection of the quality [and quantity] of water resources for the benefit of all water users'. This integrates both the management and the use as explained by Fourie, 2020.

The report has highlighted through three case studies how different countries approach the issue of groundwater management and use. The lessons learnt through engagement with literature and different policies, strategies and legislative instruments of Denmark, Australia and California in the USA can be written and interpreted within the South African context. These lessons may help shape the way South Africa manages its groundwater resources may shape the thinking to come up with more innovative and impact-oriented ways of managing and utilisation of groundwater resources. The lesson learnt from the countries that formed part of the case studies are as follows:

a) Ensure collaboration between sectors to achieve sustainable groundwater management and utilisation;
b) Groundwater management must be rested in knowledge-based approach;
c) Groundwater mapping should become an important component of groundwater management and utilisation and public entities must be appointed to ensure that the groundwater mapping is used to the best effect and interpreted within a wider context; Decentralisation of groundwater management is important;

d) The collaboration of private and public sector must have well-defined roles and responsibilities;
e) The licensing of groundwater abstraction as well as registration of abstraction wells should form part of the management of groundwater resources and this must apply in all municipalities;
f) Mapping, investigating and remediation of old contaminated sites threatening environment including groundwater to ensure sustainable management and utilisation of groundwater resources;
g) Designate valuable groundwater resources for drinking water and protect them;
h) Have a criteria assessment of the chemical status of groundwater, focus on measures to prevent or mitigate contamination of groundwater;
i) Develop groundwater protection guidelines that provide a national framework for the protection of groundwater from contamination and allow municipalities to develop policies, and strategies which are tailored to their specific needs but respond to the national guidelines;
j) Integrate surface and groundwater management especially on issues relating to the pricing, allocation and trading;
k) Employ groundwater user charges to recover direct management costs such as the cost of licensing and indirect costs;
l) Increase public awareness of the value and vulnerability of groundwater;
m) Have a groundwater agency / groundwater champion for a particular basin / catchment / municipality;
n) The Department / groundwater agency / groundwater champion may provide technical assistance to entities / municipalities that extract or use groundwater.
o) Political consensus, where all stakeholders have clear objectives

11. Recommendations

This literature has provided a snapshot of groundwater management internationally and using Denmark and Australia as case studies for benchmarking how South Africa is doing compared to other countries internationally. In these two case studies, a breakdown of the legislative and policy frameworks that these countries use in terms of managing their water resources and their

implication to groundwater management was synthesised. The literature review went on to provide a brief explanation of groundwater management and use in the Southern African Development Community (SADC). Here the importance of groundwater in the region was listed and in each of the key area, a country in the region was provided as an example of that particular key area. The literature then dissected our policies, legislation and strategies that seek to govern, manage and provide ways for the utilisation of groundwater since the dawn of democracy. These policies, legislation and strategies were dissected individually and sections/issues which had groundwater management and use implications were provided.

Based on the responses gathered from the DWS technical experts and other experts that attended provincial consultations, the following recommendations are highlighted below and are divided into different categories:

a) Policy Framework

- There is a need to address the issue of water quality adequately in the draft IWQM policy, especially in aspects where groundwater quality parameters are naturally high in concentration that may well have negative environmental impacts on surface waters if left to discharge. For example, arsenic or fluoride (in some geographical areas in South Africa nitrates are an issue). Impacts to human health are considered from consumption of the water but environmental health is neglected;
- The draft IWQM Policy further needs to address issues relating to the management and control of cemeteries.
- **For noting**: The IWQM policy development process is currently underway, awaiting Cabinet approval for public consultations.

b) Legal Framework (national regulation)

- There is a need to strengthen the current legal framework and revise the Government Notice GN.704 Regulation;
- Regulation 810 in Government Gazette No. 33541 and procedure to develop and implement Resource Quality Objectives should be updated to highlight groundwater;
- There is a need to control access to groundwater through drilling regulations. Currently, groundwater management appears to start once the borehole has been drilled and is

being utilised. In reality, groundwater management starts long before this, hence the call for groundwater management to be a truly integrated and holistic process, supported by a regulation;

- The drilling regulations should also address registration of boreholes and capturing. This regulation should make registration of all drillers in South Africa compulsory;
- The drilling regulations must have a clause that provides for conviction of persons or institutions who fail to disclose the compulsory data. This provision could be applicable to drilling contractors who are supposed to submit data to DWS on boreholes drilled, whether successful or not;
- A regulatory requirement is needed whereby it must be compulsory for all municipalities using groundwater to have an in-house Geohydrologists to manage the resource. The best practice is City of Cape Town, where an in-house Geohydrologist exists;
- There is a need for regulatory frameworks such as SANS standards relating to groundwater. Addressing this need for a groundwater quality standard will ensure measurable compliance with water use licenses. This should be accompanied by proper groundwater related instrumentation for practical work and theoretical work;
- There is a need to develop a regulation governing rehabilitation of boreholes that are no longer in use as such boreholes tend to become a point source of pollution for underground water during rainfall seasons;
- There is a need for regulations that regulate groundwater level impacts. These would aid the effective implementation of control measures for groundwater drawdown impacts. The available regulatory frameworks focus on groundwater quality and neglect quantity;
- **For noting:** some of the regulations proposed are already being developed in the Department. These include Regulation to regulate borehole drilling activities and provision of groundwater data to DWS national systems by public and private stakeholders; The Government Notice GN.704 Regulation is currently being revised; DWS is currently busy working on updating the model by-laws which act as a point of reference that municipalities need to look at when drafting their own by-laws.
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c) Municipal Bylaws (local regulation)

- Municipalities need to strengthen their by-laws to address the issue of pollution, groundwater quality and various forms of groundwater management and use;
- Establishment of the standard model bylaw by DWS to guide municipalities that do not have any bylaws on certain aspects on groundwater use and management.
- **For noting**: the current model bylaw is currently being updated to incorporate groundwater issues

d) Data and Information

- Ensuring that all boreholes have unique numbering system as required by the authority.
- Regarding boreholes registered in WARMS or NGA Database. The owner/s of the boreholes must within 5-year period after borehole registration provide a status of the boreholes (in terms of use or unused, collapse, etc.) to be part of the condition/policy for all borehole owners;
- There is a need to improve submission of abstraction rates and water quality monitoring data. These requires improved information systems as well as improved communication between different functional areas in the Department.
- There is a priority need to shift the focus from groundwater use to groundwater availability. This will greatly inform the issuing groundwater use licenses, based on current real time groundwater availability calculations done through numerical modelling instead of relying on old data. This must be done by in-house groundwater specialists in the Department;
- There is a need to have enough relevant data information and coherent groundwater monitoring sites in local municipalities;
- There is a need for more technical tools to assess groundwater.

e) Compliance and Enforcement

- There is a need to enforce regulations and compliance to the conditions of the WUL;
- There is a need to relook at legal activities such as dewatering the pit during mining as such activities tend to have severe impact on neighbouring users and because they are authorised to undertake such activity there is lack of enforcement from the Departments side resulting in increased complaints over the years.

f) Funding Requirements

- Funding for the development, operation and maintenance of groundwater structures should be prioritised. This must be emphasised in the project handing over or planning, clarify the role and responsibilities in the different spheres of government form the funder (National or Provincial government) and WSA as asset owners;
- Operation and Maintenance budget for municipalities is a long-standing issue – There is poor communication and lack of consultation between Regional Bulk Infrastructure Grant section and Geohydrology specialists when it comes to decision making processes. This results in valuable data from municipalities not reaching Geohydrology section to incorporate local scale monitoring data i.e. groundwater use.

g) Institutional Arrangements/Capacity

- Catchment management strategies need to expand on the management of groundwater aquifers that are by nature not following the neatly defined surface catchment areas and tapping into a groundwater resource in one catchment may have impacts in another catchment;
- There is a need for Geohydrology Chief Directorate in Head Office for adequate operational and project-based budget allocation and streamlined Geohydrology approvals;
- The Drilling Division needs to be re-established in the Department as this unit was able to drill monitoring boreholes or exploration boreholes for much less than going out on tender, it is also pivotal for capacity building, especially for Graduate Training;
- On the effective implementation of the proposed drilling regulation, there is an urgent need for improved involvement of DWS groundwater specialists right from the exploratory stage, irrespective of whether the drilling yields success. This is due to the fact that even in instances where water was not found, this would improve groundwater mapping and certainly help to identify areas that should be avoided, whether due to lack of groundwater or simply too many other surface variables such as wetlands and rivers etc. that are groundwater dependent);
- On data and information, drilling contractors are often in competition with each other, therefore sharing of information is unlikely to be taking place. Having a centrally

coordinated function within the DWS would absolutely make sense. In this way, private landowners can also find out more, before they even get to the contractors, and somehow be more protected from (unscrupulous) drilling contractors;

- There is a need for getting the basics correct – competent scientific management personnel which will in essence infiltrate to lower structures;
- A clear groundwater governance structure with clear roles and responsibilities is required;

h) International Cooperation

- There is a need to look at transboundary agreements in order to establish system for allocating transboundary groundwater resources.

i) Implementation Issues

- The Implementations plan for RQOs must be implemented as it addresses the issues of groundwater dead storage impacts and water quality;

j) Knowledge Management / Sharing

- There is a need for an accurate and widely shared knowledge of the groundwater systems;
- As a country we further need to take more advantage of and participate more in international as well as continental initiatives to strengthen our policies and practices on groundwater management and use.

12. Limitations of the study

The study was conducted over a period of 13 months. With every study conducted, the researchers are bound to face some challenges that would limit the extent of the research. One of the problems that the researchers have encountered was the issue of coordination in all the spheres of government. The report was supposed to feature at least two rural municipalities in each of the following provinces, Eastern Cape, Limpopo, North-West, KwaZulu-Natal, Northern Cape, Free State and Mpumalanga. When the report was consulted with the provincial offices, a request was made to each of the above-mentioned provincial offices to furnish us with at least two bylaws of their rural municipalities that utilises groundwater resources. Some

provincial offices did provide us with the list, then the researchers went to look for their bylaws, and these were there challenges faced:

a) Some of the District Municipalities do not have functioning websites, therefore, bylaws could not be downloaded
b) Those District Municipalities that have functioning websites, some of them do not have municipal bylaws posted on the website
c) Some of the municipal bylaws are draft documents that are yet to be published for comments, and these municipalities cited budget constrained as a reason for not finalising those bylaws
d) The team engaged with some of the champions who are dealing with coordination between municipalities and DWS provincial offices, and as much as other responded to the request to furnish the team with bylaws of municipalities they are working with, others did not respond at all
e) Time limit is another factor in the limit of the study, where a study needed to be finished within a financial year.

13. Conclusion

A lot of recommendations were put forward by the experts within the Department of Water and Sanitation based on their experiences on the ground, however what this report found is that there are some issues which were raised that are currently being addressed, these issues includes: a) The drilling of boreholes, in which there is a team that has started with the business case on the need to develop regulations to regulate borehole drilling activities and provision of groundwater data to DWS National systems by public and private stakeholder (a legal opinion which support the development of this regulation has been provided); b) The Government Notice GN.704 Regulation is currently being revised; c) DWS is currently busy working on updating the model by-laws which act as a point of reference that municipalities need to look at when drafting their own by-laws. This on its own shows that the critical issues on the ground are being addressed thus maintaining them on this report is of paramount importance as this report will act a checklist to see whether all the issues raised are being addressed in one way or another.

- The rationale of the study was to address the policy gaps which were identified in the Water Research Commission study that was published in 2015. From what the literature has provided, and the inputs from the DWS officials, it can be concluded that the current policy provisions on groundwater use have been extensively covered in the policy and legal framework drafted by the Department of Water and Sanitation since 1997. The primary issues or challenges emanate from the implementation of the policy and legislation, resulting in the amendments of current regulations and development of others to strengthen the legal framework and adapt with the changing times. There is a need for groundwater policies, plans and finances to be aligned with society's goals

14. Reference List

1. Adams, S., Braune, E., Cobbing, J., Fourie, F., Riemann, K. 2015. critical reflections on 20 years from groundwater research, development and implementation in South Africa. *South African journal geology*, 118:(1).
2. African Union. 2015. *Agenda 2063: The Africa We Want*. African Union Commission.
3. Albert, T., Stephen, F., Frankvan, S., Amal, T., Marcus., W. 2011. *Appropriate Groundwater Management Policy for Sub-Saharan Africa*. Global water partnership.
4. African Ministers' Council on Water (AMCOW). 2018. *Africa Ministers' Council on Water Strategy 2018-2030*. Abuja, Nigeria.
5. Australian Water and Wastewater Association. 2001. *National Water Quality Management Strategy: Guidelines for groundwater Protection in Australia*. Australian Water and Wastewater Association. Artarmon.
6. Biermann, F., Betsill, M., Gupta, J., Kani, N., Lebel, L., Liverman, D., Schroeder, H. and Siebenhüner, B. 2009. *Earth System Governance: People, Places and the Planet. Science and Implementation Plan of the Earth System Governance Project*.
7. Braune, E., Adams, S., Fourie, F.2014. *20 years of underground research, development and implementation in South Africa 1994-2014*. Water research commission and Department of Water and Sanitation. Pretoria.
8. Buffalo City Metropolitan Municipality (BCMM). 2011. Water Services By-law. Provincial Gazette Extraordinary, 22 March 2011, No. 2532. Notice 4 of 2011.
9. California. Sustainable Groundwater Management Act 2014.
10. City of Cape Town. 2010. *Water By-Law*. Western Cape: Provincial Gazette no. 6847.
11. City of Johannesburg. 20110. *Water Services Local Regulation Case Study for the City of Joburg*, August, 201.
12. City of Johannesburg (CoJ). 2017a. 2017/2018 *Integrated Development Plan Review.*
13. City of Tshwane (TMM). 2003. *Water Supply By-law.*
14. City of Tshwane (TMM). 2014. *Tshwane Vision 2055: Remaking South Africa's Capital City.*
15. Chris Hani District Municipality. 2019. *Water Security Plan: Strategy for Sustainable Water Resources (Draft).* Eastern Cape.
16. Chris Hani District Municipality. 2020. *Water and Sanitation Bylaw*. Eastern Cape.

17. Christelis, G., Struckmeir, W. 2011. *Groundwater in Namibia: An explanation to the Hydrogeological Map.* Ministry of Agriculture, Water and Rural Development. Windhoek.
18. Clifton, C., evans, R., Hayes, S., Hirji, R., Puz, G., Pizarro, C. (2010). *Water and climate change: Impacts on groundwater resources and adaptation options (World Bank Working Note No. 25)*. Washington, DC: World Bank.
19. Closas, A and Molle, F. 2016. *Groundwater Management in Sub-Saharan Africa. IWMI* Report No:2.
20. Collin, G.2014. Legal Protection for Groundwater-Dependent Ecosystems. *Michigan Journal of Environmental & Administrative Law*, 14(1).
21. Department of Environmental Affairs. 2010. *National Strategy on Sustainable Development*. DEA. Pretoria.
22. Department of Land Affairs. 2001. *The White Paper on Spatial Planning and Land Use Management: Wise Land Use*. DLA. Pretoria.
23. Department of Water Affairs and Forestry. 1997. *The National Water Policy*. Department of Water Affairs and forestry. Pretoria.
24. Department of Water Affairs and Forestry. 2*000. Policy and strategy for groundwater quality management in South Africa*. Department of Water Affairs and Forestry Republic of South Africa. Pretoria.
25. Department of Water Affairs and Forestry. 2003. *A protocol to manage the potential of groundwater contamination from on-site sanitation*. Department of Water Affairs and Forestry. Pretoria.
26. Department of Water Affairs and Forestry. 2004. *The National Water Resource Strategy, First Edition*. DWAF. Pretoria.
27. Department of Water Affairs and Forestry. 2007. *A Framework for A National Groundwater Strategy (NGS)*. Department of Water Affairs and Forestry. Pretoria.
28. Department of Water Affairs and Forestry. 2008. *A guideline for the assessment, planning and management of groundwater resources in South Africa*. Department of Water Affairs and Forestry. Pretoria.
29. Department of Water Affairs and Forestry, South Africa. 2009a. *Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas: First Stage Reconciliation Strategy Report*. Prepared by: DMM Development Consultants, Golder

Associates Africa, Kwezi V3 Engineers, WRP Consulting Engineers and Zitholele Consulting. Report No. PWMA 11/000/00/0907.

30. Department of Water Affairs. 2010. *Groundwater Strategy 2010.* Department of Water Affairs. Pretoria.
31. Department of Water Affairs. 2010c. *Contract Wp 9711 Development of a Reconciliation Strategy for all Towns in the Northern Region City of Tshwane Metropolitan Municipality First Order Reconciliation Strategy for Tshwane and Surrounding Settlements Pretoria Cluster* DRAFT VERSION 1.2 OCTOBER 2010.
32. Department of Water Affairs, South Africa. 2011a. *Algoa Reconciliation Strategy*. Prepared by E van der Berg and Dr MJ Shand of Aurecon, as part of the Water Reconciliation Strategy Study for the Algoa Water Supply Area. DWA Report No. WMA 15/M00/00/1409/04.
33. Department of Water Affairs. 2013. *National Water Resource Strategy, Second Edition*. DWA. Pretoria.
34. Department of Water and Environmental Regulation. 2019. *Policy: Managing unlicensed groundwater use*. DoWER. Joondalup.
35. Department of Water and Sanitation. 2015a. *Support to the Continuation of the Water Reconciliation Strategy for the Western Cape Water Supply System – Status Report October 2015*. Report to the Strategy Steering Committee, Draft, October 2015.
36. Department of Water and Sanitation. 2016. *National Groundwater Strategy 2016. Department of Water and Sanitation.* Pretoria.
37. Department of Water. 2003. *Water resource considerations when controlling groundwater levels in urban development.* DoW. Perth.
38. Department of Water. 2009. *Operational policy no.5.12- Hydrogeological reporting associated with groundwater well licence*. DoW. Perth.
39. Dippenaar, M.A. 2013. *Hydrological Heritage Overview: Pretoria's Fountains – Ateries of Life*. Water Research Commission SP 44/13. Pretoria.
40. Dowing, J. 2018. UC groundwater research: A survey. *California Agriculture* 72(1):8-15. https://doi.org/10.3733/ca.2018a0008.
41. EDMS. 2007. *Review of the international water resources management policies and actions and the latest practice in their environmental evaluation and strategic environmental assessment*. Environmental Protection Department. Hong Kong.

42. Ekurhuleni Metropolitan Municipality. 2012. *Water Supply Bylaws Council Resolution: MI 191/2001 dated 29 November 2001*.
43. Ekurhuleni Metropolitan Municipality. 2015. *Spatial Development Framework.*
44. eThekwini Municipality (eTMM), *Water Supply By-laws 2017.*
45. Fienen, M.N & Arshad, M. 2015. The international scale of the groundwater issue. In Jakeman, A.J., Barreteau, O., Hunt, R.J., Rinaudo, J.D., Ross, A (eds) *Integrated Groundwater Management: Concepts, Approaches and Challenges.* Springer International Publishing, Switzerland.
46. Foster, S & Guarduno, H. 2013. Groundwater-resource governance: Are governments and stakeholders responding to the challenges. *Hydrogeology journal*, 21:317-320.
47. Foster, S., Garduno, H., Tuinhof, A. and Tovey, C. 2009. *Groundwater governance: conceptual framework for assessment of provisions and needs* (No. 57555, pp. 1-16). The World Bank.
48. Fourie, F. 2020. *Twelve (12) Underlying Principles of Groundwater Management*. DWS Report No GH4342, Department of Water and Sanitation, Pretoria, South Africa. pp 1-77.
49. FutureWorks Sustainability Consulting. 2014. *Review of the Buffalo City Metropolitan Municipality Integrated Environmental Management Plan and Coastal Zone Management Plan Draft State of the Environment*. Report 30 April 2014.
50. Giordano, M. 2009. Global groundwater? Issues and solutions. *Annu Rev Environ Resour* 34: 153–178.
51. Henriksen, H. J., Troldborg, L., Nyegaard, P., Sonnenborg, T. o., Refsgaard, J. C., & Madsen, B. (2003). Methodology for construction, calibration and validation of a national hydrological model for Denmark. *Journal of Hydrology, 280*, 52–71.
52. Herbertson, P.W., Tate, E.L. 2001. *Tools for water use and demand management in South Africa. Secretariat of the World Meteorological Organization* – Geneva – Switzerland.
53. Jorgensen, L.F., Villholth, K.G. & Refsgaard, J.C. 2017. Groundwater management and protection in Denmark: A review of pre-conditions, advances and challenges. *International Journal of Water Resources Development*, 33(6): 868-889.
54. Kelbe, B and Rawlins, B. 2016. *South Africa: Groundwater Management*.

55. Kiparsky, M., Milman, A., Owen, D., Fisher, A.T. 2017. The importance of institutional design for distributed local-level governance of groundwater: The case of California's Sustainable Groundwater Management Act. *Water*, 9(755): 1-17.
56. Klee, P (ed). 2013. *Greater water security with groundwater- groundwater mapping and sustainable groundwater management. The Rethinking Water network and Danish Water forum white papers*. Copenhagen.
57. Knuppe, K. 2011. The challenges facing sustainable and adaptive groundwater management in South Africa. *Water SA*, 37(1): 67-80.
58. Leahy, T.C. 2015. Desperate Times Call for Sensible Measures: The Making of the California Sustainable Groundwater Management Act. *Golden Gate Univ. Envtl*, 9(5).
59. Le Maitre, D., Seyler, H., Holland, M., Smith-Adao L., Maherry, A., Nel, J., Witthüser, K. 2017. *Enhancement of the method to identify and delineate South Africa's Water Source Areas*, Final Draft Report, WRC Project (K5/2431). May 2017
60. Mangaung Metropolitan Municipality. 2013. By-law relating to environmental health services. Provincial Gazette no 60 of 25 October 2013.
61. McCarthy, T.S. 2006. Groundwater in the wetlands of the Okavango Delta, Botswana, and its contribution to the structure and function of the ecosystem. *Journal of hydrology*, *320*(3-4):264-282.
62. Mechlem, K. 2016. The Role of Legal Frameworks at the Local and National Level—Established Practice and Emerging Trends. *Water*, 8(347):1-16.
63. Mesissner, R. 2017. *Paradigms and theories influencing policies in the South African and international waster sectors*. Gewerbestrasse: Springer International Publishing AG.
64. Mineral and Petroleum Resource Development Act 28 of 2002.
65. National Environmental Act 178 of 1998.
66. National Environmental Act: Air Quality Act 39 of 2004.
67. National Environmental Act: Waste Act 59 of 2008.
68. National Planning Commission. 2019. National Water Security Framework. National Planning Commission. Pretoria.
69. National Water Act, 1998. Act 36 of 1998.
70. Nussbaumer, D., Sutton, I. and Parker, A., 2016. Groundwater data management by water service providers in Peri-Urban areas of Lusaka. *Water*, *8*(4), p.135.

71. Pavelic, P., Giordano, M., Keraita, B.N., Ramesh, V. and Rao, T., 2012. *Groundwater availability and use in Sub-Saharan Africa: a review of 15 countries*. International Water Management Institute (IWMI).
72. Pierre, M, Debbie, S. 2003. *Water management and climate change in South Africa: vision, driving factors and sustainable development indicators*. Energy & development research centre. University of Cape Town.
73. Pietersen, K., Beekman, H. 2010. *Groundwater Management in the Southern African Development Community*. Groundwater Management institute.
74. Pietersen, K., Beekman, H. E. and Holland, M. 2011. *South African Groundwater Governance Case Study. World Bank, in partnership with the South African Department of Water Affairs and the Water Research Commission*. WRC Report No. KV 273/11, ISBN 978-1-4312-0122-8. June 2011.
75. Piketh, S.J., Vogel, C., Dunsmore, S., Culwick, C., Engelbrecht, F., Akoon, I. 2013. Climate change and urban development in Southern Africa: The case of Ekurhuleni Municipality (EMM) in South Africa. *Water South Africa*, 40(4):749-758.
76. Riemann, K., Chimboza, N., Fubesi, M. 2011. A proposed underground management framework for municipalities in South Africa. *Water South Africa* 38(3).
77. Robert, G., Van Weert, V.F., Megdal, S.B., Gerlak, A, Iskandar, C.A., House-Peters, L. 2012. *Groundwater governance: A global framework for country action*.
78. Ross, A. 2015. Groundwater governance in Australia, the European Union and the Western USA. In Jakeman, A.J., Barreteau, O., Hunt, R.J., Rinaudo, J.D., Ross, A (eds) *Integrated Groundwater Management: Concepts, Approaches and Challenges.* Springer International Publishing, Switzerland.
79. South Africa Development Community. 2001. *Guidelines for the groundwater development in the SADC region*. Groundwater Consultants, Maseru.
80. South African Development community. 2016. *Regional Action Plan o Integrated Water Resources Development and Management Phase IV*. Gaborone, Botswana.
81. Stisen, S., Højberg, A. L., Troldborg, L., Refsgaard, J. C., Christensen, B. S. B., olsen, M., & Henriksen, H. J. (2012). On the importance of appropriate precipitation gauge catch correction for hydrological modelling at mid to high latitudes. *Hydrology and Earth System Sciences, 16*, 4157–4176.

82. Tijani, M. 2020. Presented at the AMCOW Global Webinar on Why Water Security is Key in ending hunger, Abuja, Nigeria, 21 October 2020, available at https://youtu.be/1exOJacGkdE.
83. Tredoux, G., Van Der Merwe, B. and Peters, I. 2009. Artificial recharge of the Windhoek aquifer, Namibia: Water quality considerations. *Boletín geológico y minero*, *120*(2):269-278.
84. United Nations Water Africa. 2009. Africa Water Vision 2025: Equitable and Sustainable Use of Water for Socioeconomic Development. Addis Ababa, Ethopia.
85. Vhembe District Municipality. 2014. Water and Sanitation Bylaws. Limpopo. Gazette 2422, 26 September 2014.
86. Water Act 137 of 2007. Australia.
87. Water Research Commission. 2014. *Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines.* Water Research Commission. Pretoria.
88. World Wide Fund. 2010. *The Implementation Challenge: Taking stock of government policies to protect and restore environmental flows*. The Nature Conservancy. Panda House-UK.