PAPER 3

REGIONAL-SCALE PLANNING FOR MUNICIPAL WATER TO SUPPORT TRANSFORMATIVE ADAPTATION

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ABSTRACT

Municipal water supply planning is traditionally done on a local scale and often does not consider system interconnectivities, interdependence on water resources and competition between various water users. In addition, the use of inconsistent information sources and different water resources and municipal planning models can lead to vastly different responses to water supply and drought planning across a single region. The 2015-2020 drought in the Western Cape highlighted the need for an integrated, inter-disciplinary, and pro-active approach to water supply and drought planning across the whole province with a specific focus on municipal supply.

To address this need, the Western Cape Government in collaboration with Zutari endeavoured to develop a Western Cape Integrated Drought and Water Response Plan (WCIDWRP) to support municipalities within the province. The main objective of the WCIDWRP is to deliver a costed, prioritised and sequenced action plan that would contribute to a water secure province by 2035. The plan includes both conventional and unconventional technical engineering interventions as well as programmatic and policy interventions.

To inform the water resources augmentation and bulk infrastructure needs for each of the 121 water supply systems across the 24 municipalities comprising the Western Cape, various digital decision-support tools were developed including: (i) a Water Requirement Projection Tool that projects water requirements under various scenarios, (ii) two Surface Water Availability Tools confirming dam yields and run-of-river water availability under various scenarios, (iii) a Groundwater Availability Tool summarising potential groundwater development, (iv) an Unconventional Technical Engineering Interventions Tool that analysed the potential yield from 'alternative' water resources, (v) a Municipal Information Tool providing the status quo of water supply, (vi) an interactive Water Balance Tool supporting water resources augmentation and infrastructure project planning, and (vii) a Costing Tool for calculating and escalating capital expenditure costs for all identified interventions.

Prioritisation of technical interventions was guided by a regional vulnerability assessment that analysed each system's susceptibility to drought through the lens of seven key risk indicators including probable impacts of climate change, non-revenue water, water availability versus demand, Invasive Alien Plants, current water resource dependency and diversification, unit consumption, state of infrastructure and institutional capacity.

The regional and integrated approach followed in the compilation of the WCIDWRP allows for multi-criteria decision-making that will enable the province to strategically focus their efforts to becoming water-resilient over the next 15-years.

INTRODUCTION

Municipal water supply planning is traditionally done on a local scale and often does not consider system interconnectivities, interdependence on water resources and competition between various water users. In addition, the use of inconsistent information sources (e.g. non-aligned population and economic growth projection models) and different water resources and municipal planning models can lead to vastly different responses to water supply and drought planning across a single region. The 2015-2020 drought in the Western Cape highlighted the need for an integrated, inter-disciplinary, and pro-active approach to water supply and drought planning across the whole province with a specific focus on municipal supply. It emphasised the necessity to pro-actively consider and incorporate all aspects of integrated water resources management within a catchment, whilst appreciating the local dynamics and unique challenges of each municipal water supply system.

To ultimately build additional adaptive capacity and ensure water resilience within the Western Cape Province, the Western Cape Government - Department of Local Government in collaboration with Zutari endeavoured to develop a Western Cape Integrated Drought and Water Response Plan (WCIDWRP), to support municipalities within the province. One of the main aims of the WCIDWRP was to deliver a costed, prioritised and sequenced action plan that would support a water secure province over a 15-year period (up to 2035).

The action plan includes both conventional and unconventional technical engineering interventions to be implemented within each of the 121 water supply systems across the 24 municipalities comprising the Western Cape Province (i.e. water resource augmentation and bulk water infrastructure needs) and programmatic and policy interventions to be facilitated by national, provincial and local government (i.e. policy and programmatic responses). The focus of this paper is on technical engineering interventions. Municipalities included in the plan are shown in **Figure 1**.

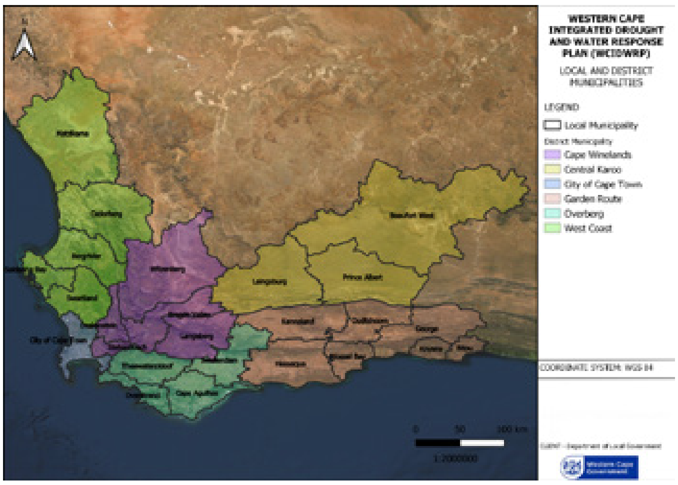

FIGURE 1: *Study area*

APPROACH

To derive the costed, prioritised and sequenced action plan for the Western Cape Province, in terms of technical engineering interventions, it was necessary to identify the water resource and bulk infrastructure needs of all of the 121 water supply systems across the 24 municipalities comprising the Western Cape Province.

The approach, as illustrated in **Figure 2**, was based on an interrogation of both the supply and demand side of the water cycle in each of the individual water supply systems, but also taking into consideration the integrated nature of the catchments in which each resides. The status quo as well as future projections in terms of water demand and supply informed:

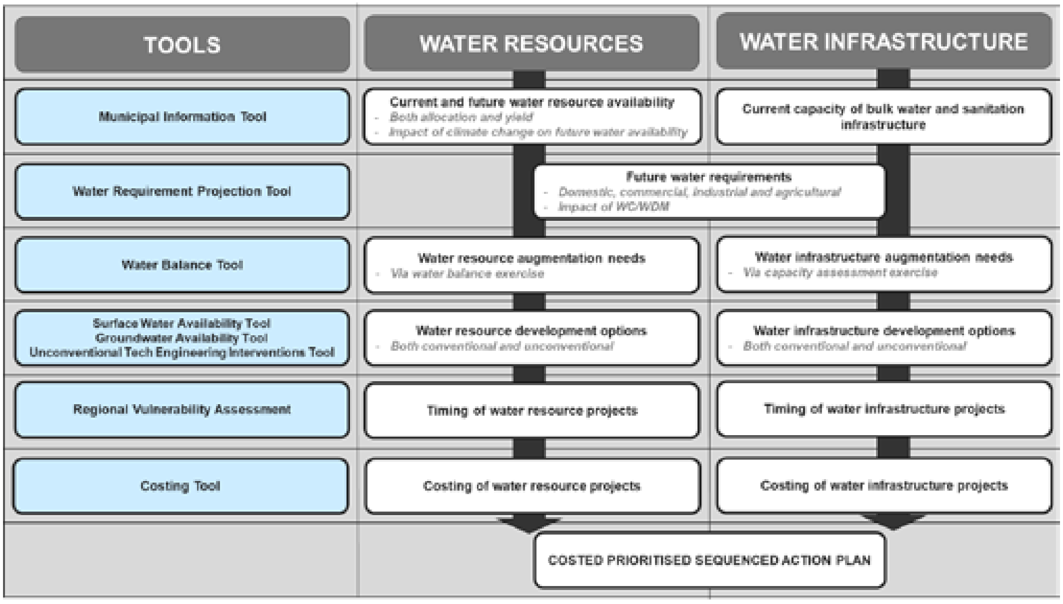

FIGURE 2: *Approach followed in the development of a costed, prioritised and sequenced action plan for the WCIDWRP*

- A water balance exercise to determine water resource augmentation, and
- A capacity assessment to determine water infrastructure augmentation

For this purpose, not only conventional water resource and infrastructure development was considered but also unconventional interventions to diversify water resources, guarantee water efficiency and ensure resilience across the province.

Special care was taken to ensure that the data aligned with information from municipal planning processes, as well as with the latest information from the Department of Water and Sanitation.

WATER RESOURCE AUGMENTATION NEEDS

The following process was followed to develop lists of augmentation projects, per water supply system, from a water resource perspective:

- The latest reports from the All Towns Study (DWS, 2011, 2015) were obtained from the Department of Water and Sanitation (DWS) and the water availability figures as well as the latest list of water resource interventions (both on the supply and demand side of the water cycle) were extracted from these.
- Water resource availability figures were updated based on either focused assessments, or information that became available since the last update of the All Towns Study (DWS, 2011, 2015). These included:
  - o Surface water yields (run-of-river abstractions and dams): Calculated at a 98% Level of Assurance (1:50 year recurrence interval), with developed Surface Water Availability Tools or obtained from recent detailed water resource studies.
  - o Groundwater yield: Taken as either the sustainable yield obtained during borehole testing, or the estimated long-term yield (assuming zero recharge over 2 years) collected via a detailed groundwater survey, or obtained from recent detailed water resource studies.
  - o Allocations: Updated allocation and water use licence information obtained from the DWS.
  - o Impact of climate change on water availability: Calculated on a source-by-source basis as informed by data obtained from the Green Book: Adapting South African settlements to climate change (CSIR, 2019).
- Water resource interventions were revised based on focused assessments which included:
  - o Surface water: Based on recent detailed water resource studies or institutional knowledge within the DWS.
  - o Groundwater: Based on detailed groundwater assessments.
  - o Catchment management interventions such as clearing of invasive alien plants: Possible increase in yield as a result of Invasive Alien Plant clearing calculated on a source-by-source basis as informed by data obtained from recent work conducted by DC le Maitre (DC Le Maitre, July 2000), (JDS Cullis, January 2007), (DC le Maitre, October 2016), (DC Le Maitre, 2020).
  - o Wastewater reclamation: Based on a portion of billed consumption water sales data per town as obtained from the various municipalities.
  - o Desalination: Assessed as a suitable intervention for all coastal towns.
  - o Rainwater harvesting: Based on percentages of the weighted mean annual precipitation over a selected rainfall period (i.e. 5 months) evaluated on a town-by-town basis.
  - o Urban stormwater harvesting: Based on a portion of the mean annual runoff on the settlement area (i.e. urban area) evaluated on a town-by-town basis.
  - o Possible integration of wastewater reclamation and urban stormwater harvesting with Managed Aquifer Recharge (MARe): Based on indications of the likelihood of MARe evaluated by the groundwater specialist on a town-by-town basis.
- Recommended interventions were discussed with the DWS, as well as with the relevant municipalities, to confirm water resource interventions needed to be implemented from 2020/2021 up to 2034/2035 to ensure sustainable supply.
- As a last step, the final list of projects was costed by either escalating existing costs or applying developed unit or generic costs.

BULK WATER AND WASTEWATER INFRASTRUCTURE NEEDS

The following process was followed to develop lists of augmentation projects, per water supply system, from a bulk water and wastewater infrastructure perspective:

- The latest Water and Sewer Master Plans were obtained from either the municipality or the relevant Consultants. Bulk water and Wastewater Treatment Works (WWTW) projects currently being planned were identified from these.
- The list of Municipal Infrastructure Grant (MIG) projects was obtained from the Western Cape Department of Local Government. The registered bulk water and sewer (WWTW only) projects for each Municipality were identified and the status of each established.
- The latest list of Regional Bulk Infrastructure Grant (RBIG) and Water Services Improvement Grant (WSIG) projects and budgets was obtained from the DWS. The registered bulk water and sewer (WWTW only) projects for each municipality were identified and the status of each established.
- The latest Water and Services Development Plans (WSDP) - either the WSDP Integrated Development Plan Input report or the latest Audit report - were obtained from the municipalities and the future bulk water and sewer (WWTW only) projects identified in these. This ensured the alignment of the bulk infrastructure needs identified during this project and the budgets and projects included in the Municipality's approved capital budgets (for bulk projects).
- Further to the above, the latest capacities of bulk water and sewer (WWTW only) infrastructure was obtained from the W&SMP as well as the WSDPs and a capacity assessment conducted to identify and confirm the additional capacity required for all components of the bulk water supply system up to 2035.
- The culmination of these projects was then discussed with the DWS, as well as the relevant municipality, to confirm the bulk water and sewer (WWTW only) projects needed to be implemented from 2020/2021 up to 2034/2035 to ensure sustainable supply.
- As a last step, the final list of projects was costed by either escalating existing costs or by applying developed unit or generic costs.

DIGITAL DECISION-SUPPORT TOOLS

To inform the water resources augmentation and bulk infrastructure needs for each of the 121 water supply systems across the 24 municipalities comprising the Western Cape, various digital decision-support tools were developed as follows: (i) a Water Requirement Projection Tool that projects water requirements under various scenarios (ii) two Surface Water Availability Tools confirming dam yields and run-of-river water availability under various scenarios, (iii) a Groundwater Availability Tool summarising characteristics associated with potential groundwater development, (iv) an Unconventional Technical Engineering Interventions Tool that analysed the potential yield from 'alternative' water resource augmentation methods, (v) a Municipal Information Tool providing the status quo of water supply, (vi) an interactive Water Balance Tool supporting water resources augmentation and infrastructure project planning, and (vii) a Costing Tool that assists with the calculation and escalation of capital expenditure costs for all identified interventions.

(I) WATER REQUIREMENT PROJECTION TOOL

The Water Requirement Projection Tool projects residential and non-residential water requirements for the 121 water supply systems across the 24 municipalities comprising the Western Cape. Projections, based on population amongst others, are done for low, medium and high growth scenarios. These scenarios adopt various assumptions in terms of economic and population growth, consumer behavioural changes, potential developments and uptake of alternative sources.

(II) SURFACE WATER AVAILABILTY TOOLS

The Surface Water Availability Tools confirm dam yields and run-of-river water availability under various scenarios. Both tools, built on the principle of a cascading water balance, incorporates runoff and landuse as well as water requirements for the whole of the Berg-Olifants and Breede-Gouritz Water Management Areas.

The Dam Surface Water Availability Tool allows a user to determine the yield at a 98% Level of Assurance of any proposed dam on a Western Cape river system through the use of dimensionless gross storage-draft-frequency characteristics. Similarly the Run-of-River Surface Water Availability Tool allows a user to determine the run-of-river water availability at a 98% exceedance probability at any point in a Western Cape river system based on the analyses of a flow duration curve at the required location.

Both tools also analyse the potential impact of climate change as well as the potential impact of clearing of existing Invasive Alien Plants, and/or the risk associated with future spread of Invasive Alien Plants, on the yield of dams or run-of-river availability.

(III) GROUNDWATER AVAILABILITY TOOL

The Groundwater Availability Tool determines the current groundwater yield and allocation and the potential for future groundwater development within each of the 121 water supply systems across the 24 municipalities within the Western Cape. It provides a high-level tabled-output on a system-by-system basis describing, amongst others, the location of the potential groundwater development, its geological setting as well as the total potential borehole yield for the target area.

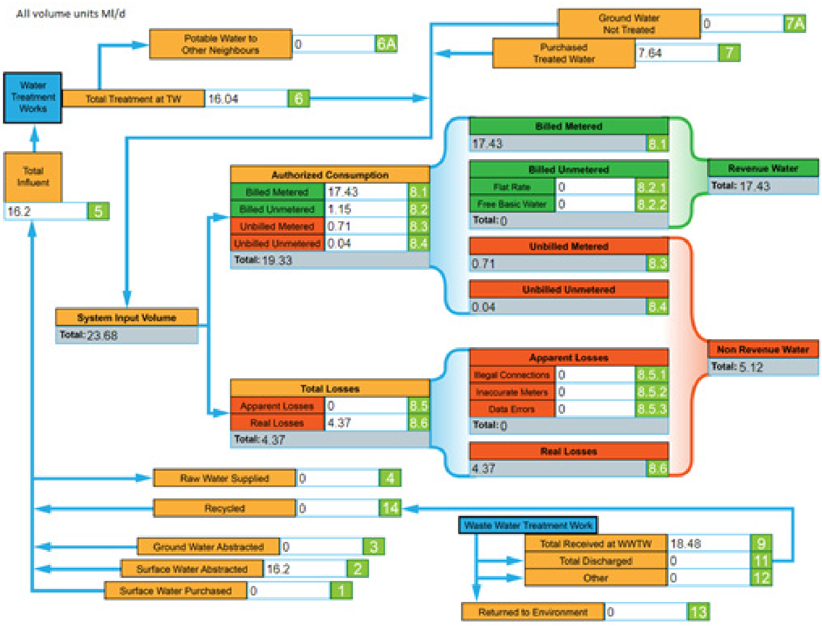

FIGURE 3: *Water balance schematic included in* Topic 5 *of the* Water Services Development Plan

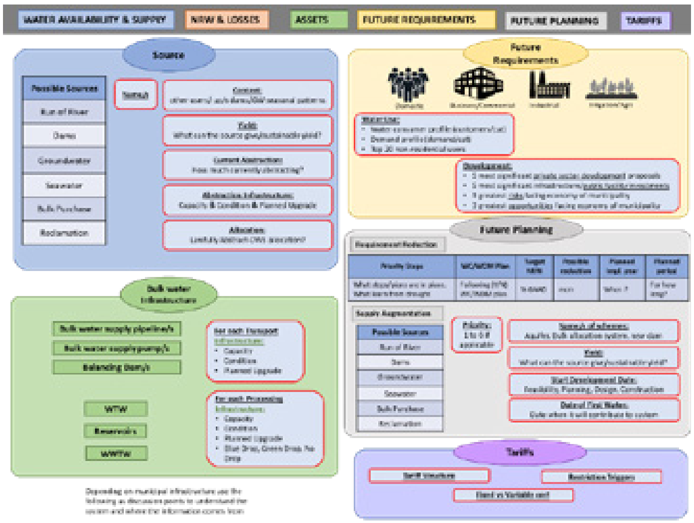

FIGURE 4: *Framework used to guide discussions with local government officials within the various municipalities*

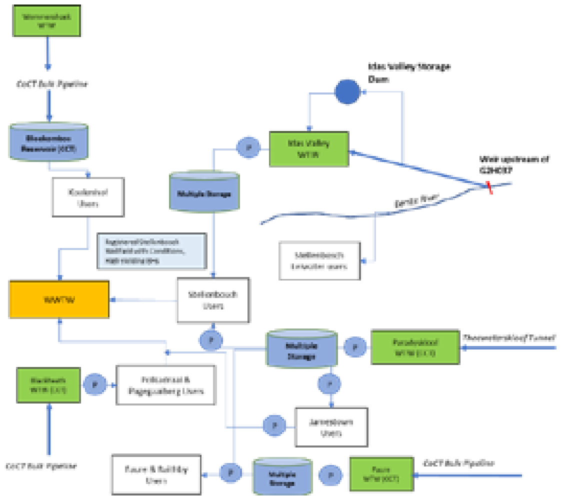

FIGURE 5: *Snippet from the Municipal Information Tool (Example: Stellenbosch)*

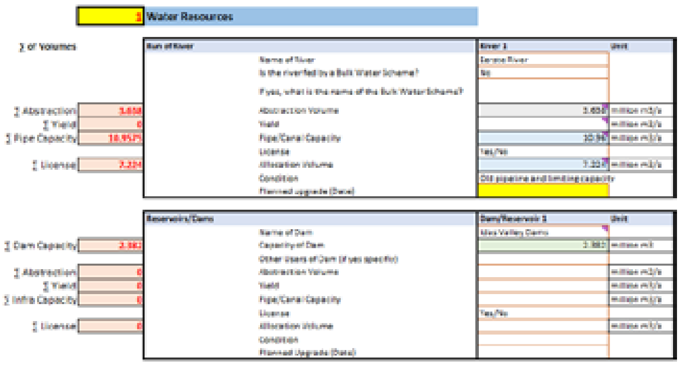

FIGURE 6: *Snippet from the Municipal Information Tool (Example: Stellenbosch)*

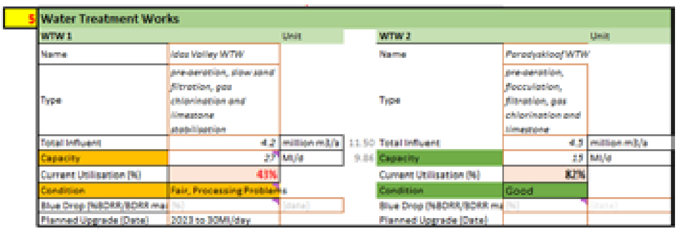

FIGURE 7: *Snippet from the Municipal Information Tool (Example: Stellenbosch)*

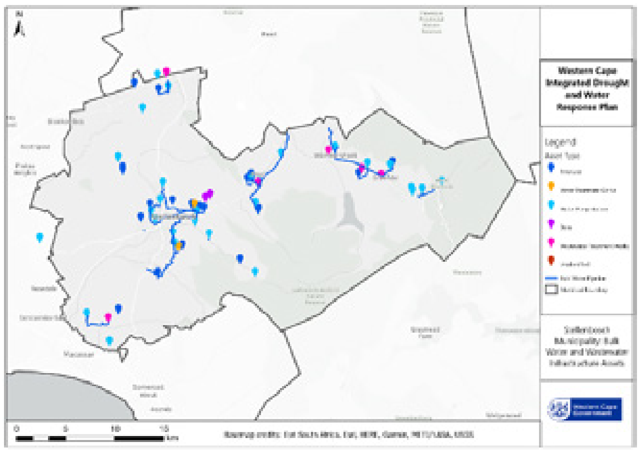

FIGURE 8: *Spatial data linked to information contained within the Municipal Information Tool (Example: Stellenbosch)*

(IV) UNCONVENTIONAL TECHNICAL ENGINEERING INTERVENTIONS TOOL

The Unconventional Technical Engineering Interventions Tool analyse the potential yield from 'alternative' water resource augmentation methods for each of the 121 water supply systems across the 24 municipalities within the Western Cape. This includes interventions such as desalination of seawater, direct and indirect re-use of treated effluent, rainwater harvesting, and urban stormwater harvesting and the possible integration with Managed Aquifer Recharge.

(V) MUNICIPAL INFORMATION TOOL

The objective of the Municipal Information Tool is to provide a status quo of the current water supply situation within each of the 121 water supply systems across the 24 municipalities within the Western Cape. This tool, roughly based on the water balance schematic included in *Topic 5.2* of the *Water Services Development Plan* which municipalities are familiar with (**Figure 3**), were populated with available information from existing documents (such as Water and Sanitation Master Plans, Water Service Development Plans and others) and validated during one-on-one contact sessions with each municipality (**Figure 4**).

The Municipal Information Tool captures, amongst others, for each water supply system:

- A basic system layout diagram
- The current issues experienced by the specific municipality in terms of water supply
- The current actions/interventions foreseen by the specific municipality in terms of water supply
- The availability of the water resources supplying each water supply system (i.e. yield, allocation, current abstraction)
- The capacities of the bulk water infrastructure within each water supply system (Raw bulk storage / Pump stations / Water treatment plants / Reservoirs / Wastewater treatment plants)
- The current extent of non-revenue water for the 2019/2020 year

Refer to **Figure 5** to **Figure 7** for some visual snippets from the Municipal Information Tool. The data is also linked to a large amount of valuable spatial, such as updated spatial bulk water and wastewater assets as can be seen in **Figure 8**.

(VI) WATER BALANCE TOOL

The objective of the Water Balance Tool is to provide an interactive platform that incorporates all the information needed to make decisions

WATER AVAILABILITY			
ALLOCATION			0
Allocation volume (Registered water use / Lawful allocation)	Yes		Note: A user ma
YIELD			
Total system yield (combined sources)	No		
Total system yield (combined sources) with probable climate change impact	No		
WATER REQUIREMENTS			
SCENARIOS (based on growth perspectives and growth outlook)			
Low water requirement scenario	No		Note: A user ma
Medium water requirement scenario	No		
High water requirement scenario	Yes		
WATER CONSERVATION WATER DEMAND MANAGEMENT (based on target WCWDM)			
Implement	No		Note: A user ma
Target % Total NRW	5%		
Planned implementation date	2030		
where Target % Total NRW = Total NRW / Total Raw Water Abstraction			
and Total NRW = Total Raw Water Abstraction - Billed Consumption			
INTRODUCTION OF ARTIFICIAL LOSSES (BETWEEN WATER SALES (BILLED&UNBILLED CONSUMPTION) AND RAW WATER ABSTRACTION)			
Implement	Yes		
% Loss	10%		

FIGURE 9: *Interactive input sheet from the Water Balance Tool (Example: Swellendam)*

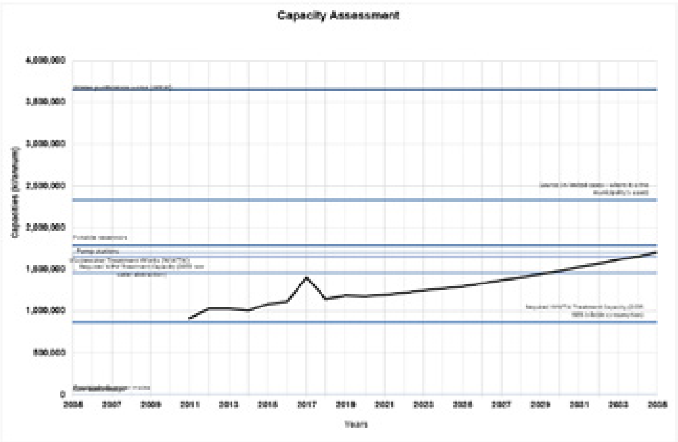

FIGURE 10: *Capacity assessment included in Water Balance Tool (Example: Swellendam)*

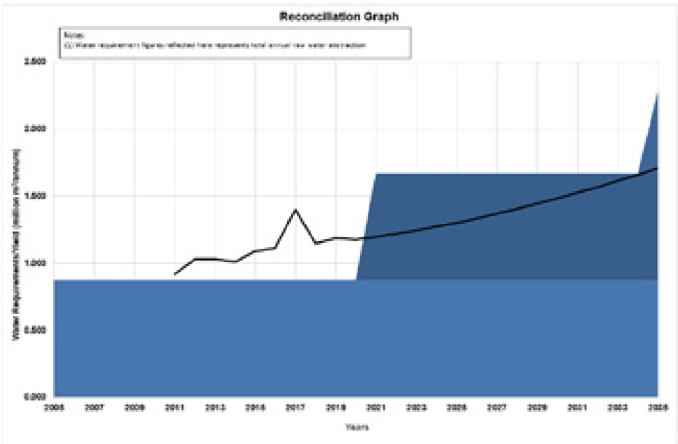

FIGURE 11: *Reconciliation graph included in Water Balance Tool (Example: Swellendam)*

		Priorities	Planning horizons
	FINAL PROJECT LIST		
	Water resources - samples		
	Future pipeline abstraction from proposed raised Buffeljags Dam	1	Short-term (1-3 years)
	Possible abstraction from Breede River (Koringlandsriver not sustainable)	2	Medium-term (4-10 years)
	Increase storage at Grootkloof Dam(s)	1	Medium-term (4-10 years)
	More sustainable supply to Malgas/NuweDorp and Infanta - Desalination?		Short-term (1-3 years)
	Infrastructure		
1	Railton PS to Railton reservoir	1	Short-term (1-3 years)
2	Swellendam WTW to Railton PS	2	Short-term (1-3 years)
3	Hermitage PS to Swellendam WTW (from Grootkloof Dam)	3	Short-term (1-3 years)
4	Demarcated water pressure zones in Railton area (4 pressure zones inst	4	Short-term (1-3 years)
5	Upgrade Swellendam WTW (to accommodate Railton development)	5	Medium-term (4-10 years)
6	Formalised wastewater treatment at Malgas/Nuwedorp and Infanta	6	Short-term (1-3 years)

FIGURE 12: *Final project list included in Water Balance Tool (Example: Swellendam)*

regarding water resource augmentation and water infrastructure projects for each of the 121 water supply systems across the 24 municipalities within in the Western Cape, up to 2035. The Water Balance Tool includes the following information for each water supply system:

- Historic and current water requirements
- Future water requirements (for a high, medium and low water requirement projection with and without Water Conservation and Water Demand Management)
- Current water availability (i.e. yield and allocation)
- Functionality to conduct a reconciliation exercise to determine water resource augmentation
- Functionality to conduct a capacity assessment to determine water infrastructure augmentation
- Costed and prioritised list of both water resource and water service augmentation projects needed up to 2035

Refer to **Figure 9** to **Figure 12** for some visual snippets from the Water Balance Tool.

(VII) COSTING TOOL

The Costing Tool assists with the escalation of an existing capital expenditure cost (where information existed) or the calculation of a high-level capital expenditure cost (where no information existed) for all conventional and unconventional technical engineering interventions.

REGIONAL VULNERABILITY ASSESSMENT

Prioritisation of conventional and unconventional technical engineering interventions was guided by a regional vulnerability assessment that analysed each water supply system's susceptibility to drought through the lens of seven key risk indicators. These include the (i) probable impacts of climate change, (ii) the state of non-revenue water, (iii) water availability versus water demand, (iv) the extent of Invasive Alien Plants, (v) each system's current water resource dependence and diversification, (vi) the unit consumption, (vii) the state of infrastructure and (viii) the municipality's institutional capacity.

Comparing the results of each of the key risk indicators across the province (refer to **Figure 13** to **Figure 18**) enables decision-makers to strategically focus efforts and take appropriate prioritised action within 'hotspots' on their journey towards becoming a water-resilient province over the next 15 years.

COSTED, PRIORITISED AND SEQUENCED ACTION PLAN

Collated information, processed with the various digital decision-support tools and used to guide the regional vulnerability assessment, enabled the compilation of a costed, prioritised and sequenced action plan both in terms of water resource augmentation and bulk water and wastewater augmentation per water supply system, which could ultimately be summarised per municipality for the whole of the province. This was done for both water resource and bulk water and wastewater augmentation (refer to **Figure 19** and **Figure 20**).

Important to note that the project costs are based on specific assumptions adopted within the various tools (e.g. regarding a specific water availability scenario, demand projection, prioritisation sequence etc.). All of these are variables that can be changed manually within the tools to analyse the impact of it from a wider Provincial perspective.

CONCLUSIONS

The Western Cape Integrated Drought and Water Response Plan (WCIDWRP) together with its associated digital decision-support tools, has equipped the Western Cape Province to pro-actively plan for and manage its water

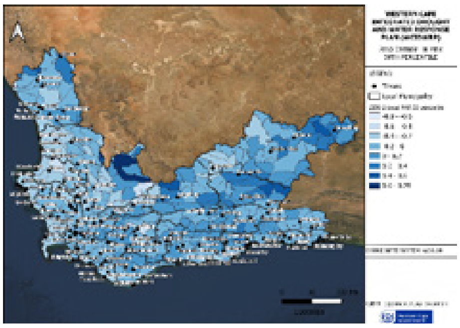

FIGURE 13: *Climate change*

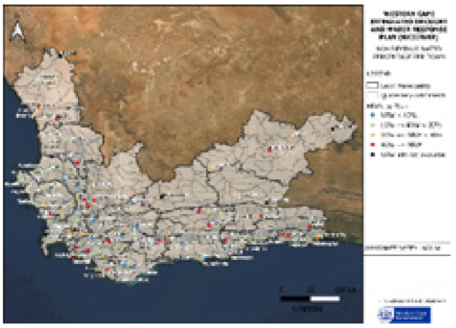

FIGURE 14: *State of non-revenue water*

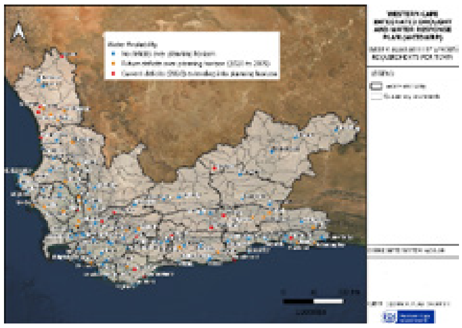

FIGURE 15: *Water availability vs. water demand*

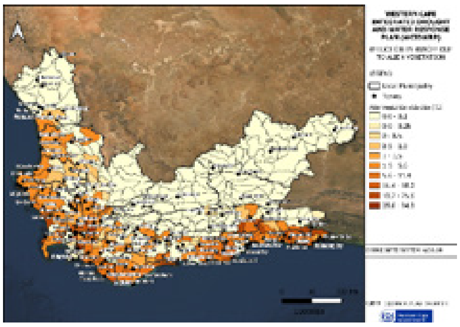

FIGURE 16: *Extent of Invasive Alien Plants*

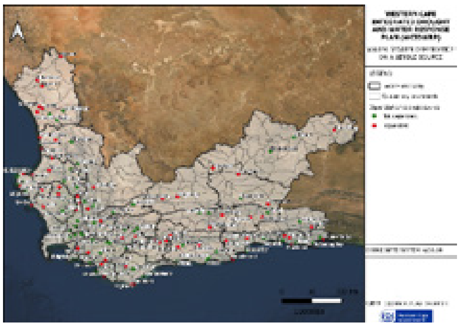

FIGURE 17: *Water resource dependence and diversification*

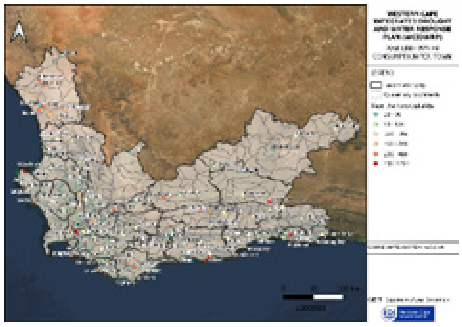

FIGURE 18: *Unit consumption*

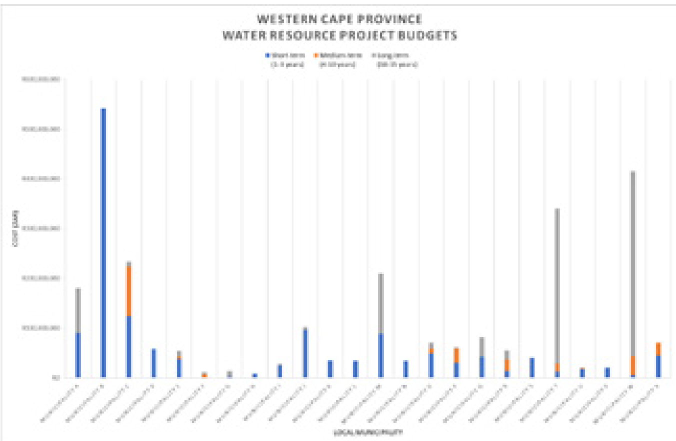

FIGURE 19: *Total project cost in terms of water resource augmentation for the Western Cape (up to 2035)*

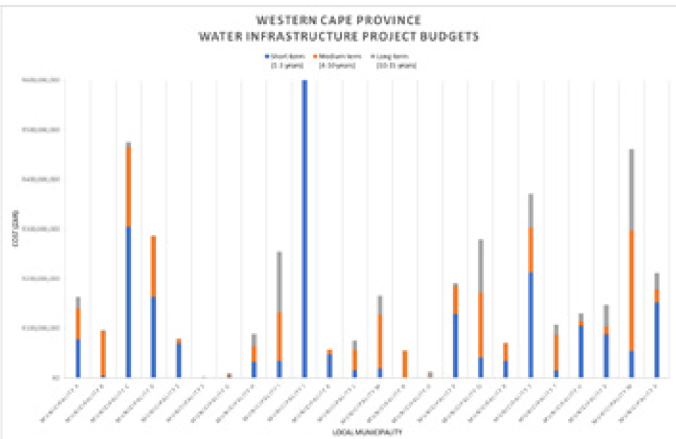

FIGURE 20: *Total project cost in terms of bulk infrastructure augmentation for the Western Cape (up to 2035)*

resources and water and wastewater infrastructure in ways that supports lives and livelihoods. The integrated plan, that has now been adopted into the Western Cape Parliamentary Bill with the support of Premier Alan Winde and other key officials, will help the province to create long-term water resilience, balancing the needs of present and future generations, while protecting the environment.

RECOMMENDATIONS

It is recommended that the digital decision-support tools that evolved as part of the development of the Western Cape Integrated Drought and Water Response Plan be used for multi-criteria decision-making that will enable the province to strategically focus their efforts to becoming water-resilient over the next 15-years. In addition, it is recommended that a similar approach be rolled-out to other provinces of South Africa to ultimately guarantee water efficiency within all water supply systems and municipalities and ultimately ensure resilience across the whole of South Africa.

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