environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Compilation of the 3rd South Africa Environment Outlook Report

Chapter_Inland Water

FIRST DRAFT

GIBB REFERENCE NUMBER: J37105

DEA REFERENCE NUMBER: E1370

04 December 2017

GIBB

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Abbreviations

DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EPWP	Expanded Public Works Programme
IPAP	Industrial Policy and Action Plan
MBI	Municipal Benchmarking Initiative
NIWIS	National Integrated Water Information System
NWR	Non-Revenue Water
SALGA	South African Local Government Association
SDG	Sustainable Development Goal
SUDs	Sustainable Drainage Systems
WMA	Water Management Areas
WC/WDM	Water Conservation and Water Demand Management
W-E-F	Water-Energy-Food
WRC	Water Research Commission

Glossary

Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.
Emerging contaminants	Emerging contaminants are chemicals that have been detected in global drinking water supplies at trace levels and for which the risk to human health is not yet known. They include pharmaceuticals, personal care products, pesticides, herbicides and endocrine disrupting compounds
Non-revenue water	Non-Revenue Water Difference between the system input volume and the billed authorised consumption (including exported water) during the assessment period. Non-revenue water includes not only the real and apparent losses but also the unbilled authorised consumption.
Renewable water resources	Natural and actual renewable water resources. Natural renewable water resources are the total amount of a country's water resources (surface and ground water) which is generated through the hydrological cycle.

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1 Inland water

1.1 Drivers and pressures: the water situation

Freshwater resources and functioning aquatic ecosystems play an essential role, if maintained, in providing ecosystem services such as the reasonable assurance of water supply, good water quality and the reduced impacts of floods and droughts. Water essentially, plays a role in the physiological processes of biodiversity. Conversely, humans need for water includes drinking and domestic use. Many industries too, rely on a steady water supply. Water demand is particularly high in the agricultural, industrial and municipal areas. Water requirements for energy are also modelled to be high as energy requirements intensify (WRC, 2017).

Water resources are however, dwindling due to a culmination of reasons that are interconnected. Two such reasons include the growing human population and climate change (Ziervogel *et.al.*, 2014; Galvin *et.al*., 2015). As indicated in Figure 1, South Africa is recognised as a "water stressed" country. In addition, South Africa is fast approaching physical water scarcity by the year 2025 (WWF-SA, 2017). As a result of water stress, South Africa walks a tightrope uncomfortably between socio-economic development and the protection of its water resources (Walter *et.al*., 2011).

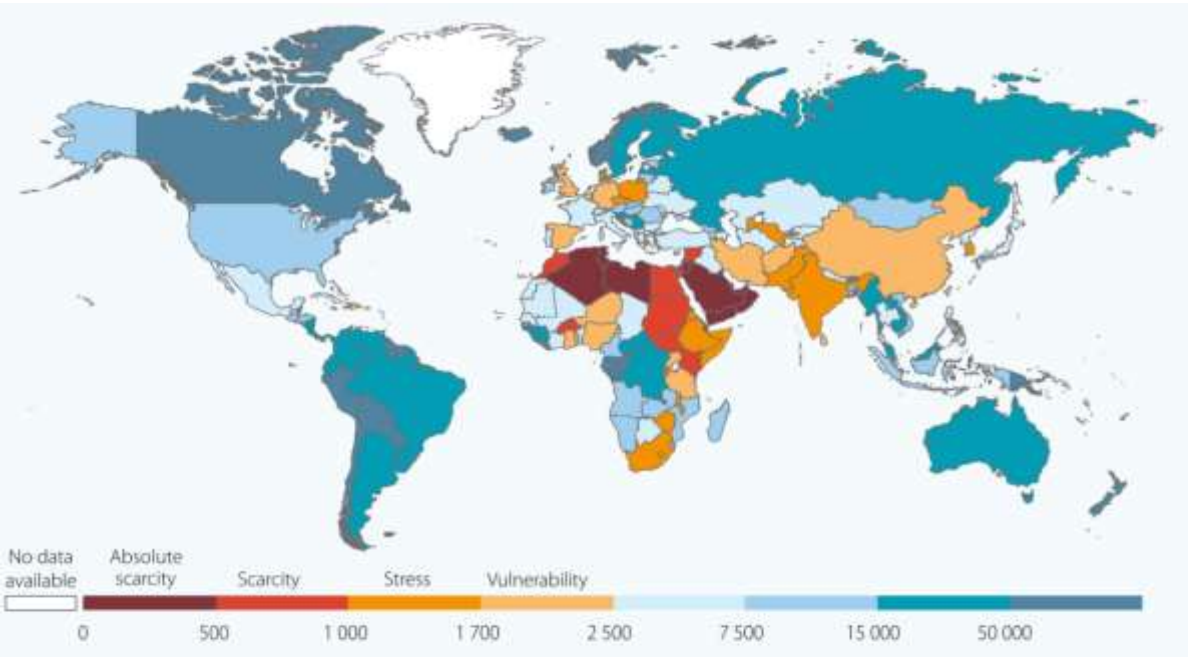


Figure 1: Total renewable water resources (per capita in m^3) (Source: WWAP, 2015)

Fundamentally, human population growth drives the demand for water in various sectors such as industry, energy, agriculture, aquaculture and households. Furthermore, in a country that is at present "water stressed", challenges are further exacerbated by climate change and water abstraction.

1.1.1 Water demand

The interconnectedness of the pressures faced by South Africa in the water space is further exacerbated by the demand-side for water. The demand for water is expected to increase annually by 1% (WWF-SA, 2017), as human population dynamics intensify, expediting the demand for water by various sectors (Table 1). Apart from human population and economic growth patterns, certain parts of South Africa are already faced with growing water demands and insufficient potable water sources to meet these demands (Haigh et.al., 2010; Pegram and Eaglin, 2011).

Table 1: Key Drivers for Water Demand in South Africa (Source: WWF-SA, 2017)

	Major water uses	Key drivers for water supply and demand	Effect on water
Agriculture	• Crop irrigation • Livestock watering and Confined animal feeding operations	• Weather variation: More surface water used in droughts, which depletes stores • Population growth: More food and liquids consumed from the rising number of residents • Labour intensive sector: Government supports sector growth due to job creation • Dietary shifts to fats / oils: Livestock requires significant water usage	• Over-application of fertilizer contributes to water pollution • Over-use of stored water leads to low dam levels • Habitats and ecosystems destroyed to create room for agricultural land
Municipal	• Municipal sector uses 26% of water supply and is expected to grow mostly due to demographic drivers. • Major uses include gardening, toilets, and personal hygiene, accounting for 84%.	• Population growth: Increased urbanization and standards of living • Urbanization: Increased total water usage per household with increased access to water for families living in cities	• Untreated and poorly treated sewage and sewage leaks pollute the water, especially in urban areas with limited wastewater treatment • Cumulative pollutant load from industrial areas

	Major water uses	Key drivers for water supply and demand	Effect on water
Industrial	• Industrial sector uses 11% of water supply; manufacturing is the highest user of water at 53% and expected to grow to 70% in 2030 ***Manufacturing applications:*** • Processing of minerals and crops • Textile, chemical refinement • Component and auto supplies ***Mining and power applications:*** • Extraction, refining, and cooling	• Weakening Rand: Creates demand for water-intensive exports • Population growth: Higher demand for water, electricity, and consumer products • Price of water: Higher water tariffs curb water wastage and promote water reuse • Water governance: Legislation enforces reduced water consumption and pollution	• Industrial spillages and acid drainage degrades water quality • Warm water discharge disrupts surrounding biodiversity • Large industrial disasters pollute entire water basin

As seen in Figure 2, Industry and municipal requirements for water is 11% and 26%, respectively, while primary agriculture comprises the highest demand for water with 63% (WWF-SA, 2017). While these statistics portray the demand for water currently, it can be reasonably expected that the demand for water will increase in all sectors.

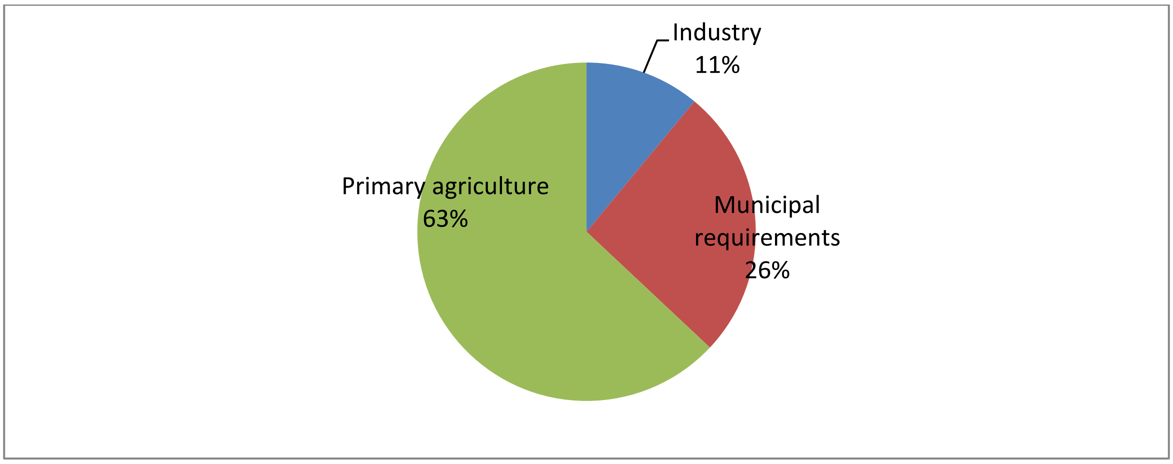


Figure 2: Major sectors contributing to water demand (WWF-SA, 2017)

Water requirements are however, increasing as the demand for energy increases, food security becomes challenging and municipal demands for water intensify. As seen in Figure 3, increasing the supply will not be sufficient to meet the growing demand for water. Figure 3 indicates that by 2030 the gap between supply and demand increases to over 3.5km^3, with a small reduction to 3.2km^3 in 2035 (WRC, 2014). The modelled reduction took into consideration an expected drop in coal production due to increased growth in the renewable energy sector. The implications of such constraints may lead to the water being over-exploited, which may have an impact on the environmental resilience of aquatic ecosystems, water quality and economic development.

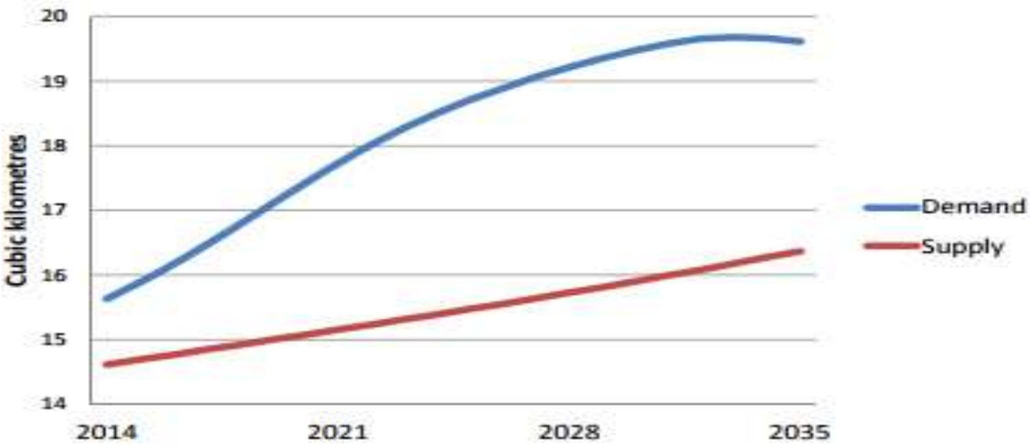


Figure 3: South Africa's increasing gap between water demand and supply (Source: WRC, 2014)

In an effort to curb demand and plan effectively for future demands, some sectors are making advances in the development on strategies. For example, growth in the energy sector is supported by the introduction of alternative sources of energy such as biogas generation (WRC, 2015/2016). Strategies such as carefully-managed water rationing and restrictions or the introduction of subsidies to incentivise the adoption of water technologies are found to be most appropriate for the industrial and agricultural sectors (WRC, 2016).

1.1.2 Climate variability

In South Africa, the main sources of water are rainfall, surface water and groundwater. Issues around rainfall variability caused by factors such as drought cycles and/or climate change, have however led to increased water stress in South Africa (WWF-SA, 2017; DWS, 2015/16; WRC, 2015/16). Changes in rainfall patterns indicate impacts on various sectors with agriculture experiencing severe losses. Water, in this instance, is essential for sustainable agriculture, leading to economic development. Refer to the chapter on climate change for further details on rainfall variability.

1.1.3 Infrastructure

A major concern associated with infrastructure in the water sector is that the network is ageing (Colvin *et.al.*, 2016). Moreover, a 25% loss to leaks in municipal systems is reported by WWF-SA (2017) and can be attributed to ageing infrastructure. In order to provide basic sanitation services as well as to refurbish and upgrade existing infrastructure, a significant amount of capital, R44.75 billion, is required (Colvin *et.al.*, 2016).

Efforts by the DWS, through its National Integrated Water Information System (NIWIS), seek to monitor various aspects of water governance, including Non-Revenue Water (NRW) per province and municipality. This essentially, takes various categories of water use into consideration including water loss, leaks accounted for and unaccounted for water. As seen in Figure 4 Non-revenue water persisted as a challenge between the period 2008 and 2012.

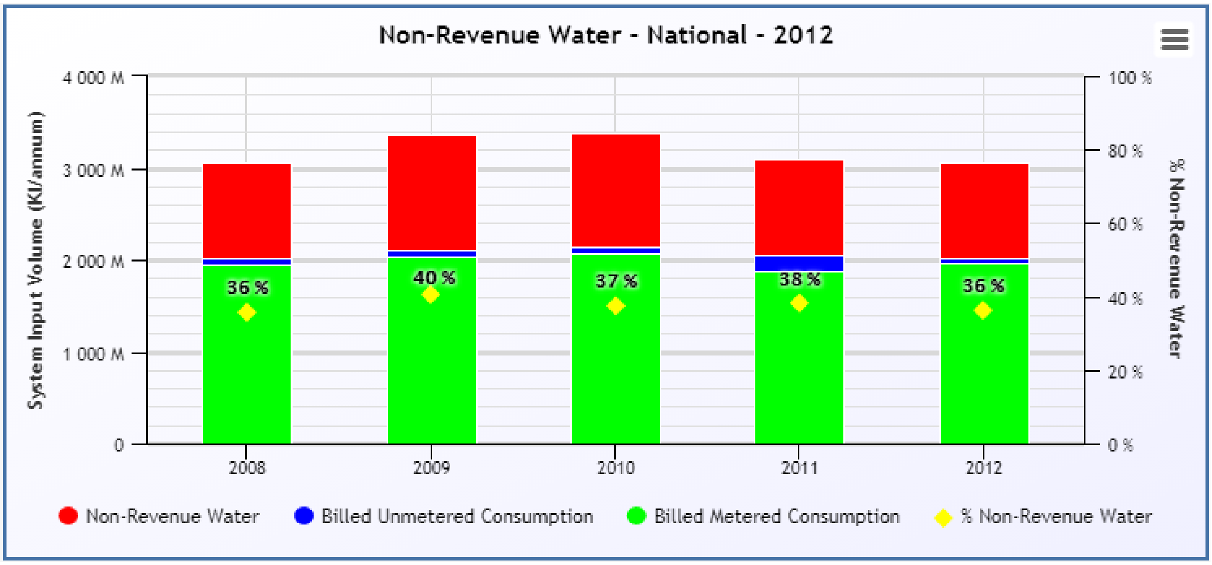


Figure 4: National representation for Non-Revenue Water (2008 - 2012) (Source: DWS, 2012)

In understanding the root cause, it can be said that challenges faced by Municipal Water Services Authorities are more practical in nature, as these institutions are the last point of delivery before water is received by the end-user (Colvin *et.al.*, 2016):

- Rapid urbanisation;
- Ageing infrastructure;
- Insufficient refurbishment;
- Deteriorating operations and maintenance; and
- A lack of skilled personnel.

1.2 State and impact: consequences of the water situation

1.2.1 Water availability

In a country where water is considered to be a stressed resource, it is important to understand where and how fresh water is available and where and what demands are placed on it. This enables better decision-making around the allocation of water to different users. Historically, South Africa was divided into 19 Water Management Areas (WMA) to facilitate water resource management, however, these were rationalised into 9 WMAs (Table 2).

Table 2: Water management areas and major rivers (Source: DWS, 2016)

1	**Limpopo:** rivers include the Limpopo, Matlabas, Mokolo, Lephalala, Mogalakwena, Sand, Nzhelele, Mutale and Luvuvhu
2	**Olifants:** rivers include Elands, Wilge, Steelpoort, Olifants and Letaba
3	**Inkomati-Usuthu:** rivers include Nwanedzi, Sabie, Crocodile (East), Komati and Usuthu

4	**Pongola-Mzimkulu:** rivers include the Pongola, Mhlatuze, Mfolozi, Mkuze, Thukela, Mvoti, Umgeni, Umkomazi, Umzimkulu and Mtamvuna
5	**Vaal:** rivers include the Wilge, Liebenbergsvlei, Mooi, Renoster, Vals, Sand, Vet, Harts, Molopo and Vaal
6	**Orange:** rivers include the Modder, Riet Caledon, Kraai, Ongers, Hartbees and Orange
7	**Mzimvubu-Tsitsikamma:** rivers include the Mzimvubu, Mtata, Mbashe, Buffalo, Nahoon, Groot Kei and Keiskamma, Fish, Kowie, Boesmans, Sundays, Gamtoos, Kromme, Groot and Tsitsikamma
8	**Breede -Gouritz:** rivers include the Breede, Sonderend, Sout, Bot, Palmiet, Gouritz, Olifants, Kamanassie, Gamka, Buffels, Touws, Goukou and Duiwenhoks
9	**Berg -Olifants:** rivers include the Berg, Diep and Steenbras, Olifants, Doorn, Krom, Sand and Sout

Water availability across South Africa is faced with three major challenges. Firstly, South Africa has uneven spatial distribution; therefore, only 8% of South Africa's land area produces runoff, which makes up 50% of the volume of the river systems (Colvin *et.al.*, 2016). Secondly, South Africa experiences relatively low stream flow in rivers. South Africa's river systems contribute, in volume, to the majority of available surface water. Freshwater ecosystems receiving runoff water include lakes, ponds, rivers, streams, springs and wetlands; conversely a significant portion of the waste, sediment and pollutants have also entered these freshwater ecosystems (Colvin *et.al.*, 2016). Rainfall is the predominant source of freshwater. According to WWF-SA (2017), South Africa, however has low rainfall and low per capita water availability (500 mm average annual rainfall and 843 m^3 water per capita per annum). From the rainfall received by South Africa, the annual surface water runoff is only 30% (WWF-SA, 2017). Thirdly, the location of industrial and urban areas from large water sources necessitates large-scale water transfers. Further to this, various regions in South Africa still experience water availability issues.

(a) Surface water availability

The DWS (2017) noted that South Africa is still reliant on surface water. Furthermore, the supply deficit is predicted to be approximately 1 billion m^3 by 2035 if current supply patterns continue (WRC, 2017). The challenge that surface water availability presents is a knock-on effect, affecting, for example, water supply for agricultural needs which in turn affects Gross Domestic Product (GDP) and food-security for South Africa. The chapter on climate change further expands on the issues of food-security.

The number of dams recorded by the Dam Safety Office is approximately 4718, including 305 dams which are owned by the Department of Water and Sanitation (DWS) (Colvin et.al., 2016). The dams owned by the DWS make up a total capacity of 29.2 billion m^3. The DWS monitors full capacity supply regularly for 215 dams nationally (refer to Table 3 and Figure 5). Despite the percentages for full capacity supply in most dams, not all storage dams benefit from surface water runoff. Water supply is remarkably low in the Water Management Areas Berg Olifants and Breede Gouritz.

Figure 5: Illustrative results for full supply capacity as at 22 October 2017 (Source: DWS, 2017a)

Table 3: Surface water storage (dam capacity) as at 22 October 2017 (Source: DWS, 2017a)

Reservoir	Full Capacity Supply (mm3)	Water in Dam(Mm3)	% Full Supply Capacity
National	32350.1	20663.2	64%
Berg Olifants	544.7	264.2	48%
Breede Gouritz	1318.6	417.6	32%
Inkomati Usuthu	1398.1	955.7	68%
Lesotho	2362.6	835.9	35%
Limpopo	1297.6	1017.8	78%
Mzimvubu Tsitsikamma	1827.6	1096.1	60%
Olifants	1857.5	1231.8	66%
Orange	9085.7	5857.5	64%
Pongola Mtamvuna	4782.7	2347.4	49%
Swaziland	333.7	193.8	58%
Vaal	7541.2	6445.5	85%

It is important to note that although South Africa has a large dam registry; dams are reported as altering the ability of freshwater ecosystems to support good water quality (Colvin *et.al.*, 2016). In addition, South Africa has a mix of obsolete, old and new water and sanitation infrastructure. Dams are therefore, not without challenges.

(b) Groundwater availability

According to the National Water Resource Strategy 2 (DWS, 2013), groundwater resources will be instrumental for sustaining water security. However, only 4% of South Africa's groundwater is attributed to recharge by rainfall; of which many communities rely on groundwater for water supply (Colvin *et.al.*, 2016). Holistically, the majority of water comes from dams, while only 10% comes from groundwater systems (WWF-SA, 2017).

The National Groundwater Strategy (2016) highlights that more than 60% of communities in villages and small towns in South Africa utilise groundwater for domestic water and general livelihood (DWS, 2016). Utilising groundwater does however present its own set of challenges (DWS, 2016). Firstly, groundwater was previously manageable serving as simply an emergency water supply; presently, there are many users which make management of groundwater challenging (DWS, 2016). Secondly, some municipal schemes for groundwater usage have failed (DWS, 2016).

Unlocking the potential in groundwater may therefore assist South Africa in alleviating water security challenges; however, groundwater usage is presently on an unsustainable path (DWS, 2016). As a result, South Africa's major aquifers are termed as being vulnerable (refer to Figure 6 for vulnerable area in which aquifers are located) due to over-abstraction, declining water levels and water quality degradation. For an indication of groundwater quality refer to Figure 7. By measuring the electrical conductivity at the various monitoring stations (Figure 8), the DWS is able to understand salinity. The Berg Olifants and Orange Water Management Areas represent the greatest threat in terms of electrical conductivity (>520 mS_m).

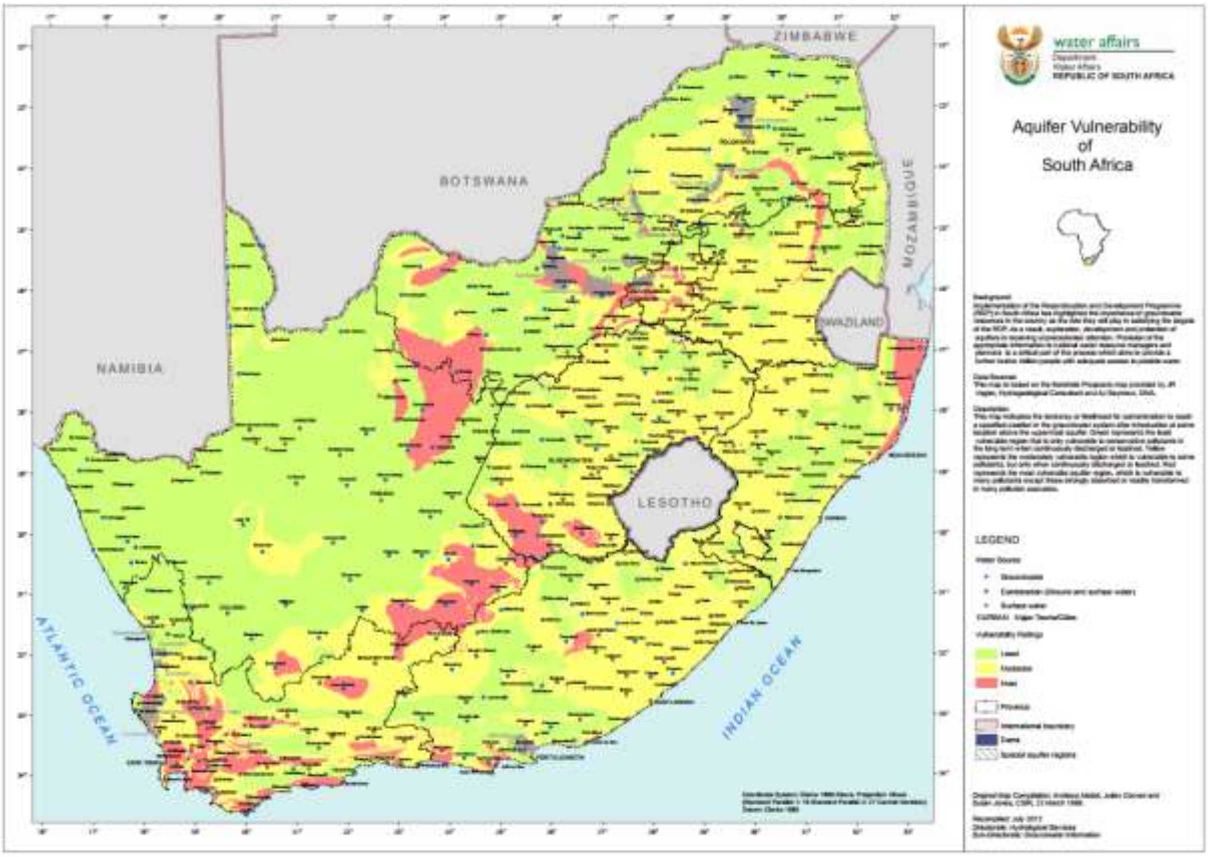


Figure 6: Aquifer vulnerability of South Africa (DWS, 2013)

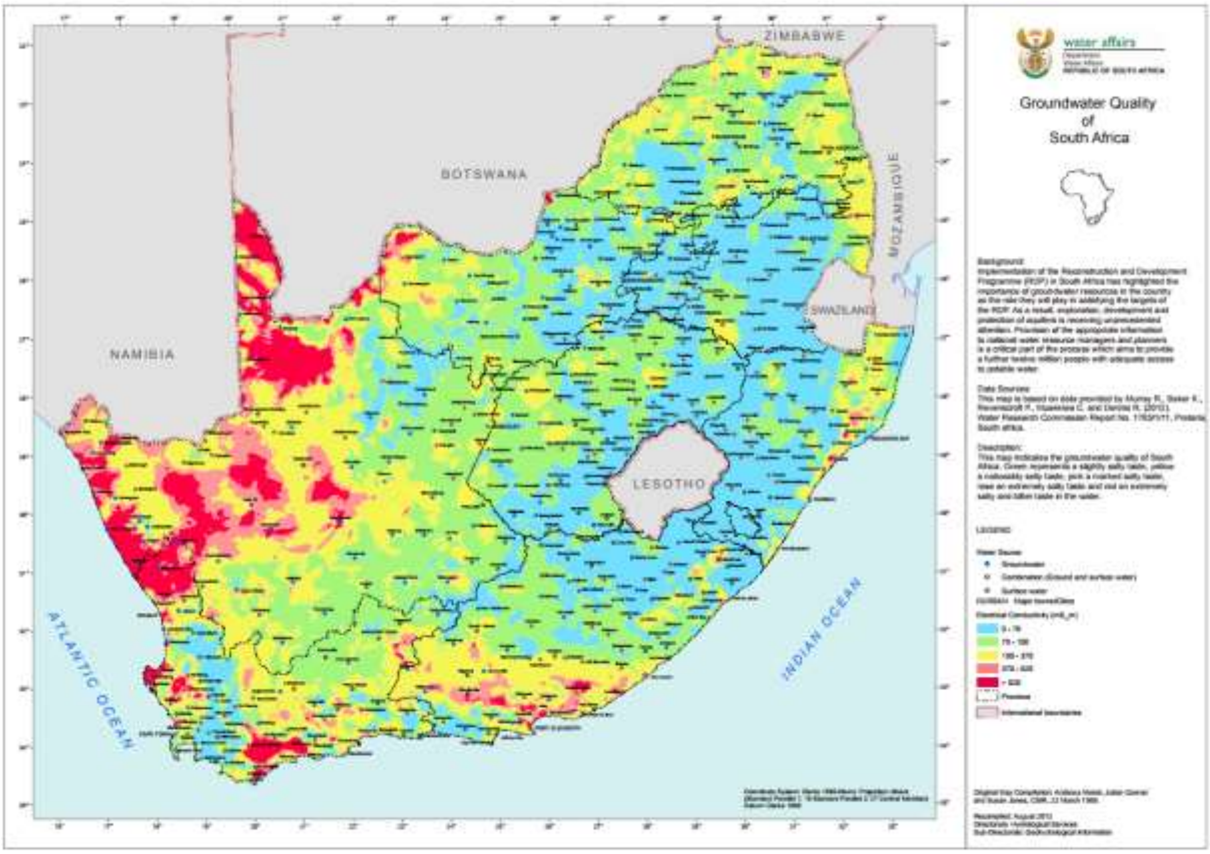


Figure 7: Groundwater quality of South Africa (DWS, 2012)

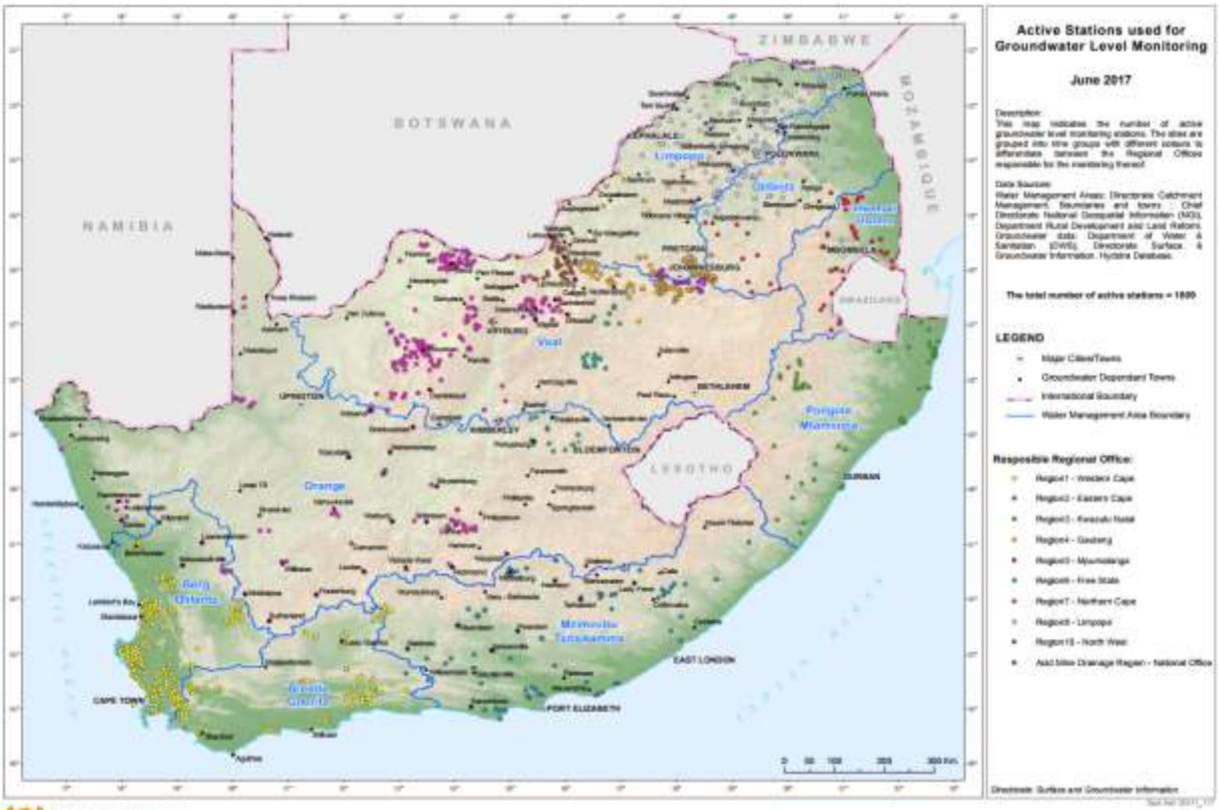


Figure 8: Active stations used for groundwater level monitoring

1.2.2 Water Quality

Water quality refers to the physical, chemical and biological characteristic of water and describes its suitability for use (Madhlopa *et.al.,* 2016). It is also an important concern in water resource management. The effects of water quality can be translated into health risks to humans, livestock and ecosystems (WWF-SA, 2017). WWF-SA (2017) further added that treatment of contaminated water is costly. The impacts and deterioration of water quality is attributed to effluent discharges and run-off from urban and industrial areas, seepage and discharges from areas that support mining and pollution from intensive agriculture (DWS, 2017b):

- "Sewage from urban areas is often not treated properly prior to discharge, due to inadequate or broken sewerage systems, overloaded or poorly managed sewage treatment plants, aging infrastructure and poor management capacity at municipal level resulting in poor operation and maintenance of infrastructure.
- Many industrial processes produce waste that contains hazardous or even toxic chemicals that are discharged into sewers, rivers or wetlands.
- Waste products disposed of in landfills or slag heaps may release pollutants that seep into nearby watercourses or groundwater.
- The mining sector is a significant source of water pollution, both immediate and long-term.
- Agricultural practices add to the pollution burden, with pesticides and fertilisers entering water resources".

The impacts of the above can be summarised into the percentage compliance for Electrical Conductivity (EC), sulphates, chloride, ortho-phosphates, ammonia, pH, *E.coli* and faecal coliforms (refer to Figure 9 for a summary of ideal, acceptable, tolerable and unacceptable levels for compliance).

Colour rating					
Compliance	0% - 20%	>20% - 40%	>40% - 60%	>60% - 80%	>80% - 100%

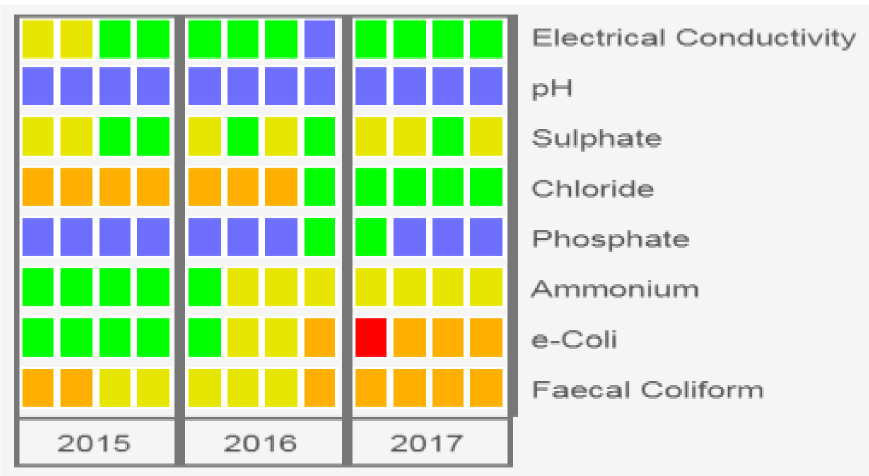


Figure 9: Summary of national percentage compliance (276 monitoring points) (DWS, 2017b)

Despite the poor water quality being attributed to anthropogenic activities, studies conducted by Peterson *et.al.* (2017) indicate that catchments altered by human and **natural events** reflect in changes in water quality. Further to this, the DWA (2013) specifies that water quality problems should be solved at the source. Consideration should therefore be given to determining water quality problems at the source.

(a) Wastewater treatment

The DWA (2013) identifies pollution from wastewater treatment works as a major concern. The effect of poor wastewater treatment results in eutrophication, microbiological contamination, micro-pollutants and increased salinity. Increased salinity is mostly attributed to poor waste water treatment and its effects result in depleted dissolved oxygen, which affects biodiversity.

Sewage contamination is a major challenge resulting in effluent of unacceptable quality is discharged into the environment (Rand Water 2015/15; SACN, 2016). Micro-pollutants resultant from poorly treated wastewater poses a serious threat to biota and humans. Aquatic biodiversity is particularly at risk from micro-pollutants and endocrine disrupting chemicals since the aquatic environment provides a sink for hormonally-active chemicals.

BOX 1. Trophic Status
Certain parts of KwaZulu-Natal, Eastern Cape and Limpopo provinces were found likely to be hypertrophic (extraordinary algae multiplication) (DWS, 2017). Various parts of the Limpopo catchment however, were reported to have many hypertrophic sites (DWS, 2017).

(b) Salinity

Dissolved solids in water systems (also known as salinity) come from agricultural return flows, urban and industrial run-off. Increased salinity of water has significant effects, such as reduced crop yields, scale formation and corrosion of water pipes, and changes in freshwater biotic communities. Salinisation is a persistent issue throughout most of South Africa. In some areas groundwater salinity is an issue, reporting yields above the recommended concentration for human consumption (Madhlopa *et.al.*, 2016) (refer to groundwater availability). Some river systems are however, naturally saline, which and therefore contributes to increased salinity of water sources (Madhlopa *et.al.*, 2016).

(c) Industrial pollutants

Mining and ore processing activities, particularly AMD
Acid mine drainage still remains a critical challenge to water quality (Rand Water, 2015/16). Decanting of acid mine water presents threats in the form of sinkhole formation and pollution of surface water and groundwater (Rand Water, 2015/16).

BOX 2. Initiatives by Rand Water

Short term plans involved the neutralisation of acid mine water by discharging into the Tweelopiespruit and Klip River from the Central Basin (Rand Water, 2015/16). The average salinity entering the receiving streams is 2500 – 3000 mg/l, while the result after dilution, in the Vaal River, is 570 mg/l. Challenges with the short term plan however, is that rainfall variability has seen the Vaal Dam reaching low percentages and there are many applications for new mines (Rand Water, 2015/16).

Industrial effluents containing pharmaceutical endocrine-disrupting chemicals in the manufacturing of products such as shampoo, pesticides, dyes and plastics

Emerging contaminants, for example pharmaceuticals, personal care products and endocrine disrupting compounds, have been given attention as a result of growing concern (WRC, 2015/16). Industrial effluents are an issue that primarily causes concern during and after wastewater treatment. Highly polluted industrial effluents released in large amounts into the water can potentially disrupt the biological processes in sewage treatments. Rand Water (2015/16) reported that large amounts of industrial effluent are entering the Vaal Barrage Catchment Area. Despite the Industrial Effluent Monitoring Programme being in place, certain industries are noted as having challenges. The edible oils industry, for example, is reported to combine all different waste water streams before treatment (Welz *et.al.*, 2017).

Agricultural runoff including fertilisers, sediment and pesticides

Agricultural activities are often a source of hazardous chemicals in water resources. Pesticides, in particular, created cause for concern since these have the potential to affect aquatic systems and human health, if entered into water systems (WRC, 2015/16). In high water yield areas and where great rainfall intensity is expected, sedimentation is also likely to occur. The effect of this leads to increased sedimentation in dams, which has implications for water treatment and water supply infrastructure (DWA, 2013). Notwithstanding the negative effects of agricultural runoff, runoff can potentially be managed through plantation forestry. Refer to the chapter on Land for the positive effect created through plantation forestry.

(d) Eutrophication

Eutrophication (the enrichment of water with nutrients) is noted to encourage the growth of microscopic green plants and algae, which promote the growth of cyanobacteria (van Ginkel, 2011), which can pose risks to the health of humans and biodiversity. As such, eutrophication also causes the depletion of oxygen in water which can lead to biota mortality. Apart from posing a risk to societal health, there are other detrimental effects associated with cyanobacterial and algal blooms, such as a reduction in the ability to use water bodies for recreational purposes and foul smelling odours which can be problematic to people who live near the water bodies.

In addition, there is growing concern about eutrophication, where wastewater treatment facilities are producing poorly treated water (Thornton *et.al.*, 2013). The DWS, through the NIWIS dashboard monitors eutrophication hotspots in South Africa or at Water Management Area scale. The measurement scale, *as represented below illustrates ratings for chlorophyll levels, mainly in dams*:

Class	Description	Key
Oligotrophic	Low in nutrients and not productive in terms of aquatic animal and plant life	**Nutrient levels**
Mesotrophic	Intermediate levels of nutrients, fairly productive in terms of aquatic animal and plant life and showing emerging signs of water quality problems	Low (green)
Eutrophic	Rich in nutrients, very productive in terms of aquatic animal and plant life and showing increasing signs of water quality problems	Medium (yellow)
Hypertrophic	Very high nutrient concentrations where plant growth is determined by physical factors. Water quality problems are serious and can be continuous	High (red)

Figure 10: Eutrophication hot spots as at 03 June 2017 (DWS, 2017d)[1]

Sources of eutrophication are domestic waste water treatment, the application of fertilizer on crops and industrial and mining processes (van Ginkel, 2011). Refer to the chapter on biodiversity and ecosystem functioning for further details on eutrophication.

[1] A total of 2554 samples were taken from 01 July 2016 till 03 June 2017.

(e) Microbiological pollutants

Informal settlements and rural areas in particular, are more susceptible to the effects of poor sanitation because sanitation services are still progressive. Sanitation services such as the collection, removal, disposal or treatment of human and domestic waste is still considered a challenge in South Africa (Trollip, 2016). This sector, although still considered an issue, is seeing breakthroughs by means of improvements in toilet design, pit emptying and sludge treatment (Trollip, 2016). Microbiological contamination of water resources can be attributed to informal settlements and poor wastewater treatment works.

In an effort to determine the extent to which health risks are incurred as a result of using untreated water from rivers and dams, the DWS monitors coliforms nationally. Between January 2016 and August 2017, a total of 518 samples were taken in the Vaal and Limpopo Water Management Areas. The results indicate that water users using untreated water in these Water Management Areas are likely to experience health risks.

Figure 11: Total coliform count as at 13 October 2017 (Source: DWS, 2017c)

Over and above the health risks, much research has been conducted investigating the link between water quality and microbiological safety of food (WRC, 2015/16). *Escherichia coli,* being a major concern, was found to be prevalent in irrigation water, which is indicative of contamination from sewage wastewater.

BOX 3. Microbiological compliance at municipal level

The microbiological compliance reported for 2014 (SALGA, 2016) illustrates that the national average achieved, as determined by the Blue Drop Certification programme, is 93% where the requirement is 97% (refer to Figure 12 for further details).

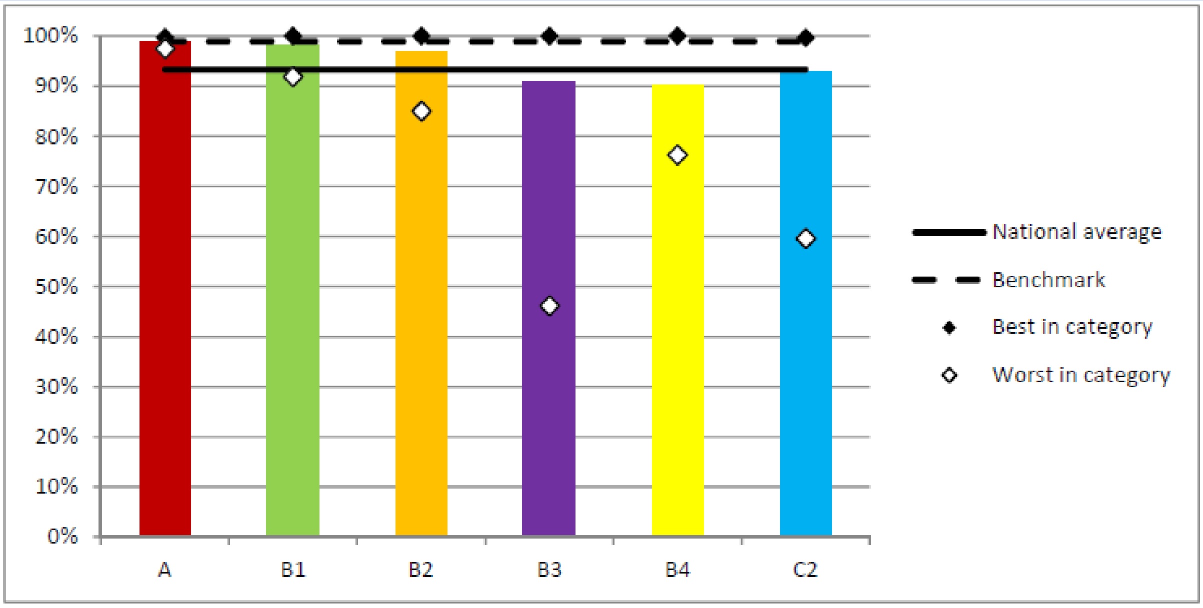


Figure 12: Microbiological compliance (*E.coli*/faecal coliform) over a 12 month period (Source: SALGA, 2014)[2]

1.2.3 Floods and droughts

Globally, the year 2016 was the hottest year recorded (WRC, 2017b). During this period, South Africa experienced one of the worst droughts in decades (National Treasury, 2017; WRC, 2017b), placing strain on the agricultural sector (declining agricultural output food price inflation) and consumers likewise (National Treasury, 2017). Despite 2016 having been the hottest year, drought conditions persist in various regions of South Africa. This becomes evident by the number of Water User Authorities placed under water restrictions. As seen in Table 4, restrictions are faced by a number of provinces.

Table 4: Intervention by restrictions

Province	Catchment	System	Dams (Schemes)	Comments
Western Cape	Breede, Gourits, Berg	Western Cape Water Supply, Clanwilliam	2 Systems	Urban sector compliant, irrigation not complying
Mpumalanga	Olifants	Mkhombo, Flag Boshielo	2 Dams	Monitoring of compliance still an

[2] A = Metropolitan municipalities; B1= Local municipalities with a large town or city as its urban core; B2 = Local municipality with a medium town or towns as its urban core; B3 = Local municipality with a small town or towns as its urban core; B4 = Local municipality with no urban core; C2 = District municipality.

Province	Catchment	System	Dams (Schemes)	Comments
				issue
Northern Cape	Karee Dam	Calvinia	1 System	Ground Water users restricted from 27 Jan 2017
KwaZulu-Natal	Umgeni, uMhlathuze, uMfolozi	Umgeni, uMhlathuze, Vryheid, Hluhluwe	4 (incl 3 systems)	Users complying with restrictions
Freestate	Caledon-Modder	Bloemfontein	1 System	Users complying with restrictions
Limpopo	Letaba	Tzaneen, Polokwane	2 Systems	Compliant
North West	Marico	Kleinmaricopoort	1	Compliant
Eastern Cape	Gamtoos, KromRiver	Algoa	1 system	Compliant

BOX 3. Initiatives by Rand Water

Cape Town, for example, has experienced the worst drought since 1904 (WRC, 2017). The drought in particular has been impactful, resulting in losses of maize exports. This created a ripple effect which resulted in job losses of 37 000 in the agricultural sector (WWF-SA, 2017).

1.2.4 Functioning ecosystems

Aquatic ecosystems provide numerous goods and services, including, among others, the ability of wetlands to purify water, buffer and attenuate flooding, regulate stream flow and control geomorphological processes (WRC, 2017).

Freshwater ecosystems provide valuable natural resources, with economic, aesthetic and recreational value. The integrity of these ecosystems is however, in a decline (Trollip, 2016). Trollip (2016) reports the decline is a result of challenges that are practical, socio—economic and institutional. Practically, management of large areas between land and freshwater ecosystems is an issue. Socio-economically, there are challenges of competition for the use of water and institutionally, challenges exist between appropriate co-governance and co-management mechanisms.

Many of South Africa’s wetland and river ecosystem types are threatened. This is concerning since wetlands make up 2.4% of the country’s surface area (Colvin *et.al.*, 2016). From the total number of wetlands, South Africa currently has 23 sites designated as Wetlands of International Importance (Ramsar Sites), with a surface area of 557,028 hectares (Ramsar, 2017). Of the 1,014 total freshwater ecosystem types, Colvin *et.al.* (2016), identified that wetland ecosystems and river ecosystems are still threatened and critically endangered (refer to Table 5).

Table 5: Breakdown of South Africa's freshwater ecosystems (Source: Colvin *et.al.*, 2016)

Type of ecosystem	Number of ecosystems	Percentage threatened	Percentage critically endangered
Wetland ecosystem	791	17	48
River ecosystem	223	25	32

Stormwater drainage systems contribute to impacts on freshwater ecosystems (Trollip, 2016). At the municipal level, Trollip (2016) reports advancements in stormwater drain technology such as permeable paving, green roofs and Sustainable Drainage Systems (SuDS) treatment trains, to help mitigate the problem. Stormwater drainage systems is only one challenge contributing to freshwater ecosystems being impacted on, other challenges are presented in Table 6. Additionally, water bodies complying with national water quality statistics is poor overall. Open water bodies with good quality is 47.79% while river bodies with good quality is 45%; these statistics are exclusive of faecal coliform bacteria and does include pH, electrical conductivity, dissolved oxygen, nitrogen and phosphorous (DWS, 2017e).

Table 6: Challenges to freshwater ecosystems

<table>
<tr><th>Areas requiring attention</th><th>Effects</th></tr>
<tr><td>Freshwater aquaculture</td><td>Linked to Outcome 4 of the Outcomes Approach Delivery Agreement as a means to increase recovery levels for key fisheries (hake, abalone and rock lobster). Despite the need to increase recovery levels for key fisheries, the effect that freshwater aquaculture has is that water reticulation is high.</td></tr>
<tr><td>Free-flowing rivers (perennial)</td><td>Colvin et.al. (2013) presented a summary of South Africa’s water source areas and main rivers flowing from the water source areas. Identified free-flowing rivers are listed in Table 7.

Table 7: List of free-flowing rivers (Colvin et.al.,2013)
<table>
<tr><th>Province</th><th>Water source area</th><th>Free-flowing river</th></tr>
<tr><td rowspan="2">Western Cape</td><td>Grootwinterhoek and Langberg Mountains</td><td>Doring</td></tr>
<tr><td>Boland Mountains</td><td>Rooiels</td></tr>
<tr><td rowspan="4">Eastern Cape</td><td>Tsitsikamma</td><td>Groot Storms and Bloukrans</td></tr>
<tr><td>Amatole</td><td>Riet, Kap, Mpekweni and Mgwalana</td></tr>
<tr><td>Eastern Cape Drakensburg</td><td>Kobonqaba, iNxaxo, Qhorha, Shixini, Nqabarha, Ntlonyane, Xora, Mncwasa, Mdumbi and Kraai</td></tr>
<tr><td>Pondoland Coast</td><td>Mtakatye, Mnenu, Sinangwana, Mngazana, Mntafufu, Mzintlava, Mkozi, Msikaba, Mtentu, Sikombe, Mpahlane</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Areas requiring attention</th><th>Effects</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td></td><td>and Mzamba</td></tr>
<tr><td rowspan="3">Kwa-Zulu Natal</td><td>Southern Drakensburg</td><td>Mtamvuna; Mkomazi; Mzimkhulu; Nsonge</td></tr>
<tr><td>Mfolozi Headwaters</td><td>Mkuze, Black Mfolozi, Nsonge, Nondweni, Ngogo, Mfule and Nyalazi</td></tr>
<tr><td>Zululand Coast</td><td>Nsuze</td></tr>
<tr><td rowspan="2">Mpumalanga</td><td>Mpumalanga Drakensburg</td><td>Elands, Mbyamiti andNwanedzi-Sweni</td></tr>
<tr><td>Enkangala Drakensberg</td><td>Ntombe, Hlelo and Upper Vaal</td></tr>
<tr><td rowspan="2">Limpopo</td><td>Wokberg</td><td>Mohlapitse</td></tr>
<tr><td>Soutpansberg</td><td>MutaleLuvuvhu</td></tr>
</table>

Major threats to rivers were land degradation, climate change, invasive alien plants, fires, large-scale plantations and coal-mining (Colvin et.al., 2013). In total, there are 21 water source areas, 16 of which are recognised as South Africa’s strategic water source areas (Colvin et.al., 2013). The importance of this, should the water source areas and rivers not be sufficiently protected, is potential impacts on food and water security, and ultimately economic growth.
</td></tr>
<tr><td>Invasive alien plants</td><td>Contributing to threatened ecosystems is alien invasive species for which biological control procedures have led to approximate annual savings of R6.5 billion (Colvin et.al., 2016; Peterson et.al., 2017). The extent to which invasive alien plants affects water availability however, does not only have effects on surface water but also groundwater (WRC, 2016). The Prosopis was reported to have adaptive capabilities which manipulate groundwater (WRC, 2016). Peterson et.al. (2017) reported that a large portion of natural vegetation in the Duiwe River catchment was replaced by invasive alien plants such as A. mearnsii, A. melanoxylon and Eucalyptus species. The impact of invasive alien plants therefore has a quantitative and qualitative impact on water. For in-depth understanding of the effect of invasive alien plants, refer to the chapter on biodiversity and ecosystem functioning.</td></tr>
</table>

1.3 Responses

The sustainable use of water resources is dependent on informed decision-making and management. The key pillar of this is the extent, efficacy and integration of water resource monitoring programmes. Programmes under the Expanded Public Works Programme (EPWP) such as Working for Ecosystems, Working for Water, Working for Wetlands and Maps of Natural Resource Management priority areas make significant ground environmentally as well as socially, through job creation. These programmes are fall under the Department of Environmental Affairs (DEA). Under the DWS, an initiative such as investigating the feasibility of developing an aquifer health programme is underway. The purpose of the potential programme is to raise awareness to communities, municipalities and other relevant stakeholders regarding the protection of vulnerable aquifers (DWS, 2017e).

The National Water Resource Strategy 2 (DWA, 2013) describes achieving a water balance as a mix of water resources required to reconcile supply and demand. The water mix is listed as follows:

- Demand management;
- Water resource management;
- Managing groundwater resources;
- Re-use of water;
- Control of invasive alien vegetation;
- Re-allocation of water;
- Development of surface water resources; and
- Inter-catchment transfers.

The water mix provides a holistic and integrated management approach however, is still in the process of being expanded or built up.

1.3.1 Water planning and shortages

The economically available yield and volume of surface water yield is very low for South Africa with only 9% of South Africa's rainfall enters surface water streams (Colvin *et.al.*, 2016). The current water allocation is approximately 15 billion m^3, with expected demand of 17.7 billion m^3 by the year 2030 (Colvin *et.al.*, 2016). The 32% projected increase is mostly attributed to by population growth and industrial development. It is important to note that 60% of transboundary waterflow is shared between South Africa, Lesotho, Swaziland, Mozambique, Botswana and Namibia (Colvin *et.al.*, 2016). This plays a major part in planning initiatives.

Alternative measures are therefore being explored to alleviate and prepare for extreme situations in certain regions. The Annual Report for the WRC (2015/16) highlights research initiatives in wastewater treatment technologies such as activated sludge, bio/trickling filters, rotating biological reactors, wastewater ponds, septic tanks and aerobic granular activated sludge. Projects initiated by private institutions, and state-owned institutions include:

- A water reclamation plant, treating water from three thermal coal operations and utilising desalination technology, was established to alleviate pressure (WWAP, 2017).
- Wastewater recycling in thermal power generation is undertaken by the Lethabo Power Station, in Sasolburg, Free State (WWAP, 2017).

Although the WWF-SA (2017) identified solutions such as desalination, it is also reported that this is a highly costly and energy-intensive process. This solution, however, is making grounds in the form of accelerating the Innovative Desalination and Water Manufacturing Programme (WRC, 2017). This programme will be active between 2017 and 2020. Other programmes of particular interest include the Water Industrial Development Plan, the Next Generation Sanitation Cluster Development

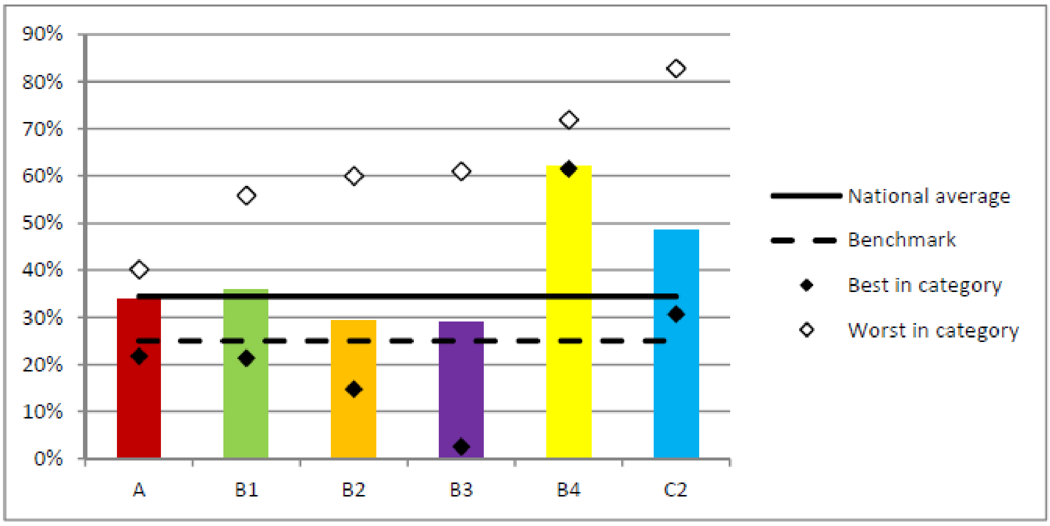
Programme, and the Modular and Advanced Wastewater Technologies Manufacturing and Capability Build Programme (WRC, 2017). A significant programme with focus on water and sanitation is the Industrial Policy and Action Plan (IPAP) 2017, which links to the Sustainable Development Goals (SDG) through build-up in the private sector as well as through entrepreneurial opportunities (WRC, 2017). Planning sufficiently for water shortages as well as instances where there may be water surpluses is an issue that therefore, requires integrative planning.

To effectively plan for drought and flooding situations, a drought portal was launched by the WRC and sector partners to provide water users with information. South Africa, as indicated by the African Flood and Drought Indicator (WRC, 2017a) is highly susceptible to drought conditions. The African Flood and Drought Indicator (WRC, 2017a) also indicate that South Africa has very low soil infiltration leading to water flowing overland. More focus should be given to address issues and concerns around climate change related effects such as flooding and drought (refer to the climate change chapter for further details). Drought, in particular, has significant impacts agricultural practices (this is further discussed in the land chapter).

1.3.2 Water conservation and water demand management

Water Conservation and Water Demand Management (WC/WDM) has been recognised as one of the most important principles that will ensure sustainable, efficient and effective service delivery (DWA, 2013). WC/WDM seeks to address challenges encountered in water supply and demand. These include physical loss of water, capital requirements for new infrastructure and the constraints of poor water availability (DWA, 2013). The primary focus, based on the KPI/target is the reduction of water loss by 50%.

The non-revenue water/system input volume for the 2014 assessment period was reported as 34%, despite the proposed benchmark being 25% (SALGA, 2014) (Figure 13). The DWS, in 2013, initiated a "No Drop" report assessment (DWA, 2013b), which builds on the success of the Blue and Green Drop Certification Programmes. Ageing infrastructure, inadequate maintenance and repairs of existing infrastructure, long response time to water leaks/bursts, technical competency shortcomings in municipalities and a culture of water wastage are some of the challenges facing South Africa. The DWS designed and implemented the "No Drop" assessments to provide verified data to support and build on results.



	Best In Category					
Benchmark	**A**	**B1**	**B2**	**B3**	**B4**	**C2**
25%	City of Cape Town (WC) 21.8%	Stellenbosch (WC) 21.4%	Saldanha Bay (WC) 14.8%	Ubuntu (NC) 2.6%	Joe Morolong (NC) 61.6%	Ugu (KZN) 30.7%

Figure 13: Non-revenue water across South Africa (Source: SALGA, 2014)[3]

Further to the monitoring of non-revenue water, the MBI built on understanding the progress made by municipalities in terms of developing a "Water Loss Management Plan and Water Balance". Nationally, between 30 – 40% of municipalities have developed a both plans while between 30 – 40% of municipalities have developed none.

1.3.3 Suitability of water for use

The Blue Drop and Green Drop Programmes have been designed by the DWS to encourage municipalities improve the performance of Water Purification Plants and WWTWs. The main purpose of the Blue Drop Programme is to improve drinking water quality while the Green Drop Programme is to ensure discharge effluents that comply to set effluent standards. The continuation and support of these programmes, as well as the introduction of the No Drop Programme is considered a successful approach in waste water treatment and good water quality.

(a) Blue drop status

The DWS introduced the Blue Drop Certification Programme in 2008 as regulatory programme. A total of 763 water supply systems were assessed for compliance with Blue Drop regulatory standards, with 316 non-compliant water supply systems (DWS, 2015/16). Confirming the challenges faced by municipal water services, the results for whether "water treatment works are operated by staff with correct skills/qualifications and experience (as per the Blue Drop requirements)" showed varying outcomes for skilled staff at water treatment works.

[3] A = Metropolitan municipalities; B1= Local municipalities with a large town or city as its urban core; B2 = Local municipality with a medium town or towns as its urban core; B3 = Local municipality with a small town or towns as its urban core; B4 = Local municipality with no urban core; C2 = District municipality.

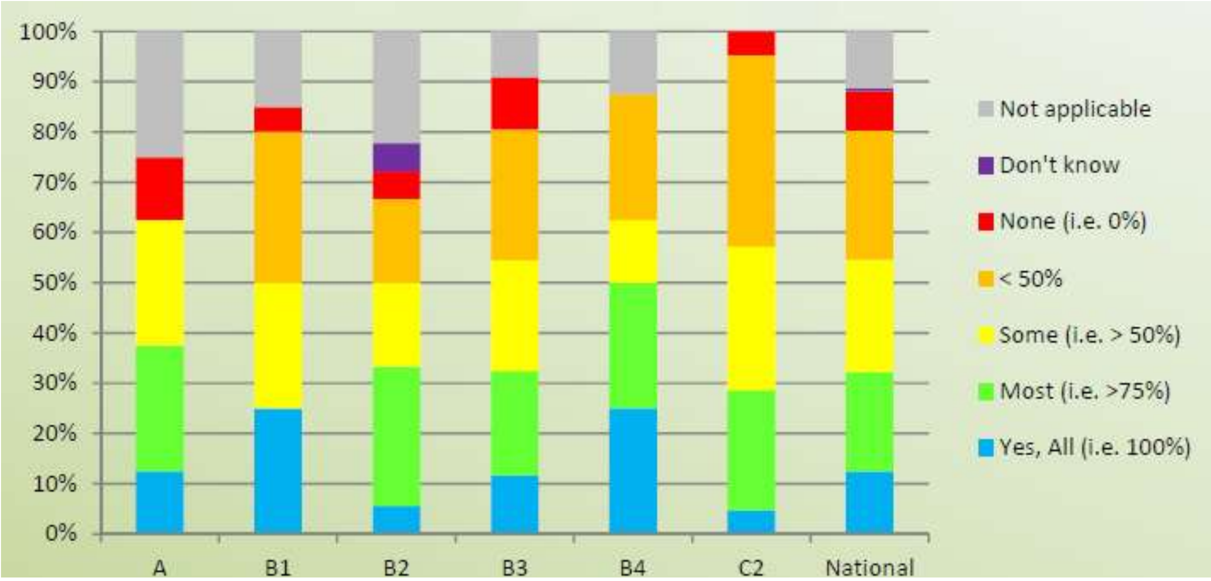


Figure 14: Percentage skilled staff at water treatment works (Source: SALGA, 2016)[4]

(b) Green drop status

A total of 318 non-compliant wastewater systems were assessed for compliance with Green Drop regulatory standards (DWS, 2015/16). Confirming the challenges faced by municipal water services, the results for whether "waste water treatment works are operated by staff with correct skills/qualifications and experience (as per the Green Drop requirements)" showed varying outcomes for skilled staff at waste water treatment works.

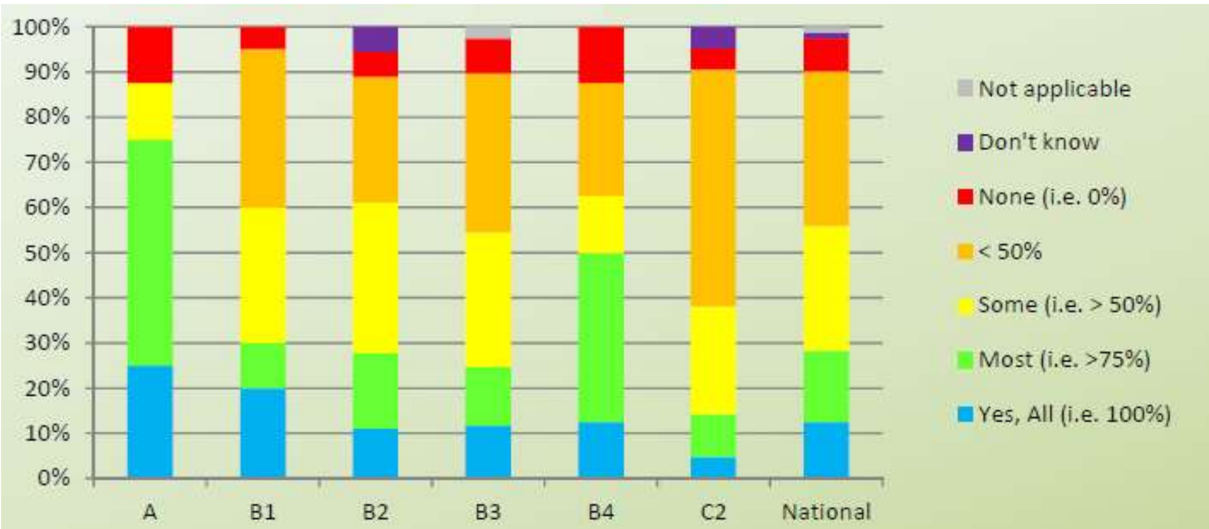


Figure 15: Percentage skilled staff at waste water treatment works (Source: SALGA, 2016)

[4] A = Metropolitan municipalities; B1= Local municipalities with a large town or city as its urban core; B2 = Local municipality with a medium town or towns as its urban core; B3 = Local municipality with a small town or towns as its urban core; B4 = Local municipality with no urban core; C2 = District municipality.

1.3.4 Water-energy-food nexus

In South Africa, the W-E-F nexus is primarily discussed within the context of water and energy or water and food, however not in combination of all three. This section therefore, provides an overview of responses pertaining to water and energy, followed by water and food.

Globally, the Water-Energy-Food (W-E-F) nexus is becoming more topical. Each component of W-E-F is dependant of each other and the use or consumption of one is dependent on the availability of the others. The World Bank (2017) has embarked on a global initiative called Thirsty Energy to help countries tackle the challenges of managing the water-energy nexus in an integrated manner. Launched in January 2014, the Thirsty Energy initiative is aimed at helping countries integrate water constraints into their energy sector planning; and better address other water and energy challenges. In South Africa, sustainable development in the energy sector includes various types of renewable energy. Particularly relating to hydropower, South Africa has an installed capacity of 3, 958 MW; this value excludes independent power producers (DWS, 2017e). The challenge with hydropower however, is that South Africa is already a water stressed country; therefore drought situations may make this an unreliable source of power.

Investment in water supply and infrastructure influences what energy solutions can ultimately, be implemented. And vice versa, the energy sector influences investments in water supply. Water is a major requirement for power production and industry. Yet power is needed to pump the water to the power plants and industries. Vital for life, water and energy are critical aspects of any economy. They also are inextricably linked: access to one often depends on availability of the other, and the infrastructure required to supply both resources is interconnected. Emerging practices that are energy intensive includes the adoption of shale gas for electricity generation. Consideration, should however be given to the broader water-related risks.

Water relating to food, also experiences its own set of challenges however, there is little information regarding a national perspective. Food security is referred to within the context of households and the use of water wise measures for backyard gardens.

1.4 Conclusion

The demand for water in South Africa is increasing as the population grows and the country develops. Practices supporting anthropogenic activities are noted to contribute to the state of water resources. The state of many of our water resources continues to deteriorate. Combating concerns around water availability, water quality and the state of ecosystems are a number of programmes and initiatives undertaken by government. The Green Drop and Blue Drop Programmes are two such examples that have been successfully implemented and are continuously monitored. The results however, do indicate a need to identify and address problems at the root.

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CLIENT	:	Department of Environmental Affairs	
PROJECT NAME	:	Development of the SAEO Report	J37105
TITLE OF DOCUMENT	:	Development of the SAEO Report	

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