Post-Drought and Emergency Interventions: Towards Higher Water Security

Report to the
Water Research Commission

by

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Executive summary

Despite the frequency of droughts in South Africa, the responses to drought are mostly reactive dealing with drought in an emergency mode rather than it being a normal, recurrent feature. The aims of the project were: identify and review lessons and initiatives from past and ongoing drought periods and major disturbances; verify and test sustainability of implemented initiatives; provide a framework for developing strategic water resilience initiatives at all levels. The review was based on a literature review and case study area investigations. The case study areas included Nelson Mandela Bay Metropolitan Municipality, Beaufort West Local Municipality and Nama Khoi Local Municipality.

The analysis showed that there are initiatives that supported pro-active drought response development in the form of climate change response plans. In the response plans the most frequent strategy is catchment rehabilitation, e.g. invasive species removal and the second most proposed strategy water conservation and demand management. Operation and maintenance of water structure and consumer education also featured highly in responses. The least favoured response was water transfer followed by promotion of greywater use, introduction of water efficient fittings, leak repairs, tariff, metering and credit control, and water sensitive designs. However, implementation of these initiatives through integration into the Integrated Development Plans (IDPs) was not clearly demonstrated and limited literature was available to verify implementation measures. For example, the Nooitgedagt Low-Level Scheme, using the Orange River was identified as an option to lessen water supply risks to NMBM in which Phase 1 was identified in the 2005-2020 Water Master Plan for completion by 2008 and Phase 2 by 2009. Phase 1 was completed by mid-2013, but numerous delays due to funding issues meant that Phase 2 was only completed in mid-2017, and the completion date for the final Phase 3 as recent as June 2021.

The Capital Portfolio Approach (CPA) approach was used to analyse resilience of urban water security for three case study areas. This is a suggested framework for developing strategic resilience at all levels. Four types of capital are required for public water supply services, and one, “social capital” complements or replaces insufficient public services. The five capitals comprise the following as developed by Krueger et al. (2019b, 2020):

- **Natural Capital**: The water resources accessed by the municipality, including the total volume of naturally available, captured, reused, desalinated water, etc.

- **Physical Capital**: The infrastructure to store, treat and distribute water customers at drinking water quality.
- **Political Capital**: The management efficacy exercised by the municipal water governance system with the ability to operate and maintain water supply services.
- **Financial Capital**: The ability to leverage and spend funding to build, operate and maintain the water system.
- **Social Capital**: The ability of a municipality or the public to adapt to insufficient [funding and] public services.

Each of the five capitals is quantified in three dimensions: its availability, robustness, and risk and includes aspects such as diversity, anticipation of shocks and preparedness to deal with disturbances. The combination of natural, human, financial and engineered elements (here: the five capitals) determines whether a city can achieve or maintain water supply security. During extended drought conditions, the towns or cities that are unprepared are left with few alternatives and are confronted with no or intermittent water supplies or excessive water restrictions. The proposed methodology was applied to three case study areas:

- **Nelson Mandela Bay Metropolitan Municipality** (NMBM) is a Category A municipality, experiencing persistent droughts resulting in acute water shortages. This is the current case as the Kouga dam, NMBM largest supply reservoir, has dropped to its lowest-yet level since it was built in 1969.
- The **Beaufort West Local Municipality** is a Category B municipality within the Central Karoo District in the Western Cape Province. Beaufort West has chronic water shortages. The water demand and availability are under constant threat, requiring urgent interventions in resource development and infrastructure establishment.
- The **Nama Khoi Local Municipality** is a Category B municipality situated on the north-western side of the Northern Cape Province in the Namakwa District

NMBM has low levels of capital availability and robustness. It has high levels of risk for all capitals. The relatively higher water availability reflects normal water supply situation. During drought, the water supply situation deteriorates dramatically, as is the current case. The ability of the communities to adapt to drought situation is low. Like NMBM, the Beaufort West has low levels of capacity and robustness. Although the Natural Capital is high under normal conditions during drought situation, the Natural Capital declines significantly. The community adaption is relatively higher

because of the reliance on more than one source of water, but the management capabilities are weak. The same issues apply to the Nama Khoi Municipality.

Any Municipality under water stress needs a long-term strategy for drought resilience interventions that considers long-term conditions and plans for permanent solutions Such a drought resilience intervention should include stakeholder engagement, functioning institutions and diversity of water sources and co-operation between local, regional and national levels of government.

- **Ensuring stakeholder engagement:** Designing drought resilience interventions requires effective and meaningful stakeholder engagement. This is a crucial prerequisite to building trust, ownership and acceptability. The reframing of stakeholder engagement as a process of social learning opens options than just participation. One of the key weaknesses in responding to, or planning for, wicked problems such as drought is to oversimplify the problem as only meteorological, as well as to adopt a technical focus with limited technical skills to act.
- **Functioning institutions**: Implementing resilience interventions requires functioning institutions to ameliorate drought impacts. Management of droughts in South Africa is facilitated by several enablers such as community leadership structures and available extensions services, although impacted upon by several barriers such as knowledge and financial constraints.
- **Horizontal and vertical co-operation**: Multiple organisations and stakeholders play a part in drought resilience in Local Municipalities. This includes formal and informal institutions. Integration – both vertical (within the sector) and horizontal (across different established sectors) – is fundamental to balanced local-level governance and policy making.
- **Ecological and critical built infrastructure**: Investing in water-related ecological infrastructure, with built infrastructure, will deliver more clean water. A framework and guidelines for water sensitive urban design for South Africa was developed to transition to water sensitive cities.
- **Improve system efficiency**: Implementing measures to conserve water and minimise losses within reticulation systems are critical to ensuring for drought preparedness.
- **Diversify of water sources**: To achieve water security requires diversifying water sources to include water reuse, stormwater capture, recycled wastewater, groundwater and more.

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List of Acronyms

CPA	Capital Portfolio Approach
FSC	Full storage capacity.
IDP	Integrated Development Plan
MDMC	Municipal Disaster Management Centre
NDMC	National Disaster Management Centre
PDMC	Provincial Disaster Management Centres
SWOT	Strengths, weaknesses, opportunities and threats

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1. Introduction

Drought is a common occurrence in South Africa, with major droughts recorded in 1964; 1986; 1988; 1990; 1995; 2004; 2015-2019. Drought can be categorized into six categories, namely meteorological, agricultural, hydrological and socio-economic, with the addition of two emerging categories, i.e. ecological and anthropogenic droughts (Jovanovic et al., 2020; Box 1). Jovanovic et al. (2020) underlined the physical properties of drought which are timing, intensity, duration and aerial extent, along with the frequency of occurrence.

Box 1: Common terminology and definitions related to drought (as cited by (Jovanovic et al., 2020)

Terminology	**Definition**
Drought	Natural but temporary imbalance of water availability caused by the lack of precipitation and high temperatures
Meteorological drought	Occurrence of reduced precipitation (e.g. <70%) compared to the long-term average for a particular region (Bruwer, 1993)
Agricultural drought	Prolonged insufficiency of available water, e.g. soil moisture, during the growth stages of crops, which often results in a reduction in yield (Pereira et al., 2009).
Hydrological drought	Persistently abnormally low water volumes in streams, reservoirs, rivers, aquifers (Pereira et al., 2009)
Anthropogenic drought	Water shortage caused and modified by human processes (Van Loon et al., 2016)
Ecological drought	Drought impacting on ecosystems and the "Natural Capital" they provide to human communities in terms of ecosystem services, e.g. quality regulation, waste treatment, erosion prevention, and recreation (Crausbay et al., 2017)
Socio-economic drought	Water demand exceeding the available supply causing damage to population, economy and society (Pereira et al., 2009)

Recently in South Africa, the surface water storage was at its lowest in 2016 at about 49 percent of full storage capacity (FSC) (Figure 1). In the early 1980s, the FSC was about 34 percent again in the early to mid-nineties (Baudoin et al., 2017). The groundwater levels since 2011 have been normal, not showing significant declines at a national level (Figure 2).

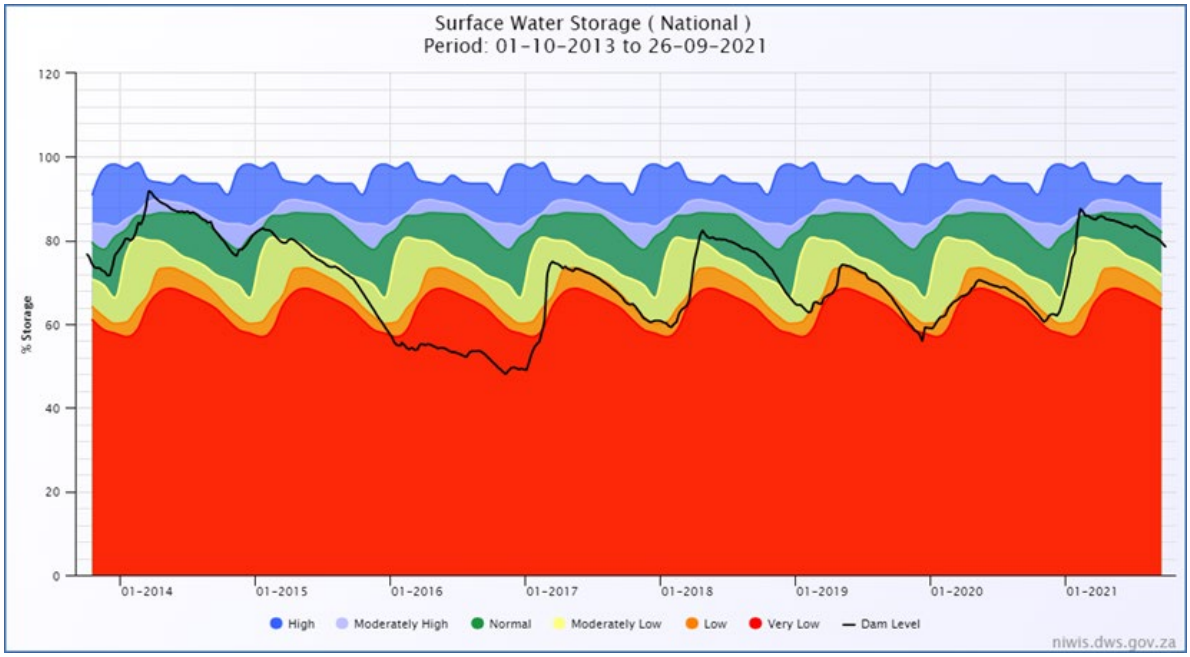


Figure 1: National surface storage from 2014-2021 (https://www.dws.gov.za/niwis2/DroughtStatusManagement/DamStatusOverview)

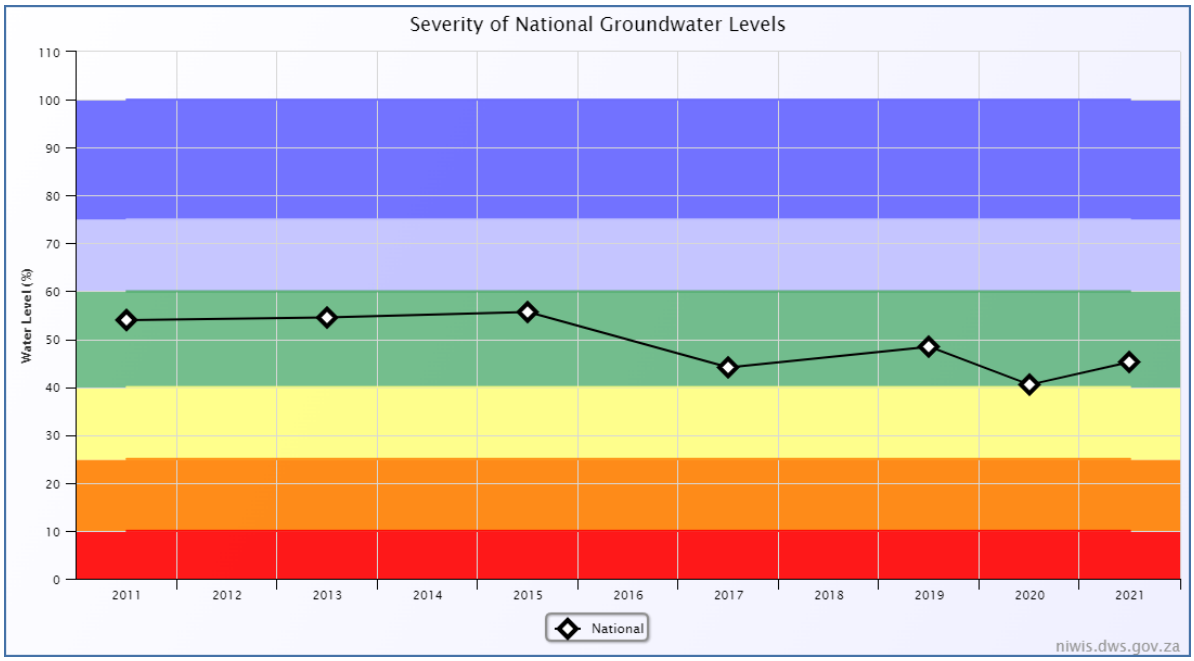


Figure 2: Severity of national groundwater levels 2011-2021 (https://www.dws.gov.za/niwis2/DroughtStatusManagement/GroundwaterStatusOverview)

Despite the frequency of droughts, the responses are mostly reactive dealing with drought in an emergency mode rather than it being a normal, recurrent feature. The transition from crisis to risk management has not been achieved. Around 90 percent of financing for disaster risk mitigation is directed at emergency response and reconstruction, leaving a shortfall in preparatory measures and resilience (Hughes, 2019). A re-active approach frequently deals

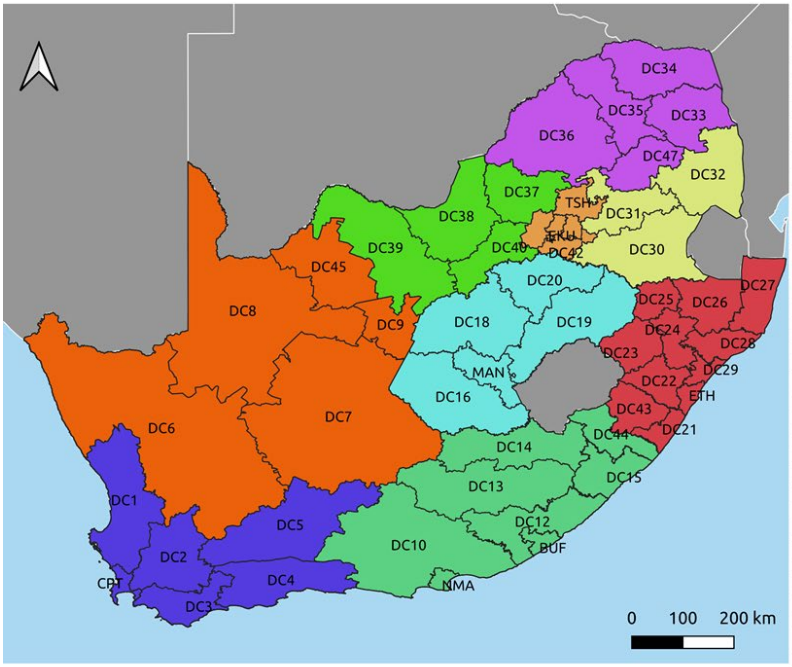
with the symptoms rather than the underlying causes for the vulnerabilities associated with the impacts. These post-impact interventions are normally relief measures in the form of emergency assistance programs aimed at providing money or other specific types of assistance (e.g. livestock feed, water, food) to the victims (or those experiencing the most severe impacts) of the drought (Wilhite et al., 2014). This reactive approach is unsound from the perspective of vulnerability reduction since the recipients of this assistance are not expected to change behaviours or resource management practices as a condition of the assistance (Wilhite et al., 2014). This situation is exacerbated by poorly operated and maintained water supply infrastructure, resulting in socio-political and economic impacts. Further, complex, and seemingly bureaucratic hurdles limiting action are shown to be cumbersome factors that impede and continue to frustrate effective drought response in the country (Baudoin et al., 2017).

The aims of the project are:

- Identify and review lessons and initiatives from past and on-going drought periods and major disturbances.
- Verify and test sustainability of implemented initiatives.
- Provide a framework for developing strategic water resilience initiatives at all levels.

This report focuses on the status of drought plans and responses in municipalities. This was done through an internet search of documentation on District Municipalities and Metropolitan Municipalities websites (Figure 3). For water utilities, drought resilience is the ability to respond to immediate water supply threats, withstand drought impacts and recover quickly (EPA 2016). Recovery includes considering long-term conditions and planning for permanent solutions. Drought-resilient utilities (EPA 2016):

- Take action to protect human health and the environment, while maintaining a minimum level of service for customers during drought.
- Manage decreases in water supply, increases in water demand and changes in water quality.
- Plan for future changes in weather and climate patterns that can reduce water supply.



Code	Name	Province	Seat	Key
DC1	West Coast District Municipality	Western Cape	Moorreesburg	1
DC2	Cape Winelands District Municipality	Western Cape	Worcester	2
DC3	Overberg District Municipality	Western Cape	Bredasdorp	3
DC4	Garden Route District Municipality	Western Cape	George	4
DC5	Central Karoo District Municipality	Western Cape	Beaufort West	5
DC6	Namakwa District Municipality	Northern Cape	Springbok	6
DC7	Pixley ka Seme District Municipality	Northern Cape	De Aar	7
DC8	ZF Mgcawu District Municipality	Northern Cape	Upington	8
DC9	Frances Baard District Municipality	Northern Cape	Kimberley	9
DC10	Sarah Baartman District Municipality	Eastern Cape	Port Elizabeth	10
DC12	Amathole District Municipality	Eastern Cape	East London	12
DC13	Chris Hani District Municipality	Eastern Cape	Komani	13
DC14	Joe Gqabi District Municipality	Eastern Cape	Barkly East	14
DC15	OR Tambo District Municipality	Eastern Cape	Mthatha	15
DC16	Xhariep District Municipality	Free State	Trompsburg	16
DC18	Lejweleputswa District Municipality	Free State	Welkom	18
DC19	Thabo Mofutsanyana District Municipality	Free State	Phuthaditjhaba	19
DC20	Fezile Dabi District Municipality	Free State	Sasolburg	20
DC21	Ugu District Municipality	KwaZulu-Natal	Port Shepstone	21
DC22	uMgungundlovu District Municipality	KwaZulu-Natal	Pietermaritzburg	22
DC23	uThukela District Municipality	KwaZulu-Natal	Ladysmith	23
DC24	uMzinyathi District Municipality	KwaZulu-Natal	Dundee	24
DC25	Amajuba District Municipality	KwaZulu-Natal	Newcastle	25
DC26	Zululand District Municipality	KwaZulu-Natal	Ulundi	26
DC27	uMkhanyakude District Municipality	KwaZulu-Natal	Mkuze	27
DC28	King Cetshwayo District Municipality	KwaZulu-Natal	Richards Bay	28
DC29	iLembe District Municipality	KwaZulu-Natal	KwaDukuza	29
DC30	Gert Sibande District Municipality	Mpumalanga	Ermelo	30
DC31	Nkangala District Municipality	Mpumalanga	Middelburg	31
DC32	Ehlanzeni District Municipality	Mpumalanga	Mbombela	32
DC33	Mopani District Municipality	Limpopo	Giyani	33
DC34	Vhembe District Municipality	Limpopo	Thohoyandou	34
DC35	Capricorn District Municipality	Limpopo	Polokwane	35
DC36	Waterberg District Municipality	Limpopo	Modimolle	36
DC37	Bojanala Platinum District Municipality	North West	Rustenburg	37
DC38	Ngaka Modiri Molema District Municipality	North West	Mahikeng	38
DC39	Dr Ruth Segomotsi Mompati District Municipality	North West	Vryburg	39
DC40	Dr Kenneth Kaunda District Municipality	North West	Klerksdorp	40
DC42	Sedibeng District Municipality	Gauteng	Vereeniging	42
DC43	Harry Gwala District Municipality	KwaZulu-Natal	Ixopo	43
DC44	Alfred Nzo District Municipality	Eastern Cape	Mount Ayliff	44
DC45	John Taolo Gaetsewe District Municipality	Northern Cape	Kuruman	45
DC47	Sekhukhune District Municipality	Limpopo	Groblersdal	47
DC48	West Rand District Municipality	Gauteng	Randfontein	48
BUF	Buffalo City Metropolitan Municipality	Eastern Cape	East London	49
CPT	City of Cape Town Metropolitan Municipality	Western Cape	Cape Town	50
JHB	City of Johannesburg Metropolitan Municipality	Gauteng	Johannesburg	51
TSH	City of Tshwane Metropolitan Municipality	Gauteng	Pretoria	52
EKU	Ekurhuleni Metropolitan Municipality	Gauteng	Germiston	53
ETH	eThekwini Metropolitan Municipality	KwaZulu-Natal	Durban	54
MAN	Mangaung Metropolitan Municipality	Free State	Bloemfontein	55
NMA	Nelson Mandela Bay Metropolitan Municipality	Eastern Cape	Port Elizabeth	56

Figure 3: District and Metropolitan Municipalities in South Africa

2. Methodology

The review was based on a literature review and case study area investigations. The case study areas included Nelson Mandela Bay Metropolitan Municipality, Beaufort West Local Municipality, and Nama Khoi Local Municipality.

2.1. Literature review

2.1.1. Resilience

Disaster planning and preparation for slow-onset city-wide shocks will be become increasingly necessary, particularly as cities face increasingly severe climate hazards (Cole et al., 2021). Resilience is increasingly applied to the context of water systems and water governance, referring to the ability of communities, cities or regions to withstand the challenges posed by an increased intensity and frequency of floods and droughts (Rodina and Harris, 2016; Rodina, 2019). Krueger et al. (2019a, 2020) developed the Capital Portfolio Approach (CPA) to quantify the resilience of urban water security. The actual services citizens receive are influenced by several components, including:

a) Access to water.
b) Infrastructure for its treatment, storage and distribution.
c) Financial capital for building and maintaining infrastructure.
d) Management efficacy for regulating and operating the water system.

Water security involves three dimensions:

a) The level of system function (i.e. supply services).
b) Risks to these services
c) Robustness of system functioning.

The intention is to apply CPA approach and build a narrative around three case study areas. This approach allows for the assessment of individual urban water systems, as well as for cross-municipality comparison of any type of municipality (Krueger et al., 2019a).

The five capitals comprise the following (Krueger et al., 2019b, 2020):

- **Natural Capital**: The water resources accessed by the municipality including the total volume of naturally available, captured, reused, desalinated water, etc.

- **Physical Capital**: The infrastructure to store, treat and distribute water customers at drinking water quality.
- **Political Capital**: The management efficacy exercised by the municipal water governance system with the ability to operate and maintain water supply services.
- **Financial Capital**: The ability to leverage and spend funding to build, operate and maintain the water system.
- **Social Capital**: The ability of a municipality or the public to adapt to insufficient [funding and] public services.

Each of the five capitals is quantified in three dimensions: its availability, robustness, and risk (Krueger et al., 2019a). Robustness refers to the ability to absorb shocks and disturbances (Carlson and Doyle, 2002), and includes aspects such as diversity, anticipation of shocks and preparedness to deal with disturbances (Krueger et al., 2019a). Risks can result from chronic (high frequency, low magnitude) or acute shocks (low frequency, high magnitude) (Garrick and Hall, 2014; Krueger et al., 2019a).

2.1.2. Disaster management in South Africa

There has been a failure to learn from past droughts, which continues to constrain effective drought risk reduction (Vogel and Olivier, 2018). The lack of recognition by decision-makers of the need to develop capabilities and responses to mitigate drought impacts results in the following vulnerabilities:

- **Water shortages** due to inadequate water services for the population in the affected municipalities mainly due to lack of capacity and climate resilient interventions to mitigate the drought
- **Water depletion** resulting from unsustainable water abstraction worsened by inadequate water monitoring and metering
- **Water losses** due to lack of maintenance of water infrastructure, including vandalism and theft
- **Water scarcity** brought about by climate variability and change

> The persistent truths of recurring drought, a failure to learn from the process of drought rather than the event, the problems of the scientific uncertainty linked to droughts and the usual crisis response to drought made by a select few, are all shown to be threats to ensuring adaptation to repeated droughts in the future – Vogel and Olivier, 2019 (Vogel and Olivier, 2018).

Box 2 provides an overview of definitions related to disaster management.

Box 2: Definitions (Republic of South Africa, 2005; EPA, 2016; Vogel and Olivier, 2018; The Brazos River Authority, 2021).

Disaster risk management: Refers to integrated multisectoral and multidisciplinary administrative, organisational and operational planning processes and capacities aimed at lessening the impacts of natural hazards and related environmental, technological and biological disasters.

Disaster risk reduction: Implies all the elements that are necessary to minimise vulnerabilities and disaster risks throughout a society. It includes the core risk reduction principles of prevention, mitigation and preparedness.

Drought: Drought is the subject of multiple framings and values – all socially, culturally and politically imbued. Therefore, drought cannot be separated into a meteorological silo when trying to devise interventions. The need to both frame and enable interactions for drought as a development issue is also required, rather than just a focus on reactive actions because of drought.

Drought contingency planning: A drought contingency plan is a strategy or combination of strategies for monitoring the progression of a drought and preparing a response to potential water supply shortages resulting from severe droughts or other water supply emergencies.

Drought resilience: drought resilience is the ability to respond to immediate water supply threats, withstand drought impacts and recover quickly.

The Disaster Management Act (No 57 of 2002 – amended in 2015) is the primary legislation dealing with drought conditions in South Africa. The Act is supported by policies and strategies such as the National Disaster Risk Management Framework of 2005 and the Drought Management Plan of 2005 (Makaya et al., 2020). The policies and legislation also put forward the institutional framework for disaster risk management (Figure 4). This includes the establishment of the National Disaster Management Centre (NDMC) and the Provincial Disaster Management Centres (PDMC) and Municipal Disaster Management Centre (MDMC). The focus of the rest of the section is on MDMC.

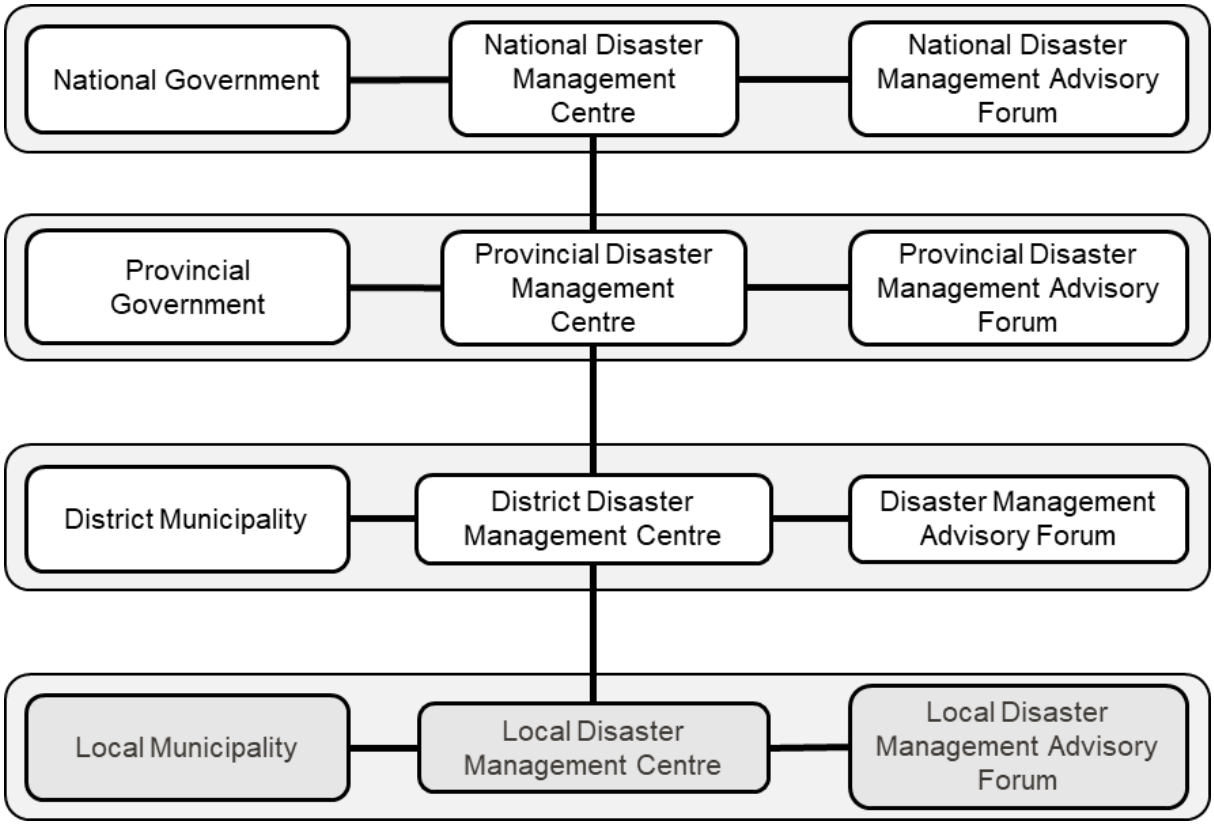


Figure 4: Institutional framework for Disaster Management in South Africa (Kong et al., 2020)

Each Metropolitan and District Municipality must have a District Disaster Management Centre in their area of authority to ensure the implementation of the local disaster management policy and that the goals and priorities of provincial and national disaster management is attainable (Wentink et al., 2017). Following consultations with Local Municipalities, a MDMC should be established which are operated jointly by the District and Local Municipalities with responsibility of ensuring that the appropriate capacity for disaster risk management, which includes personnel issues, for implementing the Disaster Management Act is established which aligned to provincial and national levels (Wentink et al., 2017). The Disaster Management Centres are supported by Disaster Management Advisory Forums at the corresponding levels of the government acting as technical advisory bodies and are attended by representatives from all organisations that can contribute to disaster risk reduction, including public, private and community based (Kong et al., 2020). The MDMC must (Republic of South Africa, 2005):

- Establish and maintain institutional arrangements that will enable the implementation of the Act
- Implement measures to develop progressive risk profiles to inform the Integrated Development Plan (IDP) processes of municipalities for the purposes of disaster risk

reduction and to determine the effectiveness of specific disaster risk reduction programmes and projects undertaken

- Facilitate the development, implementation and maintenance of disaster risk reduction strategies that will result in resilient areas, communities, households and individuals
- Monitor the integration of disaster risk reduction initiatives with development plans
- Develop and implement a comprehensive information management and communication system that is consistent with arrangements established by the NDMC and PDMC
- Facilitate the development of response and recovery plans to ensure rapid and effective response to disasters that are occurring or are threatening to occur and to mitigate the effects of those disasters that could not have been prevented or predicted
- Submit copies of its disaster risk management plans to the NDMC, the PDMC, neighbouring disaster management centres and, where applicable, disaster risk management entities in neighbouring countries
- Develop and implement mechanisms for creating public awareness to inculcate a culture of risk avoidance
- Facilitate and promote disaster risk management education, training and research in the municipality
- Implement and maintain dynamic disaster risk management monitoring, evaluation and improvement programmes
- Measure performance to evaluate effectiveness of disaster risk management and risk reduction initiatives and submit copies of evaluation reports to the NDMC and the PDMC
- Monitor compliance in the municipal area with the key performance indicators outlined in the disaster management framework
- Make recommendations regarding the funding of disaster risk management in the municipal area and the initiation and facilitation of efforts to make such funding available

One important question for disaster management, as a discipline, and the application of the continuum in Figure 5 – is that it still has a disaster-oriented focus as all activities and resources are geared towards a disastrous event (Vermaak and Van Niekerk, 2004).

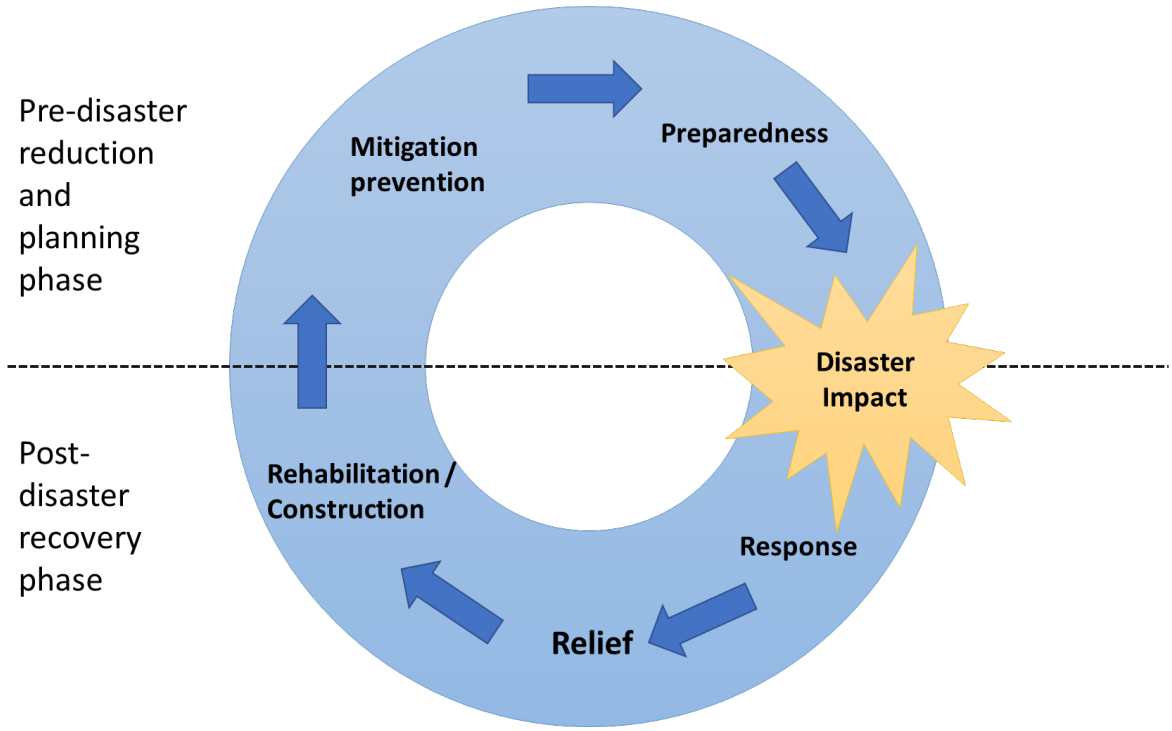


Figure 5: The disaster risk management cycle – typical phases (Bosher et al., 2021).

Bosher et al. (2021) reflected that the cyclical aspects of the disaster risk management which comprised many operational phases, have in recent years been criticised for conceptualising and representing disasters overly simplistically that typically starts with a disaster event – and subsequently leads onto yet another disaster (Figure 5). Bosher observed that such cyclical thinking has been proven to not be very useful for the complexities associated with understanding disasters and their risks. Disaster risk, vulnerability and hazardous impacts are dynamic processes, and the management of disaster risk cannot be limited to merely one event (Figure 6).

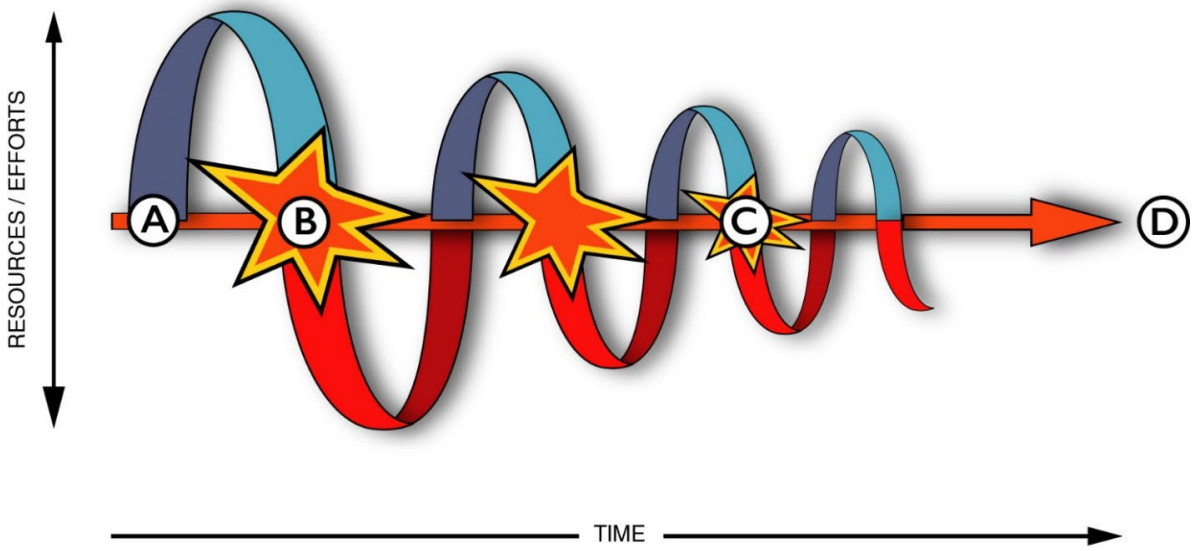


Figure 6: Helix diagram illustrating a reduction of risk over time (due to risk reduction interventions) (Bosher et al., 2021)

2.2. Case study areas

2.2.1. Nelson Mandela Bay Metropolitan Municipality

The Nelson Mandela Bay Metropolitan Municipality (NMBM) is a Category A municipality, established on 5 December 2000[1]. NMBM has experienced persistent droughts resulting in acute water shortages (NMBMM, 2017). This is the current case. The Kouga dam, NMBM largest supply reservoir, has dropped to its lowest-yet level since it was built in 1969 (Ellis, 2021).

[1]https://municipalities.co.za/overview/1/nelson-mandela-bay-metropolitan-municipality.

Figure 7: The Kouga dam near Patensie is now almost empty. (Photo: Petrus Vermaak)(Ellis, 2021).

The Algoa Water Supply System (Algoa WSS) comprises a system of dams, pipelines and canals linking the surface water resources of the Kouga and Krom rivers and some small local surface water sources to the west, the Orange River via the Fish and Sundays rivers to the east, groundwater resources and minimal water re-use. The Algoa WSS comprises three systems (Killick and Thompson, 2011):

- The Western System provides water to NMBM from the Churchill and Impofu dams on the Kromme River, from the Kouga Dam on the Kouga River and from the Loerie Balancing Dam on the Loerie Spruit, a tributary of the Gamtoos River. This System also supplies water to various small towns and to the Gamtoos Irrigation Board.
- The Eastern System receives water transferred from the Gariep Dam on the Orange River via the Orange-Fish Tunnel, the Fish River, the Fish-Sundays Canal, the Skoenmakers River, and Darlington Dam.
- The Central System consists of the older Sand, Bulk, Van Stadens and Groendal Dams and the Uitenhage Springs, all of which supply NMBM. Groendal Dam also supplies water to irrigators.

For the post-drought evaluation of measures taken, the 2005-2020 Master Plan (Nelson Mandela Bay, 2006) was used as a baseline. Since the Water Master Plan, a preliminary Algoa WSS (DWA, 2009) was issued in 2009 and finalised in 2011 (DWA, 2011a) with regular updates up to 2016 (DWS, 2016). In 2004, the average day demand of 225 megalitres per day (Mℓ/day), as treated water supplied, equated to 90.3% of the present restricted yield of 250 Mℓ/day (Nelson Mandela Bay, 2006). In 2008, the demand was 282 Mℓ/day assurance of supply of 98% (DWA, 2011a). The following post-drought interventions were recommended:

- **Maximise the yield of the existing Kouga/Loerie scheme by changing the operation of the relevant bulk infrastructure** (DWA, 2009, 2011a): This involved lowering of the operational level to which water can be abstracted from Loerie Dam (from 40% of full supply capacity to 12% of full supply capacity), to increase the yield, requiring no additional infrastructure or operating staff, but improved operation and increased periods of pumping at maximum capacity. **This recommendation was implemented in 2009**.
- **Urban WC/WDM, comprising a range of measures** (DWA, 2011a): Summary of progress with implementation of WC/WDM included (DWS, 2016):
  - **Bulk Supply Meters**: Bulk Water Task Team was set up to expedite the installation of bulk meters. By August 2016, sufficient metering was installed for the Churchill Pipeline and Loerie/Summit/Chelsea systems. The Nooitgedagt/Motherwell system will be completed in September 2016.
  - **GMA and DMA Meters**: There are approximately 25 Greater Metered Area and 180 District Metered Area meters required. A priority list was prepared, and designs of the chambers undertaken. Once designs were approved by NMBM, the work was issued to repair and maintenance contractors to construct.
  - **Remote Metering**: Advanced Metering Infrastructure must be introduced to enhance revenue collection. A triennial tender document has been prepared for the provision of Advanced Metering Infrastructure to Water Metering Systems for 1,500 meters for industrial, commercial and institutional consumers, bulk supply meters and Greater Metered Area and District Metered Area meters. The document will go through the Supply Chain Management process of the NMBM.
  - **NRW**: The non-revenue water (NRW) was 46% in 2014/2015, decreasing to 43.4% in 2015/2016. Although the NRW level has reduced from 2014/15,it remains high (DWS, 2016). In terms of non-revenue water (NRW), the municipality currently experiences physical losses of just under 30%. Leak repair remains a priority and, in 2020, NMBM introduced a multi-million rand water leaks project along with a commitment to achieve a tight

turnaround time of 24 hours for the attendance of pipe bursts (3SMedia, 2021).

- **PRV Management**: to date, some 38 Pressure Reducing Valve (PRV) stations have been audited, 22 upgraded and three new stations have been installed.
- **ICI Consumers and Billing**: Some of the problem areas identified regarding industrial, commercial and institutional (ICI) consumers include the estimation of consumers' water use for 4 months or longer, as well as issues arising from meters with flow-restrictors. Although a task team was established to address these problem areas, the attendance of Municipal Treasury officials has been poor, which has impeded progress.
- **Water Tariffs**: The NMBM increased their domestic tariffs for 2016/17 by 9% and the industrial/commercial tariff by 19%.
- **Leak Repairs**: Assistance to the poor households for leak repairs. This program contributes to the reduction of water losses and offers work for the ward-based contractors. During 2015/16, the number of repairs increased to 20,087, and a further 38 ward-based plumbers were employed and trained to total 83. The revised target of repairs is 4,000 per month. Of the 384 schools, 107 had meters with various problems that needed replacing. The bulk of these have been replaced. The Auditor General considers leak repairs by the NMBM at schools to be unlawful expenditure. The programme will only proceed if the DoE provides the funding. The Metro's in-house leak repair teams cannot cope with the large number of leaks reported at the Call Centre. There is a backlog of 6,389 water-related complaints (reporting period March 2015 to April 2016). The NMBM is finalising the appointment of six cluster-based contractors (10 municipal wards per cluster) to carry out leak repairs within the wards of each cluster.
- **Repair and Maintenance Contractor**: The repair and maintenance contractor commenced work in January 2015, however, ceased work in November 2015 due to financial problems. The contractor only recommenced work on 14 March 2016. The delay of 4 months has had a negative impact on the NRW programme. The bulk of the work has been in the Uitenhage and Despatch areas where the water infrastructure is old.
- **Domestic Meter Audit**: The report given on 12 August 2016: 3% of stopcocks were faulty, 22% of meters were faulty, 1% of connections had leaks, 13% of internal connections had leaks and 9% of valves and hydrants were faulty.

- **Valve and Fire Hydrant Audit**: Due to other priorities this intervention was not undertaken continuously. 9,391 valves and 5,692 fire hydrants have been audited.
- **Meter Replacement**: Over the last eight years, 164,156 domestic meters were replaced, representing 75% of all domestic meters. 14,878 domestic meters were replaced in 2015/16. Problems were experienced with the triennial contractor appointed; however, the numbers are expected to improve in 2016/17.
- **Publicity and Awareness**: The municipality embarked on a Service Delivery Ambassador Programme. Ten persons per ward were selected by Ward Councilors and given leak-repair training, clothing, equipment and materials. Phase 1 of the programme included 22 wards and covered the period from October 2015 to April 2016. For Phase 1, 20,000 complaints were received, and 30,000 households visited. Phase 2 of the programme includes 29 wards and commenced in July 2016.

- **Nooitgedagt Low-Level Scheme, using the Orange River water temporarily allocated to NMBM** (DWA, 2011a): This involves increased supply from the Orange River to NMBM, supplied from Nooitgedagt Water Treatment Works via a new pipeline to the Olifantskop Reservoir. This scheme would also offer significant energy savings on account of the reduced pumping heads needed. Phase 1 was identified in the 2005-2020 Water Master Plan for completion by 2008 and Phase 2 by 2009. Phase 1 was completed by mid-2013, but numerous delays due to funding issues meant that Phase 2 was only completed in mid-2017, and the completion date for the final Phase 3 has recently been pushed back to June 2021 (NMBMM, 2017; Matthews, 2020).
- **The development of groundwater sources** (DWA, 2011a): This includes fast-tracked implementation of the Jeffreys Arch, Van Stadens River Mouth Arch, Bushy Park and the South-eastern Coega fault new groundwater schemes. Some of these schemes could either supply NMBM or alternatively supply small coastal towns, freeing up water for NMBM. A decision was taken during 2015 to exploit groundwater resources from five boreholes in the Coega Kop Wellfield with an expected sustainable yield of up to 20 Mℓ/d. The Coega Kop Biofiltration Plant has been designed for a maximum abstraction capacity of 20 Mℓ/d of groundwater from five boreholes.
- **Desalination at the Swartkops estuary**(DWA, 2011a): A seawater desalination plant that can be sited at the old Swartkops Power Station and will discharge brine via the existing sea outfall of the Fishwater Flats WWTW is a drought backup option(DWS, 2016).

- **Re-use of water from the Fishwater Flats and the Coega Wastewater Treatment Plants to supply the Coega IDZ**(DWA, 2011a):

2.2.2. Beaufort West Local Municipality

The Beaufort West Local Municipality is a Category B municipality located within the Central Karoo District in the Western Cape Province[2]. Beaufort West has chronic water shortages (Visser, 2021) (Figure 8). The water demand and availability are under constant threat requiring urgent interventions in resource development and infrastructure establishment (GreenCape, 2019). The Beaufort West municipality has three dams supplying the area with water — the Gamka, Springfontein and Walker Dams. It also relies on 40 boreholes and the water reclamation plant in the town. The demand is approximately 6.3 Mℓ/d (Beaufort West Local Municipality, 2021). Vandalism is hampering bulk water supply as cable theft causes down-time for boreholes (Beaufort West Local Municipality, 2021). The following interventions have been recommended for implementation, in order of priority and sequence in the reconciliation strategy (DWS, 2015):

Figure 8: Gamka Dam, in the Karoo is empty and there is no respite in thirst on November 08, 2017 in Beaufort West, South Africa. (Photo by Gallo Images / The Times / Esa Alexander)

- **Full implementation of the Water Conservation and Water Demand Management Strategy measures to reduce water losses and achieve savings in water consumption**.

[2] https://municipalities.co.za/overview/1212/beaufort-west-local-municipality.

- **Integration of recently drilled and equipped boreholes into the supply system**. Bulk water pipelines, the mechanical and electrical equipping of five existing boreholes, and the construction of a booster pump station at the existing reclamation plan were completed in 2019 (IMIESA, 2019).
- **Development and implementation of integrated operating rules for the complete supply system, including the Gamka Dam and the different wellfields to possibly increase the yield of the system**.
- **Further incremental groundwater development**.

2.2.3. Nama Khoi Local Municipality

The Nama Khoi Local Municipality is a Category B municipality situated on the north-western side of the Northern Cape Province in the Namakwa District[3]. The Concordia-Springbok Cluster consists of the settlements of Concordia, Bulletrap, Carolusberg, Nababeep, O'kiep and Springbok (DWA, 2011b). The Concordia-Springbok Cluster's current water use was estimated at 16.671 Mℓ/d. With population of 30,257 people, Concordia-Springbok Cluster's current per capita water use of 551 ℓ/c/d is excessive in comparison with the benchmark level of 213 ℓ/c/d(DWA, 2011b). This required(DWA, 2011b):

- An immediate analysis of both residential and non-residential water use patterns, and of the water use within the different socio-economic brackets.
- Ensuring system efficiencies and that as much water as possible reaches consumers with minimum system losses.
- Should the high-water use be due to "wastage" by suppliers and/or consumers, then it is assumed that this wastage will be eliminated, and that benchmark figures can be used for planning and projections, then the Namakwa Water Board's demand figures included in the Lower Orange River Management Study will be sufficient for the planning period to 2030 and the Board's current registered water use entitlement will be sufficient until 2025.
- Once the current excessive water requirements have been brought down to benchmark levels, the WSA must further plan and implement Water Conservation and Water Demand Management measures to ensure that system losses are minimised throughout the supply chain and that users strive to minimise use and optimise efficiency.

[3] https://municipalities.co.za/overview/1171/nama-khoi-local-municipality.

Springbok has suffered frequent pipeline failures leading to water supply interruptions due to the ageing infrastructure and poor or no maintenance of the system[4]. Construction of refurbishment of the Namakwa Water Supply scheme commenced in September 2013 and progress in 2019 stood at 64% (Sedibeng Water, 2019).

3. Discussion

3.1. Status of drought management plans

Most municipalities have no explicit drought management plans but may have disaster management plans, integrated development plans (IDPs) (Figure 9; Figure 10), reconciliation strategies, water plans or climate change plans (Appendix 1). Appendix 1 provide an overview of the type of interventions that are needed to cope with drought in the municipalities. The proposed interventions are comprehensive but require implementation. Figure 9 and Figure 10 provides an overview of the number of mentions of drought in the District Municipalities and Metropolitan Municipalities latest IDPs, respectively. As expected, drought is mentioned most times in the municipalities that are currently experiencing drought, such as those in the Eastern Cape.

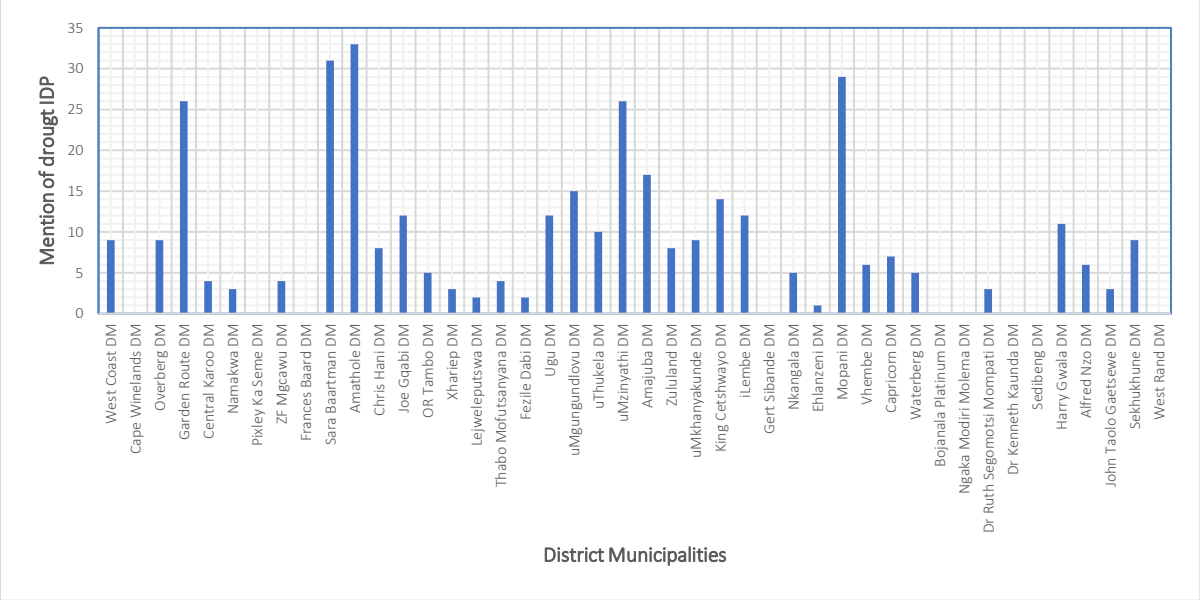


Figure 9: Number of drought mentions in IDP per district municipality

[4] https://www.gov.za/speeches/water-and-sanitation-spends-r1-billion-namakwa-water-project-5-nov-2015-0000.

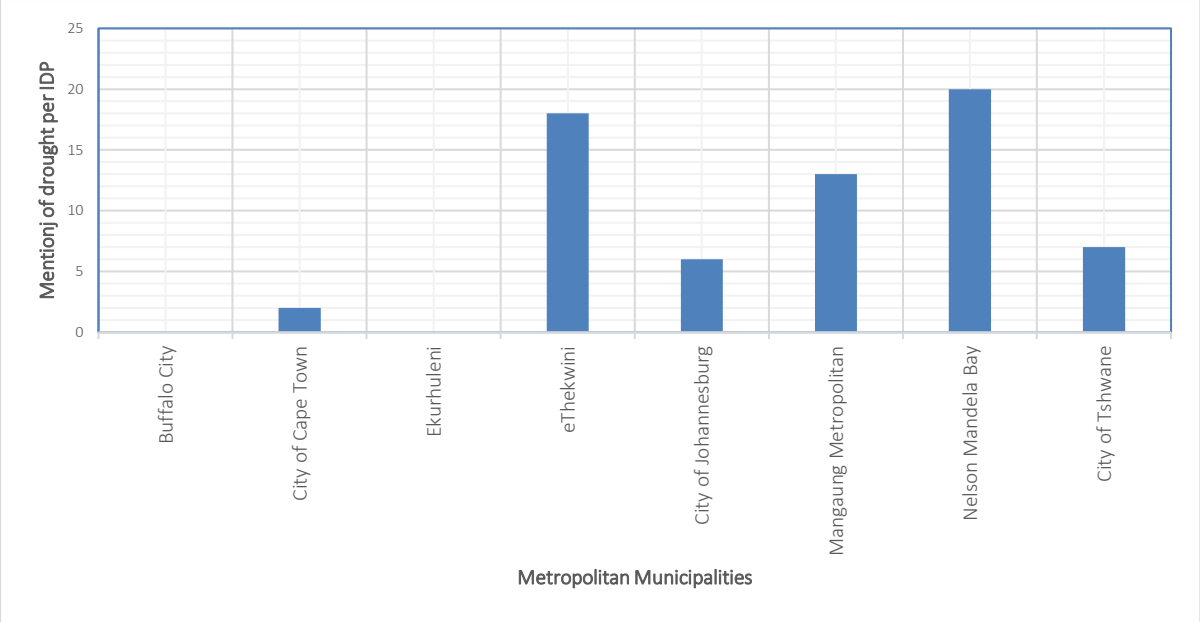


Figure 10: Number of Drought mentions IDP per metropolitan municipality

The Lets Respond Toolkit provides stakeholders with an introduction and overview on how to integrate climate change into municipal planning processes[5]. Climate change response plans have been developed for all municipalities as part of the Local Government Climate Change Support Program. Figure 11 provides an overview of the water responses strategies / actions put forward in the climate change response plans. The most frequent strategy is catchment rehabilitation, e.g. invasive species removal, and the second most proposed strategy water conservation and demand management. Operation and maintenance of water structure and consumer education also featured highly in responses. The least favoured response was water transfer followed by promotion of greywater use; introduction of water efficient fittings; leak repairs; tariff, metering and credit control; and water sensitive designs.

[5] https://letsrespondtoolkit.org/

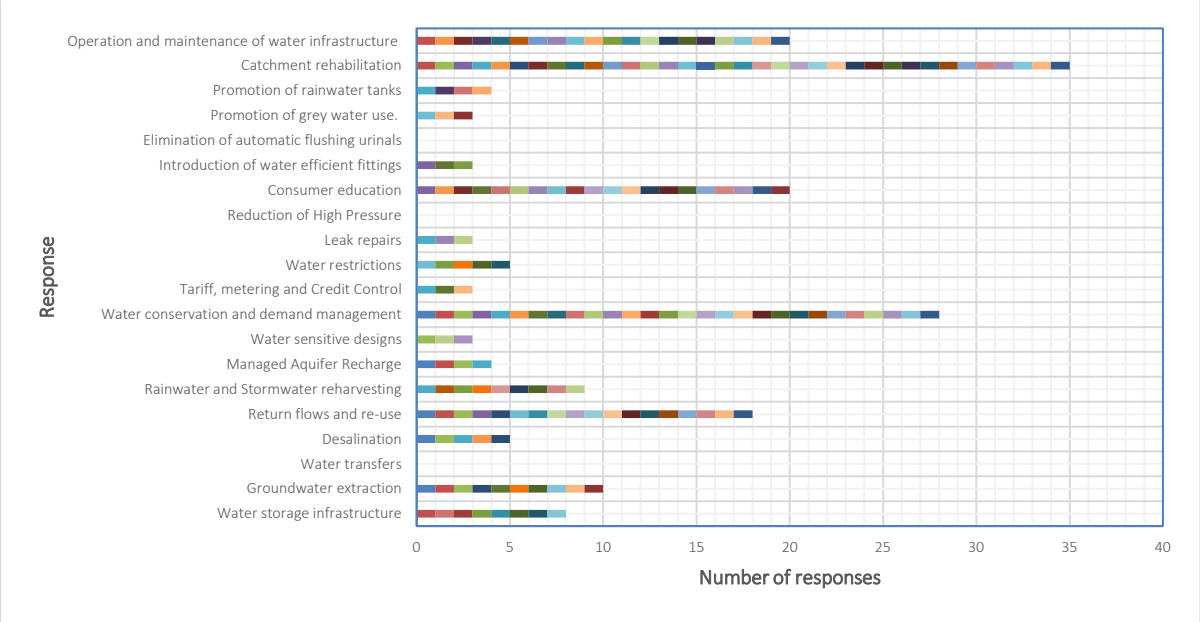


Figure 11: Climate change responses water

3.2. Case studies

The combination of natural, human, financial and engineered elements (here: the five capitals) determines whether a city can achieve or maintain water supply security (Krueger et al., 2019a). During extended drought conditions, the towns or cities that are unprepared are left with few alternatives and are confronted with no or intermittent water supplies or excessive water restrictions. Black lines are capital availabilities and dashed lines indicate capital robustness. Blue shading represents risks to each of the capitals.

NMBM has low levels of capital availability and robustness (Figure 12). It has high levels of risk for all capitals – blue shading. The relatively higher water availability reflects normal water supply situation. During drought, the water supply situation deteriorates dramatically, as is the current case (2021) – reflected in yellow shading. The ability of the communities to adapt to drought situation is low, as shown in Figure 12.

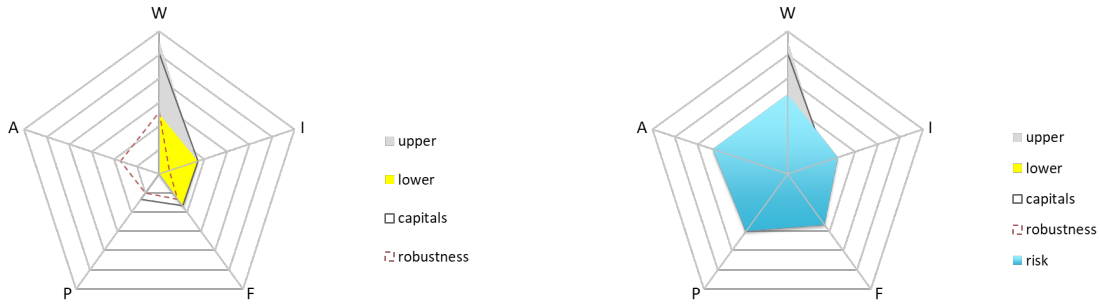


Figure 12: Capital portfolios of the NMBM case study area

Like NMBM, the Beaufort West has low levels of capacity and robustness. Although the Natural Capital is high under normal conditions during drought situations, the Natural Capital declines significantly. The community adaption is relatively higher because of the reliance on more than one source of water, but the management capabilities are weak. The same issues apply to the Nama Khoi Municipality (Figure 14).

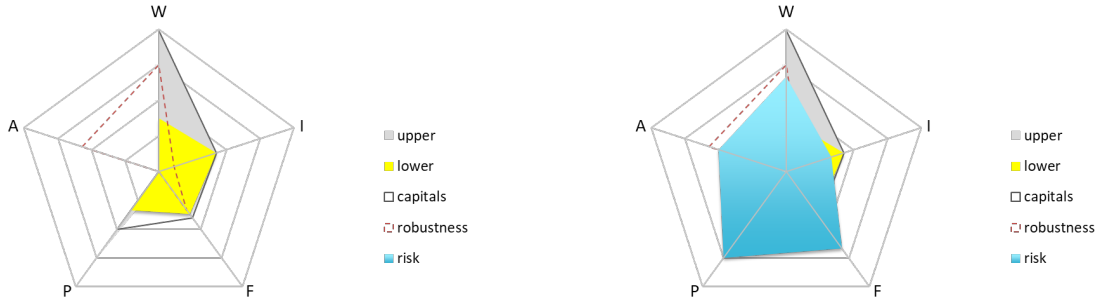


Figure 13: Capital portfolios of the Beaufort West Local Municipality case study area

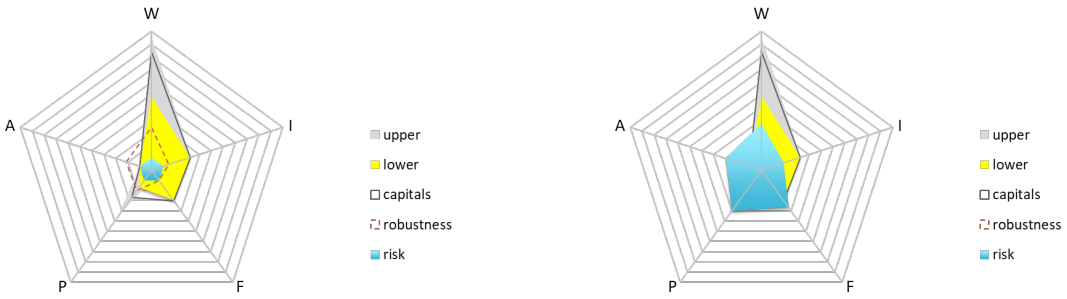


Figure 14: Capital portfolios of the Nama Khoi Local Municipality

3.3. Drought Resilience Interventions Guidelines

Any Municipality under water stress needs a long-term strategy for drought resilience interventions that considers long-term conditions and plans for permanent solutions (EPA, 2016; Parks et al., 2019). Such a drought resilience interventions should include stakeholder engagement, functioning institutions and diversity of water sources and co-operation between local, regional and national levels of government (Parks et al., 2019).

Drought-resilient municipalities (EPA, 2016; Parks et al., 2019)**:**

- **Take action to protect human health and the environment, while maintaining a minimum level of service for customers during drought**
- **Manage decreases in water supply, increases in water demand and changes in water quality**
- **Plan for future changes in weather and climate patterns that can reduce water supply**

3.3.1. Ensuring stakeholder engagement

Designing drought resilience interventions requires effective and meaningful stakeholder engagement. This is a crucial prerequisite to building trust, ownership and acceptability. The reframing of stakeholder engagement as a process of social learning opens more possibilities than just participation as it carries an explicit purpose which underpins design and process considerations (Wehn et al., 2018). One of the key weaknesses in responding to, or planning for, wicked problems such as drought is to oversimplify the problem as only meteorological, as well as to adopt a technical focus with limited technical skills to act (Vogel and Olivier, 2018). (Reed et al., 2010)

Social learning may be defined as a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks (Reed et al., 2010)**. To be considered social learning, a process must** (Reed et al., 2010)**:**

1. **Demonstrate that a change in understanding has taken place in the individuals involved**
2. **Demonstrate that this change goes beyond the individual and becomes situated within wider social units or communities of practice**
3. **Occur through social interactions and processes between actors within a social network**

The value proposition of stakeholder engagement includes:

- More informed and transparent decision-making

- Conflict prevention because of consensus seeking and transparency in decision-making
- Trigger local stakeholder initiatives to implement demand and supply measures and reduce the cost of regulation.

The guiding principles for effective stakeholder engagement comprise (Dobbin et al., 2015):

- Stakeholder engagement is based on the belief that those who are affected by a decision have a right to be involved in the decision-making process
- Stakeholder engagement includes the promise that the participants' contribution will influence the decision
- Stakeholder engagement promotes sustainable decisions by recognizing and communicating the needs and interests of all participants, including decision makers
- Stakeholder engagement seeks out and facilitate the involvement of those potentially affected by or interested in a decision
- Stakeholder engagement seeks input from participants in designing how they participate
- Stakeholder engagement provides participants with the information they need to participate meaningfully
- Stakeholder engagement communicates to participants how their input affected the decision.

3.3.2. Functioning institutions

Implementing resilience interventions requires functioning institutions to ameliorate drought impacts. Management of droughts in South Africa is facilitated by several enablers, although impacted upon by several barriers (Makaya et al., 2020). This is shown at the different operational scales in Table 1.

Table 1: Enablers and barriers to successful drought management (Makaya et al., 2020)

Community-level enablers	Community-level barriers
• Community leadership structures • Available extension services • Constituted farming communities • Water use pressure groups • **District- or municipal-level enablers** • Disaster management committees • Available drought management • information • Water management institutions	• Lack of knowledge about management of droughts • Lack of skilled human capital within the communities • Financial constraints • **District-or municipal-level barriers** • Bureaucracy – decision-making takes long due to departmental • consultations • Financial management – including misappropriation of financial resources • Limited information and communication

The South African Water Management Institutions is shown in Figure 15. The Department of Water and Sanitation (DWS) is required to provide support or assistance to municipalities in drought matters. This includes regulating the water abstraction considering the sustainable use of the resource. The assistance to Local Municipalities is best done through local level water management institutions such as Water User Associations. Catchment Management Agencies can support municipalities at a regional level, becoming anchor institutions.

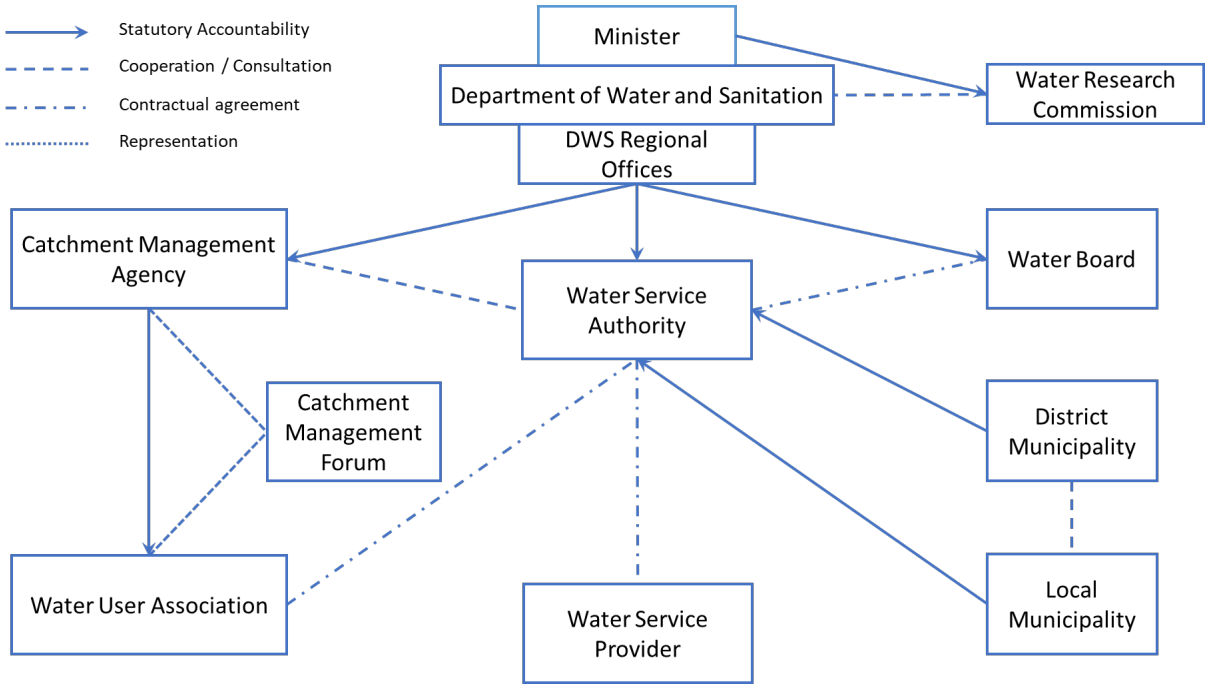


Figure 15: The South African Water Management Institutional landscape (modified from Weaver et al. (Weaver et al., 2017))

The following keys to management success of water institutions has been identified – modified from US EPA (US EPA, 2017):

- **Leadership**: Leadership must respond to both internal organisational and broader external community imperatives. It is critical for effective local level] governance, particularly in the context of leading and inspiring change within an organisation and in its surrounding community and stakeholders. Leadership refers both to individuals who can be effective champions for improvement, and to teams that provide resilient, day-to-day management continuity and direction.
- **Strategic Business Planning**: A strategic business plan provides a framework for decision making by: (i) assessing current conditions and conducting strengths, weaknesses, opportunities, and threats (SWOT) analysis; (ii) characterizing a continuum of possible and likely future conditions; (iii) assessing underlying causes and effects of future conditions; and (iv) establishing vision, objectives, strategies, and underlying organisational values. A successful strategic business plan is dynamic and adaptable, allowing the local-level institutions to capitalise on new and emerging opportunities. It is made more robust by engaging with staff and external stakeholders, and by utilising planning methods that can accommodate and address a variety of future operating scenarios (e.g. managing for uncertainty through stress testing a plan's ability to hold up during extreme events, such as extended drought).
- **Knowledge Management**: Knowledge management is another cornerstone of effective management and is critical to ensuring reliable operations. It spans standard operating procedures, human resource management, and business systems and operating systems data integration and utilisation to support dependable operations and continual improvement
- **Measurement**: Measurement is critical to management improvement efforts and is the backbone of successful continual improvement management and strategic business planning. A measurement system serves many vital purposes, including focusing attention on key issues, clarifying expectations, facilitating decision making, supporting learning and improving, establishing and maintaining accountability, and communicating effectively internally and externally.
- **Continual Improvement Management**: Continual improvement plays a central role in effective local-level governance and is critical to making progress on drought resilient interventions. Continual improvement management includes:
- Conducting an honest and comprehensive self-assessment – informed through staff engagement – to identify management strengths, areas for improvement, priority needs, etc.
- Conducting frequent sessions among interested parties (stakeholders) to identify improvement opportunities

- Following up on improvement projects underway
- Establishing and implementing performance measures and specific internal targets associated with those measures
- Defining and implementing related operational requirements, practices, and procedures
- Defining supporting roles and responsibilities to derive clear accountability for conducting assessments and implementing performance improvements
- Implementing measurement activities such as regular evaluation through operational and procedural audits
- Responding to evaluations using an explicit change management process

3.3.3. Horizontal and vertical co-operation

Multiple organisations and stakeholders play a part in drought resilience in Local Municipalities. This includes formal and informal institutions. Integration – both vertical (within the sector) and horizontal (across different established sectors) – is fundamental to balanced [local-level] governance and policy making (Figure 16) (Varis et al., 2014). Example indicators of local drought risk governance include (modified from Turnbull et al., 2013):

- **Inclusion and participation**
  - Participation by all, especially vulnerable and marginalised groups, in decision making and implementation so that decision making happens at the right level.
  - Gender equality, with women and men participating equally in decision making and implementation.
  - The specific needs of children and young people are considered.
  - Partnerships exist between local government, community, private sector, civil society, academia and others to foster knowledge co-generation.
- **Local capacity**
  - Drought risk reduction policies are in place to protect vulnerable people from disasters and climate change (the elderly, children and youth, the disabled, migrants) and these policies are regularly reviewed.
  - Local drought risk reduction practices consider local knowledge, skills, and resources.
  - There is a local plan of action to turn policies into practice.
  - Local government has an adequate budget for drought risk reduction activities.
- **Accountability and transparency**
  - A reference point or baseline has been established from which to measure progress in implementing drought risk reduction policies.

- Communities and civil society are involved with local government in monitoring drought risk reduction to make complaints and to get a response when there is a lack of progress.
- Information gathering regularly takes place to collect, review and map drought risks and climate change.
- Updated and easily understood information about drought risks and prevention measures is provided regularly to vulnerable people.

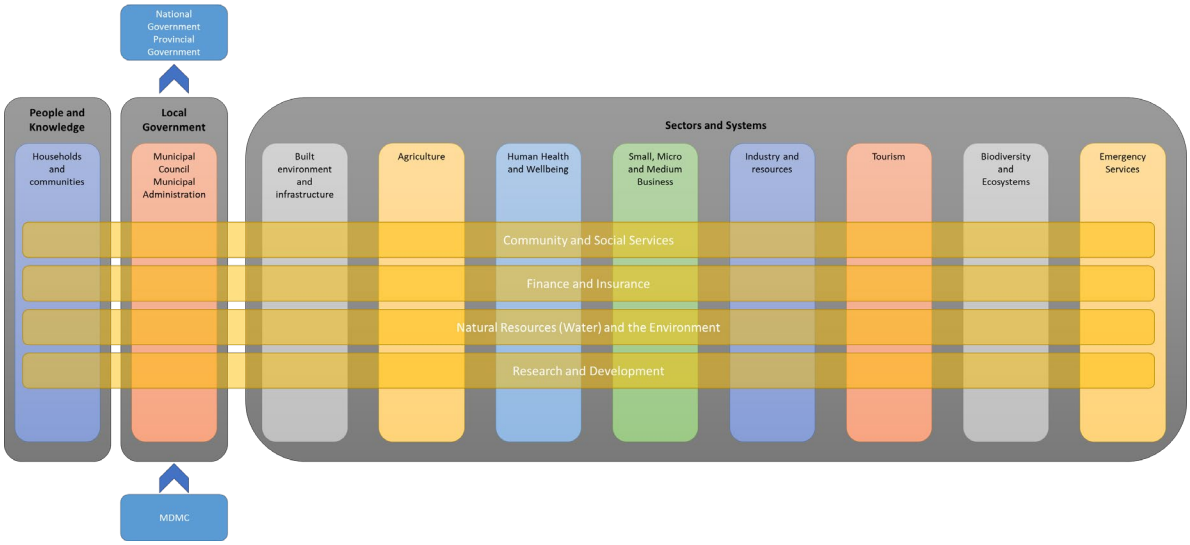


Figure 16: Cross-sector coordination – horizontal and vertical integration.

3.3.4. Ecological and critical built infrastructure

Investing in water-related ecological infrastructure, with built infrastructure, will deliver more clean water from our land (Petersen et al., 2020). Commonly, the evolution of towns and cities towards water resilient urban areas was presented as a continuum of six water management regimes (Brown et al., 2008; Kotze, 2019). Armitage et al. (2014) presented framework and guidelines for water sensitive urban design for South Africa modifying the continuum of six water management designs (Figure 17). Any attempt to transition to water sensitive cities will need to consider both formal areas, as well as the informal settlements where high densities and limited infrastructure are common (Armitage et al., 2014).

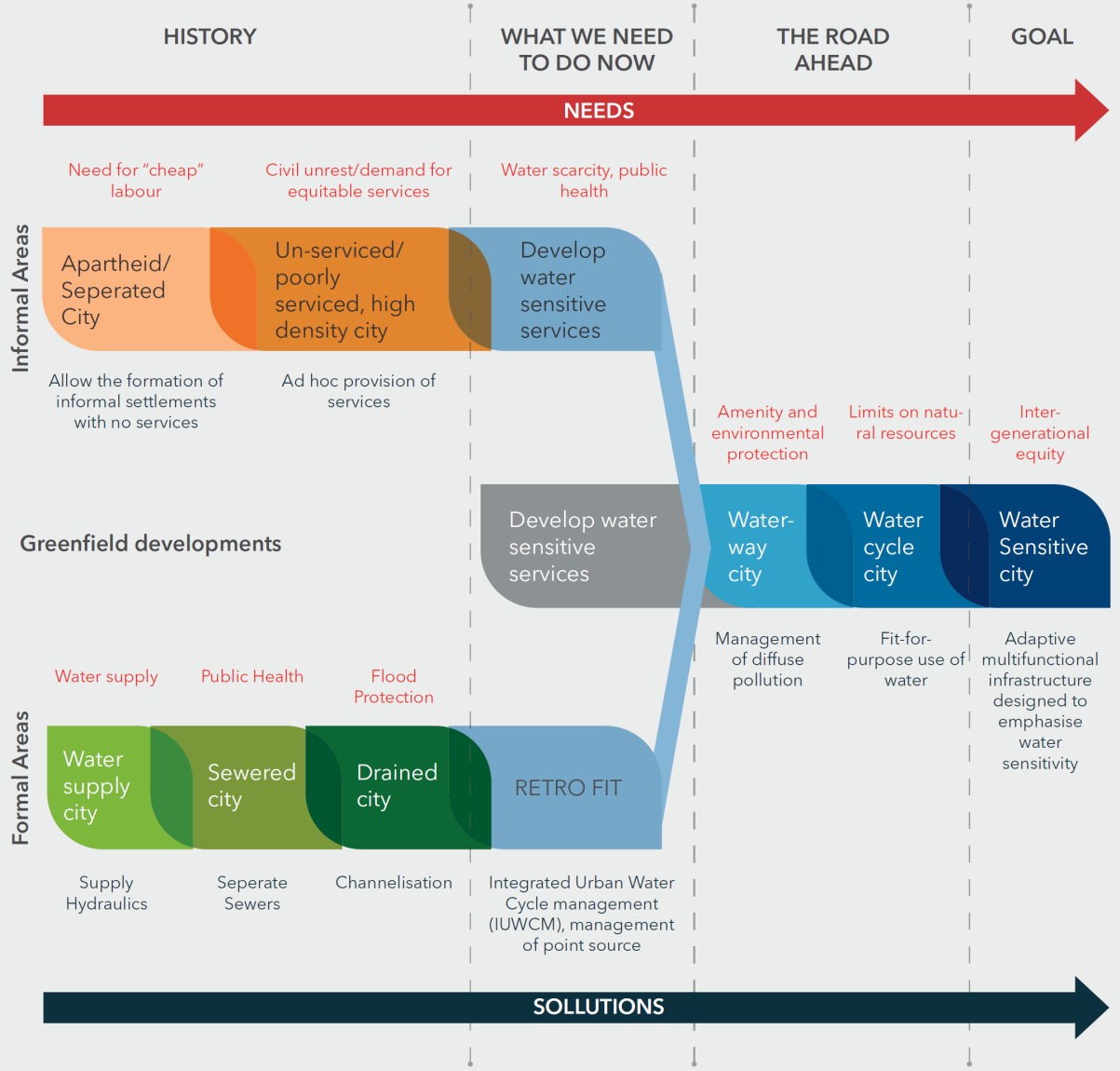


Figure 17: Urban Water Transition Phases (Brown et al., 2009; Armitage et al., 2014; Carden et al., 2018).

Priority pathways and key actions for urban water resilience and the roles of Local Government are represented below (Workalemahu Habtemariam et al., 2021):

- **PLAN FOR WATER**: Mainstream risk-informed land management and water-sensitive urban development
  - Mainstream information on water, climate, and health risks in urban and regional planning
  - Recognize hydrologically linked regions, often larger than urban boundaries, to account for water resilience priorities based on ecosystems, rural-urban landscapes, and regional networks
  - Incentivise development in less hazard-prone areas and/or areas with regulations and planning that support water-sensitive development

- Offer planning, policy, and regulatory incentives for floodplain restoration and watershed protection, including preservation of green spaces within and around cities
- Increase capacity to implement regulatory frameworks and incentives, such as building permits, limits on groundwater extraction, and ecosystem protection
- Draw upon nature-based solutions to proactively address water challenges and support communities
- Ensure the rights of the most marginalized groups are protected in existing and proposed schemes, including measures to restore floodplains, remove dams and levees, and retreat from zones subject to flooding or sea level rise

- **PRIORITISE THE MOST VULNERABLE**: Increase equitable access to safe water and sanitation
  - Collect and use data disaggregated by social groups and spatial areas, on local climate and environmental risks, and on urbanization patterns to identify the most vulnerable areas
  - Integrate local knowledge and community participation in decision-making around improving water access and water resilience
  - Support strategic and cost-effective policies that strengthen water resilience for the most socially vulnerable
  - Support community-led and or government-led upgrading of informal settlements and water insecure areas (e.g. flooding zones, hillsides)
  - Support the integration of small-scale, decentralized, and / or informal water and sanitation providers
  - Strengthen the role of public institutions to ensure the safety and affordability of innovative, off grid water and sanitation solutions
- **CREATE CHANGE AT SCALE**: Develop innovative institutions and pursue partnerships for water resilience
  - Incentivise collaboration across jurisdictions and agencies to jointly consider a mix of green and grey infrastructure and create cost-saving synergies
  - Support cross-departmental coordination, resource support, and capacity development, including identifying strategic opportunities to advance multiple outcomes among sectors that impact and are impacted by water (e.g. roads, transport, land authority)
  - Prioritize multistakeholder engagement processes that align agendas and build consensus, trust, and relationships crucial for building resilience
  - Strengthen partnerships at the regional level to effectively manage the watershed region

- Support and recognize leadership at the community level to cocreate partnerships and knowledge grounded in the everyday realities of water challenges
- Build capacity to plan, implement, and operationalize resilience in long-term strategies, business plans, and investments
- Build leadership capacity for reflective learning and experimentation
- Build capacity in soft skills, such as contract negotiations and partnership building with community groups

- **GET FINANCE RIGHT**: Increase and align water resilient investments across sectors
  - Develop financing mechanisms to improve own-source revenue streams, such as land value capture
  - Create a shared vision with partner organizations, donors, the private sector, and the largest water consumers to increase investments in equitable water-sensitive design
  - Develop mechanisms and incentives to align water-sensitive priorities and investments across sectors
  - Establish dedicated funding pathways to channel external resources to water resources conservation and nature-based solutions
  - Revise economic valuation methods to account for long-term economic benefits, avoided costs, and livelihood gains from urban water resilience actions
  - Implement measures to capture value from building water resilience in the medium to long term. Increase transparency and equity criteria in investment allocations

3.3.5. Improve system efficiency

Implementing measures to conserve water and minimise losses within reticulation systems are critical to ensuring for drought preparedness (EPA, 2016):

- Reducing pressure throughout all or part of the distribution system, while maintaining necessary pressure for “high priority” users, such as hospitals and firefighters.
- Limiting main flushing as much as possible, while still meeting all regulatory requirements.
- Exploring beneficial uses for flushed water, such as irrigation, construction, fire-fighting storage or other non-drinking water uses.
- Recirculating backwash water to the head of the treatment plant.

- Aggressively finding and repairing leaks; consider including the following considerations and actions in your leak detection and repair program

3.3.6. Diversify of water sources

To achieve water security requires diversifying water sources to include water reuse, stormwater capture, recycled wastewater, groundwater and more. This requires (US EPA 2020):

- **Construct new infrastructure**: Diversify options for water supply and expand current sources: Diversifying sources helps to reduce the risk that water supply will fall below water demand. Examples of diversified source water portfolios include using a varying mix of surface water and groundwater, employing desalination when the need arises, and establishing water trading with other utilities in times of water shortages or service disruption.
- **Build infrastructure needed for aquifer storage and recovery**: Increasing the amount of groundwater storage available promotes recharge when surface water flows are more than demand, thus increasing climate resilience for seasonal or extended periods of drought and taking advantage of seasonal variations in surface water runoff. Depending on whether natural or artificial aquifer recharge is employed, the required infrastructure may include percolation basins and injection wells.
- **Increase water storage capacity**: Increased drought can reduce the safe yield of reservoirs. To reduce this risk, increases in available storage can be made. Methods for accomplishing this may include raising a dam, practicing aquifer storage and recovery, removing accumulated sediment in reservoirs, or lowering water intake elevation.
- **Practice conjunctive use**: Conjunctive use involves the coordinated, optimal use of both surface water and groundwater, both intra- and inter-annually. Aquifer storage and recovery is a form of conjunctive use. For example, a Local Municipality may store some fraction of surface water flows in aquifers during wet years and withdraw this water during dry years when the river flow is low. Depending on whether natural or artificial aquifer recharge is employed, the required infrastructure may include percolation basins and injection wells.

4. Conclusion

Despite the frequency of droughts in South Africa, the responses are mostly reactive, dealing with drought in an emergency mode rather than it being a normal, recurrent feature. The aims of the project were: identify and review lessons and initiatives from past and ongoing drought periods and major disturbances; verify and test sustainability of implemented initiatives; provide a framework for developing strategic water resilience initiatives at all levels. The review was based on a literature review and case study area investigations. The case study areas included Nelson Mandela Bay Metropolitan Municipality, Beaufort West Local Municipality and Nama Khoi Local Municipality.

The analysis showed that there are initiatives that supported pro-active drought response development in the form of climate change response plans. In the response plans, the most frequent strategy is catchment rehabilitation, e.g. invasive species removal and the second most proposed strategy water conservation and demand management. Operation and maintenance of water structure and consumer education also featured highly in responses. The least favoured response was water transfer followed by promotion of greywater use; introduction of water efficient fittings; leak repairs; tariff, metering and credit control; and water sensitive designs. However, implementation of these initiatives through integration into the IDPs was not clearly demonstrated and limited literature was available to verify implementation measures.

The CPA approach was used to analyse resilience of urban water security in three case study areas. NMBM has low levels of capital availability and robustness. It has high levels of risk for all capitals. The relatively higher water availability reflects normal water supply situation. During drought periods the water supply situation deteriorates dramatically, as is the current case. The ability of the communities to adapt to drought situation is low. Like NMBM, the Beaufort West LM has low levels of capacity and robustness. Although the Natural Capital is high under normal conditions during drought situations, the Natural Capital declines significantly. The community adaption is relatively higher because of the reliance on more than one source of water, but the management capabilities are weak. The same issues apply to the Nama Khoi Municipality. The report concludes with drought resilience intervention guidelines (section 3.3). Any Municipality under water stress needs a long-term strategy for drought resilience interventions that considers long-term conditions and plans for permanent solutions Such a drought resilience intervention should include stakeholder engagement, functioning institutions and diversity of water sources and co-operation between local, regional and national levels of government.

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Appendix 1: Status of drought plans

<table>
<tr>
<td>Alfred Nzo District Municipality

ALFRED NZO
DISTRICT MUNICIPALITY</td>
<td>Reference material:
• Climate Change Response Strategy(Alfred Nzo District Municipality, 2015).
• Climate Change Adaptation Summary Report(Alfred Nzo District Municipality, 2017).
• Reconciliation strategies – summary report Alfred Nzo District Municipality(DWA, 2011c).</td>
</tr>
<tr>
<td colspan="2">Supply side responses:
1. Water storage infrastructure.
• Extension of the Makoba Scheme.
• Detailed planning and construction of the Kinira River Dam for supply to the Matatiele Growth Node and surrounding villages.
• Detailed planning for and raising of the Ntenetyana Dam for supply to the Mount Frere Growth Node and surrounding villages.
• Detailed planning and construction of the Siroqobeni River Dam for supply to the Mount Ayliff Growth Node and surrounding villages.
• Feasibility study and detailed planning for a new dam in the Mkemane River to supply Mount Frere and surrounding villages.
2. Groundwater extraction.
• Determine the yield of the boreholes currently supplying Cedarville and update the Water Services Development Plan accordingly.
• Feasibility study to determine current yield of wellfield, options for optimization of well-field management and possible future targets.
• Feasibility study with hydrogeological investigation and exploratory drilling and testing to confirm groundwater potential (Molteno Formation and the Tarkastad Subgroup) and identify target areas for well-field development across the District Municipality area.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting.
7. Managed aquifer recharge.
8. Water sensitive designs.</td>
</tr>
<tr>
<td colspan="2">Demand sides responses:
1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.</td>
</tr>
</table>

11. Catchment rehabilitation.

- Catchment management that conserves natural resources.
- Develop investment opportunities in ecosystem goods and services.

12. Operation and maintenance of water infrastructure

- Upgrade the Matatiele WTW to a suitable capacity and standard.
- Replace all broken pipes and fittings, implement metering at all connections and conduct a water balance to determine actual losses.

Amajuba District Municipality 	Climate Change Vulnerability Assessment and Response Plan(Amajuba District Municipality, 2018). Reconciliation strategy for Newcastle Water Supply Scheme Area Reconciliation strategy for Newcastle Water Supply Scheme Area(DWA, 2011d)

Supply side responses:

1. Water storage infrastructure.

- The District together with Newcastle LM to conduct a feasibility study on the construction of new raw water storage / dams in the District Municipal Area.
- Increase water use entitlement from Ntshingwayo Dam and the tertiary catchment V31 system.
- Reserving up to 23 million m^3/a of water from the Ntshingwayo Dam and tertiary catchment V31 system to meet the future water requirements.

2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Undertake a feasibility study to determine the viability of reuse of treated effluent, type of users, infrastructure requirements.
- Prepare targets for industries to implement water recycling programme.
- The District together with Newcastle LM to conduct a feasibility study by 2022 on the possibility of recycling stormwater in the District Municipal Area for agricultural use.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Draft a proposal for the removal of silt from major dams that will be sent to the Department of Water and Sanitation by 2021.
- Review and revise all District and Local Municipality By-Laws and policies relating to water and sanitation that affect the environment, by 2020.
- Draft a proposal for the removal of silt from agricultural and rural village dams that will be sent to the Department of Agriculture and Rural Development by 2021.
- Conduct a feasibility study on the removal of silt from dams used for domestic and industrial water use.
- The District together with all the LMs to establish an Expanded Publics Works

Programme project focusing on the cleaning of stormwater drains and culverts by 2021.

- Local Municipalities to install mesh screens (sieves / filters) on all stormwater drains in the District to stop solid waste from entering stormwater drains by 2022.
- Establish a project to construct gabions to redirect stormwater away from vulnerable areas, and into rivers and streams.

12. Operation and maintenance of water infrastructure.

- The District to compile a status quo report of the water infrastructure in the District Municipality and encourage the Water Services Development Plan to include climate change by 2026.
- Provide metering for raw water abstraction.
- Upgrade the raw water abstraction works and pipelines.
- Upgrade the WTW and the treated bulk water supply pipelines.
- Upgrade the service storage reservoir capacities

Amathole District Municipality	Climate Change Vulnerability Assessment and Response Plan(Amathole District Municipality, 2018). Amatole Water Supply System Reconciliation Strategy(DWA, 2012).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Amathole District Municipality to develop an aggressive water demand and water loss management plan and competency for the District Municipality.
- Amathole District Municipality to develop proactive drought contingency plans by 2020.

2. Tariffs, metering, and credit control.
3. Water restrictions
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Partnerships for improved management of catchments and water resources.
- Prioritize the importance of waste minimization and recycling in waste management planning.
- Implement a project aimed at reusing and recycling waste.

12. Operation and maintenance of water infrastructure.

- Mains replacement programme in Stutterheim.

Buffalo City Metropolitan Municipality	Amatole Water Supply System Reconciliation Strategy(DWA, 2012).

Supply side responses:

1. Water storage infrastructure.

- Integrated system operation: Long-term operating rules for the Amatole Water Supply System have been determined and when implemented, would result in a system yield of 100.1 million m^3/a.
- Wesselshoek Dam (Kwelera River) – the most favourable of the options.
- Ravenswood Dam (Keiskamma River) – only if a large yielding dam is required.
- Stone Island Dam (Nahoon River) – potential environmental implications.

2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt Water Re-use Strategy in 2012.
- Commence studying potential water re-use schemes as from 2012, which seek to deliver an additional yield of 2.9 million m^3/a per year over five years, effective from 2020, i.e. the latest start date for the planning to implement the first project is 2014.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Plan and implement WC/WDM projects, which should seek to achieve an average requirement savings of 1.2 million m^3/a per year over an eight-year period, starting from 2012.
  - Reducing non-revenue water.
  - Increasing billed metered consumption.
  - Reducing raw water treatment losses.
  - Mains replacement (AC pipes).
  - Enhancing the institutional capacity to implement WC/WDM measures on a sustainable basis.
  - Promoting of water use efficiency.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.

9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
- Streamflow enhancement.
12. Operation and maintenance of water infrastructure.

Cape Winelands District Municipality  	Climate Change Adaption Summary Report (Cape Winelands District Municipality, 2018) Reconciliation strategies – summary report Cape Winelands District Municipality(DWA, 2011c).

Supply side responses:

1. Water storage infrastructure.

- Breede Valley Local Municipality.
  - Feasibility study considering the possibility to abstract water from the various water sources, namely the Osplaas Dam, Roode Els Dam, Lakensvallei Dam, Brandvlei Dam, Breede River, WCWSS transfer scheme.
  - Investigate linking Rawsonville to the Worcester system (Stettynskloof Dam).
  - Feasibility study considering the possibility to abstract water from the Hex River, Amandel River, Grootkloof River, Touws River, Spek River and Koo River.
  - Investigate further abstraction from the Waterkloof and Donkerkloof streams.
- Langeberg Local Municipality.
  - Feasibility study to consider the potential for abstraction from the Keurkloof River.
  - Yields from the Keisie and Kingna rivers. Hydrology assessment and Feasibility study.
- Drakenstein Local Municipality.
  - Potential for additional abstraction from Voëlvlei Dam. Hydrology assessment and feasibility study.
  - Investigate abstraction from Berg River.
  - Investigate Wit River Scheme.
- Stellenbosch Local Municipality.
  - Feasibility Study for further abstraction from Eerste River.
- Witzenberg Local Municipality.
  - Feasibility study on surface water options, with cost analysis, considering future competing interests within the DM and potentially within the WCWSS area.

2. Groundwater extraction.

- Breede Valley Local Municipality.
  - The sustainable yield of the boreholes is unconfirmed. Test boreholes and update Water Services Development Plan accordingly.
- Witzenberg Local Municipality.
  - Undertake groundwater feasibility study for the development of groundwater well field for emergency supply and diversification.
  - Pre-feasibility on different exploration targets and feasibility study on preferred TMG groundwater availability, and pilot well-field project.

3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Facilitate research into the re-use of wastewater within the District Municipality.

- Stellenbosch Local Municipality.
  - Feasibility study for the potential and costs of water re-use scheme.
- Rainwater and stormwater harvesting

6. Managed aquifer recharge

- The replenishment of aquifers by infusion of purified wastewater should be researched.

7. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Invasive aquatic weeds removal and management in Berg and Breede Rivers. Continuous clearing should be done annually between September and April. The specific area to be targeted is between the R45 and Hermanus.
- Increase alien clearing in catchments.

12. Operation and maintenance of water infrastructure.

- Facilitate the assessment of existing infrastructure for water storage.
- Breede Valley Local Municipality.
  - Additional reservoirs Breede Valley Local Municipality.
  - Upgrade pipeline from Stettynskloof Dam to Worcester.
  - Fix bulk water losses and implement Water Conservation and Water Demand Management Strategy. Very high-water losses (55%) in Touws River.
- Langeberg Local Municipality.
  - Investigate potential upgrade or rehabilitation of WWTW in Ashton, Bonnievale, McGregor and Montagu.
- Drakenstein Local Municipality.
  - An additional 1.1 Ml reservoir is required Upgrade.
  - Upgrade Wellington WTW to a 10 Ml/d plant (0.365 million m^3/a).
  - Bulk supply pipeline from the Leeu River in poor condition. Pipeline must be upgraded.
- Stellenbosch Local Municipality.
  - Upgrade of wastewater treatment works for Franschhoek and Jamestown, and new wastewater treatment works for Klapmuts required.
  - Additional storage capacity is needed for Pniel, Kylemore and Groot-Drakenstein.
- Witzenberg Local Municipality.
  - Investigate condition of reticulation network, including reservoirs, and implement maintenance and replacement where required to reduce losses.
  - Improve O&M resources for Tulbagh wastewater treatment works.
  - Upgrade of Wolseley wastewater treatment works.

Capricorn District Municipality 	Climate Change Vulnerability Assessment and Response Plan(CDM, 2016) Establishment of Operating Rules for the Glen Alpine System: Executive Summary(DWA, 2011e). Operating Rules for the Glen Alpine System(DWA, 2011e). Operating Rule for the Houtrivier Dam System(DWA, 2014a). Operating Rule for the Mashashane Dam System(DWA, 2014b). Operating Rule for the Seshego Dam System(DWA, 2014a). First order reconciliation strategy for the Aganang East ground water scheme(DWA, 2011f). First order reconciliation strategy for the Alldays groundwater scheme(DWA, 2011g). First order reconciliation strategy for the Archibald groundwater scheme(DWA, 2011h). First order reconciliation strategy for the Avon ground water scheme(DWA, 2011i). First order reconciliation strategy Badimong regional water supply scheme(DWA, 2011j). First order reconciliation strategy for the Bakone groundwater scheme(DWA, 2011k). First order reconciliation strategy for the Blouberg regional water scheme(DWA, 2011l). First order reconciliation strategy Boyne regional water supply scheme(DWA, 2011j). First order reconciliation strategy Chuene Maja regional water supply scheme(DWA, 2011m).

Supply side responses:

1. Water storage infrastructure.

- Establishment of Operating Rules for the Glen Alpine System.
  - A study on the impact of raising the existing dam wall on the yield availability is recommended.
  - Requirements for environmental releases from this sub-system is recommended.
- Aganang Local Municipality
  - Operating Rule for the Mashashane Dam System.
    - The Mashashane sub-system is inadequately gauged. It is recommended that gauge plates be installed at the dam as soon as possible.
    - The operating rule developed in this study recommends supplying 37% of 0.282 Mm^3/year from the dam (supply 0.29 Ml/day or 0.10 Mm^3/year).
- Polokwane Local Municipality
  - Operating Rule for the Houtrivier Dam System.
    - Gauge stations be installed and maintained to measure inflows and outflows from the dam.
    - A basin survey should be conducted to establish the dam characteristics and gauge plates should be installed to measure dam levels and for monitoring storage.

- Operating Rule for the Seshego Dam System.
  - Polokwane Local Municipality should apply for allocation for water from the dam.
  - Abstraction from the dam is not being measured because of lack of instrumentation. There are raw water meters at the water treatment plant. These should be used for monitoring of abstraction.
  - No measuring storage levels are being taken. The old gauge plates at Seshego Dam should be replaced as soon as possible.
  - The operating rule developed in this study recommends supplying 74% of the abstraction from the dam under current practice.
- Badimong regional water supply scheme
  - Water use requirements for domestic users are currently based on benchmark estimates. These requirements need to be balanced with the actual use.
  - The present allocation from the Ebenezer pipeline needs to be revised to meet the balance of additional requirements.
- Chuene Maja regional water supply scheme
  - Confirm the yield of the Chuene Dam. Should this be confirmed at 1.0 Million m^3/a and should the Chuene Maja RWS supplying this cluster be the only major user, then there are adequate water resources to meet the needs of the cluster, particularly given the effective implementation of WC/WDM.
  - Water use requirements of domestic users are currently based on benchmark estimates. These requirements need to be firmed up, and the Maratapelo WTW upgraded over and above current capacity to meet additional needs. This must be undertaken as a matter of urgency.
  - Any additional demands on the Chuene Dam need to be listed and factored into the water availability scenario.
  - A Water Conservation and Demand Management Strategy must be developed and implemented.
    - A water management metering system with leakage detection and a repair programme must be implemented. Individual use must also be managed.
    - Illegal connections from the bulk pipeline must be routed to the reticulation pipeline and all use metered.
  - Further opportunities to utilize groundwater should be explored. Groundwater should be used in all areas where distribution of surface water is too expensive. Groundwater can also be used conjunctively to supplement surface water.
  - With accurate metering in place, annual water use must be monitored and requirements adjusted as indicated by trends in population and use.

2. Groundwater extraction.

- Aganang Local Municipality
  - Aganang East ground water scheme
    - Undertake a detailed investigation to determine actual water usages, sustainability of source and availability of future supply. Should there be sufficient groundwater resources, augment the current domestic supply by

either:

- Utilising the existing boreholes within the study area. Water Services data indicates that there are 89 equipped boreholes and 108 unequipped boreholes in the area for which the use is not specified.
- Drilling and equipping additional boreholes within the study area.

- Develop and implement a Water Conservation and Demand Management plan with clear performance targets. This must include limiting the wasteful use of water to control water consumption and utilise the available resources to their full potential and limit wasteful water use.
- Water use should be accurately monitored through a network of water meters which should be recorded on a regular basis. As a critical step when introducing measures to encourage water conservation, it is important to have an accurate set of baseline data against which any progress can be measured. The priority must therefore be to ensure that there is an adequate network of water meters and accurate readings are recorded on a regular basis.
- Register existing water use and ensure that planned increases in water use are registered with the DWA.

- Bakone groundwater scheme
  - Undertake a detailed investigation to determine actual water usages, sustainability of the local aquifer, as well as availability of future supply.
  - Should it be confirmed that sufficient water is available, augment the current water supply from the local aquifer. This may require either equipping existing boreholes or installing new boreholes. It is estimated that an additional 0.270 Million m^3/a will be required for domestic supply from this resource by 2030.
  - Develop and implement a Water Conservation and Demand Management plan with clear performance targets. This must include limiting the wasteful use of water to control water consumption and utilise the available resources to their full potential and limit wasteful water use.
  - Implement comprehensive monitoring of the groundwater table and of groundwater use by all users (domestic and agricultural) in the area to ensure sustainable use.
  - Register existing water use and ensure that planned increases in water use are registered with the DWA.

- Blouberg Local Municipality
  - Alldays groundwater scheme
    - Short term
      - Review and implement water treatment of the local groundwater prior to distribution to the community.
      - Conduct an in-depth hydrogeological assessment of the groundwater to confirm the available resources, water users and volume available for augmentation.
      - Based on the hydrogeological assessment results, either:
        - Augment the water supply with local groundwater.
        - Equip the three boreholes in De Vrede which have been

dedicated to Alldays and install a supply pipeline.
        - ❖ The combined use of both resources is most likely.
    - ➢ Investigate the actual agricultural use of groundwater with regards to the potential to buy-out a portion of the agricultural allocation to be used for domestic supply.
  - Long-term
    - ➢ Formalise and monitor groundwater use in the area.
    - ➢ Develop and implement a Water Conservation and Water Demand Management strategy to ensure the effective use of water resources.
- Archibald groundwater scheme
  - Short term
    - ➢ Review and implement water treatment of the local groundwater prior to distribution to the community.
    - ➢ Conduct an in-depth hydrogeological assessment of the groundwater to confirm the available resources, water users and volume available for augmentation.
    - ➢ Augment the water supply with local groundwater, with special consideration to abstraction along the banks of the Mogalakwena River.
  - Long term
    - ➢ Formalise and monitor groundwater use in the area.
    - ➢ Develop and implement a Water Conservation and Water Demand Management strategy to ensure the effective use of water resources.
- Avon ground water scheme
  - Undertake a detailed investigation to determine actual water usages, sustainability of source and availability of future supply.
  - Develop and implement a Water Conservation and Demand Management plan with clear performance targets. This must include limiting the wasteful use of water to control water consumption and utilize the available resources to their full potential and limit wasteful water use.
  - As a critical step when introducing measures to encourage water conservation, it is important to have an accurate set of baseline data against which any progress can be measured. The priority must therefore be to ensure that there is an adequate network of water meters and accurate readings are recorded on a regular basis.
- Blouberg regional water scheme
  - Undertake a detailed investigation to determine actual water usages, sustainability of source and availability of future supply. Should there be sufficient groundwater resources, additional boreholes will need to be installed to augment the domestic supply to the scheme.
  - Additional water resources are said to be available from the Ga-Hlako settlement. This will need to be confirmed and used to augment the Blouberg RWS.
  - Develop and implement a Water Conservation and Demand Management plan with clear performance targets. This must include limiting the

wasteful use of water to control water consumption and utilise the available resources to their full potential and limit wasteful water use.
    - As a critical step when introducing measures to encourage water conservation, it is important to have an accurate set of baseline data against which any progress can be measured. The priority must therefore be to ensure that there is an adequate network of water meters and accurate readings are recorded on a regular basis.
    - Implement comprehensive monitoring of the groundwater table and of groundwater use by all users (domestic and agricultural) in the area to ensure sustainable use.
    - Register existing water use and ensure that planned increases in water use are registered with the DWA.
- Polokwane Local Municipality
  - Badimong regional water supply scheme
    - The rehabilitation of groundwater resources upgraded over and above current capacity to meet additional needs. This must be undertaken as a matter of urgency.
    - Groundwater should be used in all areas where distribution of surface water is too expensive. Groundwater can also be used conjunctively to supplement surface water.
  - Boyne regional water supply scheme
    - Water use requirements for domestic users are currently based on benchmark estimates. These requirements need to be balanced with the actual use, and the rehabilitation of groundwater resources, upgraded over and above current capacity to meet additional needs. This must be undertaken as a matter of urgency.
    - The present allocation from the Ebenezer pipeline is adequate to meet the balance of additional requirements.
    - Groundwater should be used in all areas where distribution of surface water is too expensive. Groundwater can also be used conjunctively to supplement surface water.
    - Any additional demands on the Boyne RWS need to be listed and factored into the water availability scenario.
    - A Water Conservation and Demand Management Strategy must be developed and implemented.
      - A water management metering system with leakage detection and a repair programme must be implemented. Individual use must also be managed.
      - Illegal connections from the bulk pipeline must be routed to the reticulation pipeline and all use metered.
    - With accurate metering in place, annual water use must be monitored, and requirements adjusted as indicated by trends in population and use.

3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Identify and implement innovative water harvesting and savings initiatives to enable

adaptation to reduced water for irrigation and drinking water.

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Plan for projected increases in drought cycles because of climate change and introduce appropriate measures to maintain an acceptable assurance of water supply.
- Polokwane Local Municipality
  - Badimong regional water supply scheme
    - Any additional demands on the Badimong RWS need to be listed and factored into the water availability scenario.
    - A Water Conservation and Demand Management Strategy must be developed and implemented.
      - A water management metering system with leakage detection and a repair programme must be implemented. Individual use must also be managed.
      - Illegal connections from the bulk pipeline must be routed to the reticulation pipeline and all use metered.
    - With accurate metering in place, annual water use must be monitored, and requirements adjusted as indicated by trends in population and use.

2. Tariffs, metering, and credit control.
3. Water restrictions.

- Polokwane Local Municipality
  - Operating Rule for the Houtrivier Dam System.
    - The 5-year storage forecasts with starting storage of 65.54% of full supply capacity and an annual abstraction of 1.24 Mm^3/year show that the dam would reach very low levels in the fourth year if inflow below the 75% exceedance level is experienced. Therefore, restrictions would be required.

4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.
- Promote knowledge generation, knowledge sharing, stakeholder participation and awareness-raising regarding reduced water availability.
- Collect information on indigenous knowledge which has previously been utilised in the past and will contribute towards building resilience.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Conduct a climate change impact assessment on health risks to aquatic systems.
- Identify and implement wastewater monitoring initiatives that will indicate risks to

aquatic systems.

- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.
- Implement watershed management that responds to reduced water availability to optimize yields of clean freshwater and storage capacity in dams.

12. Operation and maintenance of water infrastructure.

- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

Central Karoo District Municipality	Climate Change Adaptation Summary Report(Alfred Nzo District Municipality, 2017)

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- Increase ground water monitoring and record keeping.

3. Water transfers.
4. Desalination

- Consider reverse osmosis water reclamation plants in other parts of Central Karoo – and share best practice with other local municipalities.

5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Report on assessment of alternative mechanisms for water capture across all local municipalities by 2018/19.

7. Managed aquifer recharge

- Consider mechanisms to increase water recharge, for example, crescent shaped earthen dams across the landscape help to capture water in one place and lets this then percolate into the groundwater aquifers.

8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Continue reduced urban water demand measures and drought measures (e.g. greywater reuse, emergency tariffs, water leak detection and reporting, ensure working equipment for water measurement, groundwater monitoring, etc.).
- Encourage low/no water use agri-processing techniques, water demand management, increase in water reuse technologies, and possible 'water from air' technologies.
- Support zero water using industries and businesses and further attract those economic activities that will not negatively impact on groundwater supplies.

2. Tariffs, metering, and credit control.

- Assess potential for implementation of smart meters for water (to protect water sources).

3. Water restrictions.
4. Leak repairs

- Report on water losses investigations – understanding what causes the leaks. Across all local municipalities by 2018/19. To be done by EPWP.

5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.

9. Promotion of greywater use.

10. Promotion of rainwater tanks.

- Conduct and assess alternative mechanisms for water capture (rooftop rainwater harvesting & landscape harvesting into underground tanks). Increased evapotranspiration means that all water bodies need to be protected further from much more rapid evaporation as the region warms.

11. Catchment rehabilitation.

- Continued support for Drought schemes by Department of Agriculture and farmers, and motivation for annual drought financial budget from national treasury.

12. Operation and maintenance of water infrastructure.

Chris Hani District Municipality	Climate Change Vulnerability Assessment and Response Plan(Amathole District Municipality, 2018)

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Engineering Department to develop a stormwater management plan by December 2018.

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Implementation of an Expanded Public Works Programme (EPWP) and Community Work Programme (CWP) plan by June 2019. Both projects will be implemented in Enoch Mgijima LM in Ward 12 (Mlungisi Area) and Ward 6 (Ezibeleni Area) and will be Grant Funded.

12. Operation and maintenance of water infrastructure.

- Engineering Department to develop a water infrastructure maintenance plan by December 2018

City of Cape Town  	Western Cape Water Supply System Reconciliation Strategy study: Summary Report(DWAF, 2007). Water Strategy(City of Cape Town, 2019).

Supply side responses:

1. Water storage infrastructure.

- Voëlvlei Phase 1.
- Berg River augmentation scheme.
- Michell's Pass Diversion.
- Upper Wit River Diversion.
- Raising Steenbras Lower Dam (including pre-feasibility of Upper Campanula Dam).
- Lourens River Diversion Scheme.
- Upper Molenaars Diversion.
- Steenbras Pumped Storage Scheme Intake.
- Possible additional off-channel raw water storage at Misverstand Dam.
- Operation of Kleinplaas Dam.

2. Groundwater extraction.

- Promotion of private boreholes and wells
- TMG Aquifer Feasibility Study.
- TMG Regional Monitoring.
- Newlands Aquifer.
- Cape Flats aquifer (phases 1 and 2).
- Table Mountain Group aquifer (phases 1 to 3).
- Atlantis aquifer (improved management).
- Conjunctive use.

3. Water transfers.
4. Desalination

- Pilot Desalination Plant.
- Desalination (further phases).

5. Return flows and re-use.

- Effluent Re-use (policy, effluent treated to potable standards, effluent treated for irrigation/industry use).
- WCWSS Use of Treated Effluent Study.
- Integrated WSWSS Re-use of Water Study (including Berg River water exchange)
- Faure new water scheme.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge

- West Coast Aquifer Recharge (Langebaan Road Aquifer).
- Artificial Recharge.
- Artificial Recharge: Breede River Alluvium.

8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- CCT 8-year WC/WDM Strategy and Programme
- City will also continue to review and improve its by-laws, regulatory mechanisms, and

other incentives to promote water efficiency and the treatment and reuse of groundwater, stormwater, and wastewater.

- Water Trading.

2. Tariffs, metering, and credit control.

- Adjustment of water tariffs, metering, and credit control.
- The City will use pricing to promote wise water use.

3. Water restrictions.

- Three restriction levels.

4. Leak repairs

- Leakage detection and repair

5. Reduction of high pressure.
6. Consumer education.

- User education.

7. Introduction of water efficient fittings.

- Use of water efficient fittings.

8. Elimination of automatic flushing urinals.

- Eliminate auto flush urinals.

9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Implications of implementing ecological Reserve on existing water resources.
- Invasive alien vegetation clearance (catchment management).

12. Operation and maintenance of water infrastructure.

City of Ekurhuleni	Climate Change Response Strategy(Ekurhuleni Metropolitan Municipality, 2015)

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Promote the use of rainwater harvesting systems in households and businesses.
- Build retention dams to accommodate the overflow and assist with managing storm water.

7. Managed aquifer recharge

8. Water sensitive designs

- Consider permeable pavements, green roofs, and rain tanks to increase on-site retention of storm water.
- Promote the planting of indigenous trees around riverbanks to control runoff.

Demand side responses:

1. Water conservation and demand management.

- Implement Water Demand Management and Water Loss Strategies.
- Monitor unlawful water use.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs

- Identify water losses in the water supply system to the municipality and implement a programme of fixing leaks and other losses from the water supply chain.

5. Reduction of high pressure.
6. Consumer education.

- Conduct awareness and education campaigns for water conservation.

7. Introduction of water efficient fittings.

- Encourage the use of water conservation technology, e.g. low flush toilets, low flow shower heads.
- Improve residential, industrial, commercial, and shopping centre water usage by regulation of installation of low usage taps. Use incentives, and water-wise campaigns.

8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.

- Support new technologies to utilize greywater and rainwater.

10. Promotion of rainwater tanks.

- Encourage rainwater harvesting for flushing toilets, car washing, and irrigation.

11. Catchment rehabilitation.

- Monitor stream flow particularly for improved infrastructure planning and development.
- Monitor water quality.
- Improve the groundwater monitoring system.
- Monitor the acid mine drainage.
- Preserve wetlands.
- Protect and rehabilitate aquatic systems.
- Implement policies that prevent development on wetlands.
- Conduct awareness and education campaigns.
- Develop links with water research institutes to ensure early preparation for extreme events (such as flooding).
- Maintain meteorological monitoring at the air quality monitoring station so as to provide additional climate data in the area.

12. Operation and maintenance of water infrastructure.

- Maintain and upgrade stormwater infrastructure.

City of Joburg 	Climate Change Adaptation Plan(City of Johannesburg, 2009)

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.

- Engaging with Rand Water and other water managers involved in trans-boundary and intrabasin transfers to determine security of supply in the face of climate change projections and local data.

4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs

- The CoJ should continue and, where possible, expand their capital investment programme aimed at water pipe leak reduction.

5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.

- Use of water efficient fittings (taps, showers, toilets), which is a low cost but highly effective initiative.
- Use of water efficient HVAC and refrigeration systems.
- Incentivize the use of drip irrigation systems, which are in most cases use 30-60% less water than conventional sprinkler systems.
- The use of waterless urinals (using a non-return valve) could be mandated in all CoJ administration and public buildings.

8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.

- Mandate greywater capture and re-use.

10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Use of indigenous and endemic vegetation in landscaping, not requiring water for irrigation.
- Monitoring consumers' use of ground water as far as possible to better understand the supply and demand of borehole water.

12. Operation and maintenance of water infrastructure.

City of Tshwane	Climate Response Strategy(City of Tshwane).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Implementation of the City's Water Conservation and Water Demand Management Strategy, which includes reducing apparent losses by:
  - Conducting meter audits of large water consumers in the City.
  - Replacing meters.
  - Purifying data.
  - Reducing real losses by managing water pressure effectively, replacing worn water pipes and improving leak detection and reaction time for leak repair.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Development of an Integrated Water Resource Management assessment in association with Water Research Commission and CSIR, followed by an implementation plan.

12. Operation and maintenance of water infrastructure.

Dr Kenneth Kaunda District Municipality	Climate Change Vulnerability Assessment and Response Plan(Dr Kenneth Kaunda District Municipality et al., 2016). Climate Change Vulnerability Assessment and Response Plan(Dr Kenneth Kaunda District Municipality et al., 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting

- Identify and implement innovative water harvesting and savings initiatives to enable adaptation to reduced water for irrigation and drinking water.

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Plan for projected increases in drought cycles as a result of climate change and introduce appropriate measures to maintain an acceptable assurance of water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.
- Promote knowledge generation, knowledge sharing, stakeholder participation and awareness-raising regarding reduced water availability.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Conduct a climate change impact assessment on health risks to aquatic systems.
- Identify and implement wastewater monitoring initiatives that will indicate risks to aquatic systems.
- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and

ecosystem goods and services that are required to buffer increased pollution.

- Incorporate projected climate change impacts into the planning of municipal water supply.
- Collect information on indigenous knowledge which has previously been utilized in the past and will contribute towards building resilience.
- Implement watershed management that responds to reduced water availability to optimize yields of clean freshwater and storage capacity in dams.

12. Operation and maintenance of water infrastructure.

Dr Ruth Segomotsi Mompati District Municipality 	Climate Change Vulnerability Assessment and Response Plan(Dr Ruth Segomotsi Mompati District Municipality, 2016). Climate Change Vulnerability Assessment and Response Plan(Dr Ruth Segomotsi Mompati District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to changes in water quality because of climate change.
- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Identify and implement innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.
- Prioritize and allocate resources to adaptation interventions that will minimize the pollution of drinking water.
- Conduct a climate change impact assessment on health risks to aquatic systems.

- Identify and implement wastewater monitoring initiatives that will indicate risks to aquatic systems.
- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.

12. Operation and maintenance of water infrastructure.

Garden Route District Municipality/ Eden District Municipality 	Climate Change Adaptation Summary Report(Municipality, 2018) Climate Change Adaptation Summary Report(Municipality, 2018)

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination

- Seawater desalination plants

5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.
- Strengthen wastewater treatment management plans, to enable the ability to respond to the declining water reserves.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Water Demand Management/Water Conservation Initiatives to conserve water usage/ensure water use efficiency.
- Alternative water resources – new non-potable treated wastewater pipeline for non-potable household use.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Water services perception surveys.

7. Introduction of water efficient fittings.

- Investigate international best-practice as well as new technology, innovation, and methodologies.

8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.
- Conduct a climate change impact assessment on health risks to aquatic systems.
- Research and improve understanding of climate change impacts on water quality and availability.
- Identify and implement wastewater monitoring initiatives that will indicate risks to

aquatic systems.

- Create awareness on the reuse of wastewater thus minimizing negative impacts of wastewater on aquatic systems.
- Water Resource Management Collaboration Initiatives and Partnerships – Breede-Gouritz Catchment Management Agency, City of Cape Town and some local Category B-Municipalities.

12. Operation and maintenance of water infrastructure.

Ehlanzeni District Municipality	Climate Change Vulnerability Assessment and Response Plan(Ehlanzeni District Municipality, 2016) Climate Change Vulnerability Assessment and Response Plan(Ehlanzeni District Municipality, 2016)

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to changes in water quality because of climate change.
- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.
- Identify and implement innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Prioritize and allocate resources to adaptation interventions that will minimize the pollution of drinking water.
- Conduct a climate change impact assessment on health risks to aquatic systems.
- Identify and implement wastewater monitoring initiatives that will indicate risks to

aquatic systems.

- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.

12. Operation and maintenance of water infrastructure.

eThekwini	Durban Climate Change Strategy(eThekwini Municipality, 2014).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to projected changes in water quality as a result of climate hange.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

- Recognize, make use of, and manage the role that open spaces, natural areas and agricultural land can play in providing flood and storm water protection services.
- Retrofit and modify existing infrastructure and public spaces using adaptive engineering approaches to provide protection against future water related climate impacts.

Demand side responses:

1. Water conservation and demand management.

- Implement water demand management measures to reduce water demand in the face of projected climate change impacts.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Facilitate co-operation between relevant agencies to jointly manage climate change impacts on catchments that supply water to Durban.
- Implement watershed management that responds to projected climate change impacts to optimize yields of clean freshwater and storage capacity in dams.
- Prioritize water connections to communities that are most vulnerable to projected climate change impacts such as water scarcity and health risks.

- Plan for projected increases in drought cycles because of climate change and introduce appropriate measures to maintain an acceptable assurance of water supply.
- Incorporate projected climate change impacts into proactive planning of the municipal water supply.
- Adopt a risk-averse approach to water quality protection by imposing stringent controls on water polluting land uses and activities to ensure that the impacts of climate change are not exacerbated.
- Adopt and enforce a risk-averse approach to spatial, land use and infrastructure planning and development controls that respond to potential climate change amplified flood risks.
- Research conducted into changes in projected rainfall and flood lines is incorporated into guidelines that are used when designing, planning, and implementing all types of infrastructure. Considerations should include location of new infrastructure, infrastructure design and choice of materials.
- Adopt and enforce adaptive engineering approaches that are flexible and can evolve in response to changing threats and levels of flooding.
- Identify and prioritize the relocation or upgrading of informal and low-income settlements that are vulnerable to flooding.
- Incorporate the possibility of extreme water-related climate change events into the operational planning of the provision of basic services such as public transport, water, electricity, wastewater management and refuse collection to prevent long term disruption of services and pollution of water bodies.

12. Operation and maintenance of water infrastructure.

- Identify and relocate existing critical infrastructure that is in areas of high flood risk to areas of lower risk.
- Monitor the effectiveness of storm water systems and upgrade where necessary to respond to variability in precipitation events and the projected increases in volumes of water and waste.

Fezile Dabi District Municipality	Climate Change Vulnerability Assessment and Response Plan(Fezile Dabi District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Develop and monitor a water services development plan.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.

- Provide JOJO tanks to the community to be used for rainwater harvesting within households.

11. Catchment rehabilitation.

- Ensure that wetland issues are addressed during water catchment forums.
- Improve water catchment forums.

12. Operation and maintenance of water infrastructure.

- Develop an operations and maintenance plan for the water sector.
- Conduct training and capacity building initiatives for water and sanitation officials within the municipality.
- Upgrade all wastewater treatment works and water purification plants in the District Municipal Area.

Frances Baard District Municipality	Climate Change Vulnerability Assessment and Response Plan(Frances Baard District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- Conduct a risk assessment for groundwater availability and consumption.
- Identify research gaps on groundwater systems.

3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

- Include innovative water conservation technologies (water harvesting, greywater reuse) in building and planning requirements.

Demand side responses:

1. Water conservation and demand management.

- Emergency response plan for the outbreak of waterborne diseases.
- Integrate the water sector development plan into the IDP.
- Implement Water Conservation and Water Demand Management (WCWDM).

2. Tariffs, metering, and credit control.

- Improvement of debtor management to allow municipalities to provide and maintain water infrastructure.
- Functional water balances and zonal meters to be put in place at all local municipalities.

3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Develop aggressive water awareness campaigns (water conservation).
- Develop and conduct awareness campaigns in collaboration with the department of Education, Water and Sanitation, NGOs and EHP's from municipalities.

7. Introduction of water efficient fittings.

- Promote the use of innovative water conservation technology that will result in efficient water use.

8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.

- Encourage the reuse and recycling of water (use of greywater).

10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Identify research gaps on aquatic systems.

- Review existing water quality monitoring programmes in collaboration with mining sector, local government, and research institutions to correspond with existing legislation.
- Undertake comprehensive water quality risk assessment at local and district municipality level.
- Undertake comprehensive water quality risk assessments for availability and consumption.

12. Operation and maintenance of water infrastructure.

- Plan and execute refurbishments, upgrades, and maintenance of existing sewer infrastructure.

Gert Sibande District Municipality	Climate Change Vulnerability Assessment and Response Plan(Gert Sibande District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to changes in water quality because of climate change.
- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Support the adoption and enforcement of simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Support the Incorporation of projected climate change impacts into the planning of municipal water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Support research and improvement on the understanding of climate change impacts on water quality and availability.
- Promote the Identification and implementation of innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.
- Support the prioritization and allocation of resources to adaptation interventions that will minimize the pollution of drinking water.
- Support research and improve understanding of climate change impacts on water

quality and availability.

- Support the conducting of a climate change impact assessment on health risks to aquatic systems.
- Support the identification and implementation of wastewater monitoring initiatives that will indicate risks to aquatic systems.
- Support the protection and rehabilitation of aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.

12. Operation and maintenance of water infrastructure.

Harry Gwala District Municipality	Climate Change Vulnerability Assessment and Response Plan(Harry Gwala District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

- Implement building regulations that will promote water conservation in the area.

Demand side responses:

1. Water conservation and demand management.

- The municipality to develop bylaws that will contribute towards water saving.
- Investigate understanding how the District Municipality allocates water to its communities, noting that water within the District has been requested for usage by other municipalities in the province.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Conduct awareness campaigns that promote water saving.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- The waste and gardens department to establish a rubble and garden waste site over a period of three years.
- The waste and garden department to develop a stream cleaning and waste management system.
- Enhance the capacity of the municipality to collect waste.
- The Department of Environmental Affairs to assist the District with developing an Integrated Waste Management Plan.

12. Operation and maintenance of water infrastructure.

iLembe District Municipality	Climate Change Vulnerability Assessment and Response Plan(iLembe District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- iLembe District Municipality's Technical Services Department to construct a new regional wastewater treatment works in a new, suitable location by 2025.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- iLembe District Municipality's Technical Services Department to review existing water by-laws, by 2025.
- iLembe District Municipality to motivate for increased capacity within the District's Technical Services Department to enforce water by-laws, by 2025.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- iLembe District Municipality's Technical Services Department to rehabilitate the Mbozamo River near the wetland by 2028.
- District Municipality's Planning Department to develop an Integrated Waste Management Plan by June 2019.
- District Municipality's Technical services to update the Stormwater and Waste Management Master Plan by June 2019.

12. Operation and maintenance of water infrastructure.

- iLembe District Municipality's Technical Services Department to refurbish and upgrade Sundumbili Wastewater Treatment works by 2021.
- iLembe District Municipality's Technical Services Department to rehabilitate the Mandeni River from Isithebe Bridge to the railway line bridge behind the Mandeni Mall

by 2021.

- iLembe District Municipality's Technical Services Department to identify and refurbish Ndwedwe and Maphumulo Wastewater Treatment Works by 2025.
- iLembe District Municipality's Technical Services Department to demolish and rehabilitate KwaDukuza Wastewater Treatment Works by 2028.

Joe Gqabi District Municipality	Climate Change Vulnerability Assessment and Response Plan(Joe Gqabi District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- The Senqu Local Municipality has funded the installation of stormwater systems in Sterkspruit. Project to be completed by 2019.
- The Walter Sisulu Local Municipality and Joe Gqabi District Municipality have funded a sewer system project in Aliwal North. Phase 1 of the project to be completed by 2018.

12. Operation and maintenance of water infrastructure.

- Local Municipalities to ensure continuous maintenance of sewer and bulk water supply systems.

John Taolo Gaetsewe District Municipality.	Climate Change Vulnerability Assessment and Response Plan(John Taolo Gaetsewe District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
- Improve and sustain the quality of the Kuruman Eye to suffice sufficient supply of water.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
- Implement a system to effectively treat sewage for reuse.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
- Motivate for one tariff system in the area to ensure that the Local Municipalities are financially capacitated and update the indigent list for water, electricity, and sewage property rates.
- Assess the capacity of local municipalities to render water services using section 78 of the Systems Act.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
- Implement a greywater use system in the District.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
- Establish a project to ensure that the youth are brought on board to assist with water quality and quantity projects. Possible projects include data capturing, and, installing and maintaining water flow metres to assist with improving the water balance.
- Ensure skilled staff is trained in water quality sector.
- Establish a project to eliminate alien invasive species and include a community awareness component to the project.
- Establishment of waste disposal site.
- Provide access to refuse removal in rural communities.
12. Operation and maintenance of water infrastructure.

- Upgrade water infrastructure using grants (MIG grants). This includes the construction of new dams to capture rainwater.
- Improve and upgrade wastewater treatment infrastructure to manage leakages and spillovers.
- Implement scheduled sewer system maintenance plan.

King Cetshwayo District Municipality  	Climate Change Vulnerability Assessment and Response Plan(King Cetshwayo District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
- Establish water harvesting projects.
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
- Revisit the Integrated Waste Management Plan.
- Enforce the Environmental Management Plan, NEMA and by-laws.
- Promote cleaning of streams to prevent litter from streams being washed in the stormwater system.
12. Operation and maintenance of water infrastructure.

Lejweleputswa District Municipality	Climate Change Vulnerability Assessment and Response Plan(Lejweleputswa District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs

- Conduct an assessment on leakages and spillages using the War on Leaks program.

5. Reduction of high pressure.
6. Consumer education.

- Intensify awareness on water conservation across the district.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Identify methods to minimize water contamination due to sewer spills.

12. Operation and maintenance of water infrastructure.

- Conduct a status quo assessment of reservoirs across the district to identify any required upgrades.
- Upgrade and maintain water infrastructure to eradicate asbestos pipes and manage water leaks and spillages.
- Conduct a regular assessment and maintenance of sewer infrastructure to identify blockages and aged infrastructure.

Mangaung Metropolitan Municipality  	Metropolitan Spatial Development Framework(Mangaung Metropolitan Municipality, 2020).

Supply side responses:

1. Water storage infrastructure.
- Mangaung Bulk Water Programme
2. Groundwater extraction.
3. Water transfers.
- Mangaung Gariep Water Augmentation Project
4. Desalination
5. Return flows and re-use.
- Maselspoort Reuse Project
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
- Reduce water demand in urban areas to 15% below the business-as-usual scenario by 2030.
- Implement Water Conservation and Demand Management (MMM 10-year WCDM Strategy).
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.
- Maintenance and supply availability of bulk water resources infrastructure.

Mopani District Municipality. 	Climate Change Vulnerability Assessment and Response Plan(Mopani District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Identify and implement innovative water harvesting and savings initiatives to enable adaptation to reduced water for irrigation and drinking water.

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Plan for projected increases in drought cycles as a result of climate change and introduce appropriate measures to maintain an acceptable assurance of water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Promote knowledge generation, knowledge sharing, stakeholder participation and awareness-raising regarding reduced water availability.
- Collect information on indigenous knowledge which has previously been utilized in the past and will contribute towards building resilience.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Implement watershed management that responds to reduced water availability to optimize yields of clean freshwater and storage capacity in dams.

12. Operation and maintenance of water infrastructure.

Namakwa District Municipality	Climate Change Vulnerability Assessment and Response Plan(Namakwa District Municipality, 2017).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
- Conduct further research into groundwater potential.
3. Water transfers.
4. Desalination
- Investigate the feasibility of a desalination plant in Port Nolloth.
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
- Develop and implement household water harvesting projects.
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
- Develop and align water allocation policy for the District.
- Develop and monitor a water services development plan.
- Provide drought relief assistance to farmers through drought relief funding from Disaster Management and Department of Agriculture.
- Review and implement by-laws.
- Identify the municipalities dependent on mines for water provision and develop relevant plans should mines move away.
- Increase internal capacity to deal with climate change and waste water issues and review the staff organogram and existing budgets.
- Undertake comprehensive water quality risk assessments for availability and consumption.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
- Develop education programmes to promote community monitoring processes in collaboration with Conservation South Africa and Department of Water and Sanitation.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
- Identify and implement innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.

- Develop an alien invasive eradication programme for the removal of alien vegetation, especially targeted at Prosopis.

12. Operation and maintenance of water infrastructure.

- Develop an operations and maintenance plan for the water sector.
- Conduct ongoing infrastructure monitoring programmes with associated upgrading programmes.
- Upgrade all wastewater treatment works and water purification plants in the District Municipal Area.

Nelson Mandela Bay Metropolitan Municipality. 	Water Master Plan 2005-2020 (Nelson Mandela Bay, 2006).

Supply side responses:

1. Water storage infrastructure.
- Gamtoos to Summit Pump station and pipeline
- Nooitgedagt WTW-Capacity Upgrade Phase 1 – 35 Ml/d (1 Pulsator & 4'' pump)
- Nooitgedagt WTW-Capacity Upgrade Phase 2 – 35 Ml/d (2 Pulsator & filters)
- Nooitgedagt Quality Upgrade (Phase 1 & Phase 2 RO)
- Sundays River Low Lift Water Augmentation Scheme (Phase 1)
- Motherwell/Chelsea Pipe System Capacity Upgrade (4.9 Km x 700 mm)
- 2nd Gamtoos River pipeline crossing – 600 m x 600 mm
- Schoenies to Driftsands Reservoir pipeline – 3.0 Km x 550 mm

2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
- FWF WWRW Return Effluent Scheme to Coega IDZ

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
- Water Demand Management Programme

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.
- Heatherbank P/st – upgrade capacity
- Emerald Hill P/st – Investigate capacity
- Rosedale & Kamesh P/Sts – Upgrade and install new pumps & surge control
- Greenbush's Zone – 2600 mm x 400 mm pipeline Hotel to Wedgewood
- Theescombe Zone – 6 Ml Reservoir & pipeline & pumps
- Amanzi Zone – 20 Ml Reservoir & 4.7 km x 500 mm feeder & 3.5 Km & 600 mm supply

main

- Balmoral Zone – 9 MI Reservoir & P/st & 0.5 MI tower & 7.5 Km x 300 mm
- Seaview Lower Zone – 2.5 MI reservoir & connector pipelines
- Seaview Upper Zone – 2.0 MI reservoir & approach pipelines & P/st to tower
- Vd Kempskloof Zone – 12 MI reservoir and approach pipelines
- Bethelsdorp BPT Zone – 1 MI reservoir
- Colchester Zone – Phase 2 – 1.5 MI reservoir & pipelines
- Colchester Zone – Phase 3 – Pipeline upgrading IDZ to Colchester
- Coega Kop Zone – 17 MI reservoir
- Witteklip Zone – 5 MI reservoir & approach pipeline
- St Albans Zone – 12 MI reservoir, P/st rising main and supply pipeline Cape Rd
- KwaNobuhle Zone – Replace Floating Roof with 12 MI reservoir
- Theescombe Zone Supply (Phase 1)
- Greenbushes Zone – 2nd Distribution main (550 mm) – Phase 1
- Cholchester Water Supply Upgrade – Phase 1

Ngaka Modiri Molema District Municipality	Climate Change Vulnerability Assessment and Response Plan(Ngaka Modiri Molema District Municipality, 2011).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to changes in water quality because of climate change.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Identify and implement innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.
- Prioritize and allocate resources to adaptation interventions that will minimize the pollution of drinking water.

12. Operation and maintenance of water infrastructure.

Nkangala District Municipality	Climate Change Vulnerability Assessment and Response Plan(Nkangala District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to changes in water quality because of climate change.
- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Identify and implement innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.
- Prioritize and allocate resources to adaptation interventions that will minimize the pollution of drinking water.
- Conduct a climate change impact assessment on health risks to aquatic systems.

- Identify and implement wastewater monitoring initiatives that will indicate risks to aquatic systems.
- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.
- Review the impacts of mining on water quality.

12. Operation and maintenance of water infrastructure.

Supply side responses:

1. Water storage infrastructure.
- Local Municipalities to develop specifications that regulate developments around water sources, such as dams, before June 2019.
- Conduct geological surveys which aim to identify new water sources at Ingquza, Mhlontlo and Nyandeni LM's. This should be done by the end of the financial year and include earth dams (2 for agricultural water use).
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
- Provide incentives to communities or households that are using water efficiently at Ingquza Local Municipality.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
- Purchase equipment that will assist in monitoring water use and leakages.
5. Reduction of high pressure.
6. Consumer education.
- District Municipality to coordinate and facilitate quarterly training, education and awareness campaigns for local communities and businesses, about the efficient use of water around Mthatha Dam.
- Develop a project and implementation plan to encourage conservation and efficient water use in communities. The project should link with existing community programmes.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
- Amend bylaws to allow households to have rainwater harvesting tanks, and to encourage commercial and agricultural businesses to construct underground tanks for water harvesting.
11. Catchment rehabilitation.
- Environmental Management Unit to identify sources/causes of water pollution in all Local Municipalities by the second quarter.

- District Municipality must avail grants each financial year, to communities around Mthatha Dam, who are willing to undertake restoration projects to protect and enhance natural water resources.
- Environmental Management Unit and DEDEAT to undertake quarterly monitoring of compliance regarding water specifications and regulations.

12. Operation and maintenance of water infrastructure.

Overberg District Municipality 	Climate Change Adaptation Summary Report(Overberg District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- Regulate groundwater abstraction.

3. Water transfers.
4. Desalination

- Investigate alternative water desalination options – e.g. using wave power to create the pressure needed for desalination, instead of electricity (Cape Verde, Australia); using solar/wind to generate the necessary energy for desalination.

5. Return flows and re-use.

- Technical Department in each LM to investigate alternative water sources and water re-use options by 2019/2020 financial year.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge

- Investigate alternative water storage options (e.g. underground) / dam expansion where appropriate.
- Use flooding events to store water against future drought periods.

8. Water sensitive designs

- Increase ecological infrastructure to slow, spread and sink water run-off (e.g. on-farm furrows and swales, contour farming, improving the biodiversity status of wetlands and riparian areas, as well as the construction of hard infrastructure where appropriate, e.g. gabions).

Demand side responses:

1. Water conservation and demand management.

- Technical Services in each LM to Develop/Update water loss management plan to address water reticulation losses on annual basis.
- Diversify water sources to reduce dependence on surface water as the only source available during drought periods (see water-related infrastructure responses).
- District to Develop drought management plans for areas that don't already have such plans.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Collaborative effort in conducting water quality monitoring.
- Plan for increased river sediments and its effect on dam infrastructure and storage capacity for municipal owned dams (e.g. riverbank stabilization to prevent erosion leading to sediment build-up in water storage structures).
- Manage potential point source pollution (incl. on-site treatment of stormwater runoff from informal settlements).

12. Operation and maintenance of water infrastructure.

Pixley ka Seme District Municipality.	Climate Change Vulnerability Assessment and Response Plan(Pixley ka Seme District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- Conduct a feasibility study and research on drilling additional boreholes.

3. Water transfers.
4. Desalination

- Establish additional desalination plants to support those that are currently in operation.

5. Return flows and re-use.

- Investigate the use of recycled water for irrigation.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Conduct a feasibility study and research on Hydraulic Fracturing and its impacts on groundwater.
- Conduct a feasibility study and research on proposed Asbestos waste dumping impacts on groundwater.

12. Operation and maintenance of water infrastructure.

Sarah Baartman District Municipality 	Climate Change Vulnerability Assessment and Response Plan(Sarah Baartman District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.

- Kouga Local Municipality's Environmental Management and Infrastructure Departments to improve water conservation efforts by installing rainwater (e.g. JoJo) tanks at newly developed RDP housing projects and encourage private dwellings to adopt a culture of rainwater harvesting by the 2019/2020 financial year.

11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.

- Koukamma Local Municipality's Infrastructure Department to upgrade and maintain water and sanitation infrastructure in the Koukamma Local Municipal Area by the 2019/2020 financial year.

Sedibeng District Municipality	Climate Change Vulnerability Assessment and Response Plan(Sedibeng District Municipality, 2017).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Joint project with GDARD on water harvesting initiatives that will enable adaptation to reduced water availability for drinking and irrigation across the district.
- Incorporate rainwater harvesting in housing development bylaws.

7. Managed aquifer recharge
8. Water sensitive designs

- Upgrade infrastructure with a focus on sustainable urban drainage systems (e.g. rainwater harvesting).

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.
- Increase personnel for municipal water utilities.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs

- Develop programme document to participate in National Fixing Leaks Programme.
- Encourage and promote local plumbers to address internal leaks.

5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.

- Improve sanitation infrastructure.
- Municipality to refurbish their old infrastructure.

Sekhukhune District Municipality	Climate Change Vulnerability Assessment and Response Plan(Sekhukhune District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to changes in water quality because of climate change.
- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

- Build climate change resilient drainage infrastructure that will incorporate increased litter and debris.

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Identify and implement innovative groundwater monitoring initiatives that will indicate change and variability in water salinity.
- Prioritize and allocate resources to adaptation interventions that will minimize the

pollution of drinking water.

- Conduct a climate change impact assessment on health risks to aquatic systems.
- Identify and implement wastewater monitoring initiatives that will indicate risks to aquatic systems.
- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.
- Conduct an impact assessment of climate change induced litter and debris.
- Commission a risk-averse approach to water quality protection by imposing stringent controls on water polluting land uses and activities to ensure that the impacts of climate change are not exacerbated.
- Incorporate the possibility of extreme water-related climate change events into the planning of the provision of basic services such as water to prevent long term disruption of services and pollution of water bodies.
- Develop a flooding early warning and response system.

12. Operation and maintenance of water infrastructure.

- Retrofit and modify existing water and sanitation using adaptive engineering approaches to reduce impacts of increased litter and debris.

Thabo Mofutsanyana District Municipality	Climate Change Vulnerability Assessment and Response Plan(Thabo Mofutsanyana District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Identify and commission water extraction initiatives to enable water supply to communities across the district.

2. Tariffs, metering, and credit control.
3. Water restrictions.

- Ensure the supply of water to drought-stricken communities through the use of water trucks.

4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Conduct awareness campaigns on the impacts of litter on water quality across the district (focusing on disposable nappies).
- Create an awareness on the reuse of wastewater thus minimizing negative impacts of wastewater on aquatic systems.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.

- Promote and encourage the use of greywater management systems/

10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Establish recycling centres (including registration, monitoring, and evaluation of centres) and encourage household waste separation.
- Work with Working for Wetlands, to ensure that there is regular maintenance and care of wetlands in the District Municipal Area.
- Extend youth jobs in waste programme.

12. Operation and maintenance of water infrastructure.

- Increase maintenance of dams to ensure sediment is properly controlled.

- Expand and extend existing Expanded Public Works Programme to assist in clearing of storm water systems.
- Source funding to conduct research around monitoring of water quality.

Ugu District Municipality	Climate Change Adaptation Summary Report(Ugu District Municipality, 2017).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Supply of low-cost field-testing kits in rural areas to monitor water quality and improve early warning.
- Implement community-based water quality monitoring.

12. Operation and maintenance of water infrastructure.

uMgungundlovu District Municipality	Climate Change Adaptation Summary Report(Mgungundlovu District Municipality, 2017).

Supply side responses:

1. Water storage infrastructure.

- Conduct hydrological study for high priority areas in UMDM and develop a plan for rollout of one borehole per high priority ward. To be implemented by 2020 by the District Water Authority.

2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Work with UKZN to undertake an integrated hydrological study into the current and future demand for irrigation in the UMDM using real world case studies.
- Work with UKZN to support subsistence farmers to implement farming methodologies and crop selection that conserve water. To be implemented within Ward 8, Umshwathi wards, Richmond, Msunduzi by 2020. By 2020 a plan needs to be developed to expand to three more sites.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Environmental Health to work with communities on creating awareness campaigns on impacts communities have on water quality. This can target priority river systems in each of the seven local municipalities, within two years.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.

- Support farmers in the responsible and sustainable maintenance of dams and reservoirs to secure access to sufficient water during the winter periods.

uMkhanyakude District Municipality	Climate Change Vulnerability Assessment and Response Plan(uMkhanyakude District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- uMkhanyakude District Municipality to establish borehole-driven water scheme at Makhathini Flats through the use of the MIG funding, to be done by June 2020.

3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.

- uMkhanyakude District Municipality together with Mtubatuba and Jozini Local Municipalities to upgrade the stormwater and sewer systems around Riverview (Mtuba) and Jozini CBD and conduct environmental awareness campaigns by June 2021 using the MIG funding and support through local business.

Supply side responses:

1. Water storage infrastructure.

- Consider the expansion of dams to increase storage capacity.
- Consider emergency water provision through trucking and increased bulk water storage capacity.
- Establish a project to improve bulk water storage and reticulation, over a period of 5 years, in collaboration with the Water Services and Technical Departments as well as the Department Water and Sanitation. Construction of dams and reservoirs, and the rehabilitation of springs, rivers and boreholes.

2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Encourage rainwater harvesting for uses such as toilet flushing, car washing and irrigation.

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Conduct further research on water supply and storage initiatives such as: the widening of dams, trucking of water, desalination, and development approvals in order to respond to increasing drought.

2. Tariffs, metering, and credit control.
3. Water restrictions.

- Prepare plans such as water restrictions to balance the needs of competing users when water availability is reduced (e.g. during drought years).

4. Leak repairs
   Manage and reduce leaks in all water infrastructure.
5. Reduction of high pressure.
6. Consumer education.

- Implement awareness and education campaigns that promote water conservation.

7. Introduction of water efficient fittings.

- Encourage the use of water conservation such as low flow flush toilets and low flow shower heads.

8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Improve water monitoring and forecasting systems for floods and drought by developing

links with water research institutes to ensure early preparation for droughts and flood years.

- Enhance natural barriers (e.g. wetlands and river courses) and improve land care management as to reduce flooding and soil erosion.
- Promote and support recycling as well as the development of buy back centres.
- Ensure proper disposal of waste to reduce the impacts of waste on floods, rising water tables and coastal erosion.
- Establish sound waste management practices that manage the impacts of flooding and rising water tables on waste sites.

12. Operation and maintenance of water infrastructure.

- Maintain and update drainage systems.

Vhembe District Municipality	Climate Change Vulnerability Assessment and Response Plan(Vhembe District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.

- Strengthen management plans on wastewater treatment, to enable the ability to respond to the declining water reserves.
- Adopt and enforce simple, innovative, adaptive engineering approaches wastewater treatment initiatives that will ease the burden on natural water dilution as water quantities decline.

6. Rainwater and stormwater harvesting

- Identify and implement innovative water harvesting and savings initiatives to enable adaptation to reduced water for irrigation and drinking water.

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Incorporate projected climate change impacts into the planning of municipal water supply.
- Plan for projected increases in drought cycles because of climate change and introduce appropriate measures to maintain an acceptable assurance of water supply.
- Implement watershed management that responds to reduced water availability to optimize yields of clean freshwater and storage capacity in dams.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Create an awareness on the reuse of wastewater thus minimising negative impacts of wastewater on aquatic systems.
- Promote knowledge generation, knowledge sharing, stakeholder participation and awareness-raising regarding reduced water availability.
- Conduct awareness campaigns on the type of waste materials that should not be flushed to avoid sewer blockage, e.g. dippers (disposable nappies and sanitary towels) and used condoms.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.

11. Catchment rehabilitation.

- Research and improve understanding of climate change impacts on water quality and availability.
- Conduct a climate change impact assessment on health risks to aquatic systems.
- Identify and implement wastewater monitoring initiatives that will indicate risks to aquatic systems.
- Protect and rehabilitate aquatic systems so that they can provide flow attenuation and ecosystem goods and services that are required to buffer increased pollution.
- Research and improve understanding of climate change impacts on water quality and availability.
- Collect information on indigenous knowledge which has previously been utilized in the past and will contribute towards building resilience.
- Conduct an impact assessment of climate change induced litter and debris.
- Build climate change resilient drainage infrastructure that will incorporate increased litter and debris.
- Commission a risk-averse approach to water quality protection by imposing stringent controls on water polluting land uses and activities to ensure that the impacts of climate change are not exacerbated.
- Incorporate the possibility of extreme water-related climate change events into the planning of the provision of basic services such as water to prevent long term disruption of services and pollution of water bodies.
- Develop a flooding early warning and response system.

12. Operation and maintenance of water infrastructure.

- Retrofit and modify existing water and sanitation using adaptive engineering approaches to reduce impacts of increased litter and debris.

Waterberg District Municipality	Climate Change Vulnerability Assessment and Response Plan(Waterberg District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Conduct an impact assessment of climate change induced litter and debris.
- Build climate change resilient drainage infrastructure that will incorporate increased litter and debris.
- Commission a risk-averse approach to water quality protection by imposing stringent controls on water polluting land uses and activities to ensure that the impacts of climate change are not exacerbated.
- Incorporate the possibility of extreme water-related climate change events into the planning of the provision of basic services such as water to prevent long term disruption of services and pollution of water bodies.
- Develop a flooding early warning and response system.

12. Operation and maintenance of water infrastructure.

- Retrofit and modify existing water and sanitation using adaptive engineering approaches to reduce impacts of increased litter and debris.

West Coast District Municipality	Climate Change Adaptation Summary Report(West Coast District Municipality, 2018).

Supply side responses:

1. Water storage infrastructure.

- Review the entire surface water system for catchment areas in the Western Cape by the Western Cape government in collaboration with DWS, DoA and DEA by November 2018.

2. Groundwater extraction.

- Review the entire groundwater system for catchment areas in the Western Cape by the Western Cape government in collaboration with DWS, DoA and DEA by November 2018.

3. Water transfers.
4. Desalination

- Review the entire desalination water system for catchment areas in the Western Cape by the Western Cape government in collaboration with DWS, DoA and DEA by November 2018.

5. Return flows and re-use.

- Conduct a review of wastewater treatment works by all local municipalities (Engineering Departments) to determine more appropriate technology for improved quality and recycling of treated effluent for industrial and potable use by April 2018.
- Implementation of new technology (based on outcomes of review project) at all local municipalities to improve the quality of treated effluent for industrial and potable use by April 2025.
- Review the treated effluent system for catchment areas in the Western Cape by the Western Cape government in collaboration with DWS, DoA and DEA by November 2018.

6. Rainwater and stormwater harvesting
7. Managed aquifer recharge

- Department of Water and Sanitation to conduct a study on recharging aquifers with recycled, treated effluent by June 2018.

8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.
7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.

West Rand District Municipality 	Climate Change Vulnerability Assessment and Response Plan(West Rand District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- Identify research gaps on groundwater systems.
- Identify funding for the implementation of the dolomite management strategy.

3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Develop aggressive water awareness campaigns to promote water conservation.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.

- Consult with city engineers to determine minimum safe thresholds for the use of greywater. Once these thresholds are established encourage the reuse and recycling of water (rainwater harvesting, use of greywater, etc.).

10. Promotion of rainwater tanks.
11. Catchment rehabilitation.
12. Operation and maintenance of water infrastructure.

Xhariep District Municipality. 	Climate Change Vulnerability Assessment and Response Plan(Xhariep District Municipality, 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.

- Increase internal capacity to deal with climate change and waste water issues and review the staff organogram and existing budgets.
- Advise Local Municipalities on policy implementation through the District Water Sector Forum.

2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Raise awareness on high pollution points.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Through technical intergovernmental relations (IGR), present to Local Municipalities on the impacts of climate change to the environment specifically the impact to wastewater treatment works.
- Monitor the quality of water in rivers and dams by conducting regular audits to assess the quality of water upstream and downstream for both wet and dry seasons.
- Support the Department of Agriculture in the expansion of fish farms, expand to other towns in the district.

12. Operation and maintenance of water infrastructure.

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.
3. Water transfers.
4. Desalination
5. Return flows and re-use.
6. Rainwater and stormwater harvesting
7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

1. Water conservation and demand management.
2. Tariffs, metering, and credit control.
3. Water restrictions.
4. Leak repairs
5. Reduction of high pressure.
6. Consumer education.

- Develop and implement water conservation and rainwater harvesting campaigns within the district.
- Initiate water restrictions and water awareness campaigns in the district.
- Raise awareness on the impacts of illegal water abstractions.
- Improve awareness raising regarding the pollution of natural water resources.

7. Introduction of water efficient fittings.
8. Elimination of automatic flushing urinals.
9. Promotion of greywater use.
10. Promotion of rainwater tanks.
11. Catchment rehabilitation.

- Conduct research on smart pesticides in collaboration with a research institute.
- Develop relocation plans for agriculture within flood lines.
- Encourage farmers to use agri-smart pesticides.
- Encourage relationship between farmers and DWS on better farming practices.
- Develop and initiate charcoaling community projects.
- Initiate a working for water programme to eradicate alien vegetation.
- Initiate a wastewater irrigation project.
- Collaborate with Cape Peninsula University of Technology (CPUT) to initiate a fish farming project for subsistence farmers.

12. Operation and maintenance of water infrastructure.

- Improve and upgrade wastewater treatment infrastructure to manage leakages and spill overs.
- Improve municipal green drop scores.

Zululand District Municipality	Climate Change Vulnerability Assessment and Response Plan(Zululand District Municipality 2016).

Supply side responses:

1. Water storage infrastructure.
2. Groundwater extraction.

- Zululand District Municipality to investigate the potential of groundwater resources. Zululand DM to coordinate and drive this with a team of professional service providers. ZDM will ensure that the progress of the project is tracked. Limiting factors will also form part of the assessment. Short term interventions (e.g. borehole drilling) and long-term interventions (implementing formal reticulation where high yields are obtained) will be implemented.

3. Water transfers.
4. Desalination

- Zululand District Municipality to investigate desalination possibilities.

5. Return flows and re-use.
6. Rainwater and stormwater harvesting

- Zululand District Municipality to implement rainwater harvesting

7. Managed aquifer recharge
8. Water sensitive designs

Demand side responses:

13. Water conservation and demand management.
14. Tariffs, metering, and credit control.
15. Water restrictions.

- Zululand District Municipality to implement water use restrictions.

16. Leak repairs
17. Reduction of high pressure.
18. Consumer education.
19. Introduction of water efficient fittings.
20. Elimination of automatic flushing urinals.
21. Promotion of greywater use.
22. Promotion of rainwater tanks.
23. Catchment rehabilitation.
24. Operation and maintenance of water infrastructure.