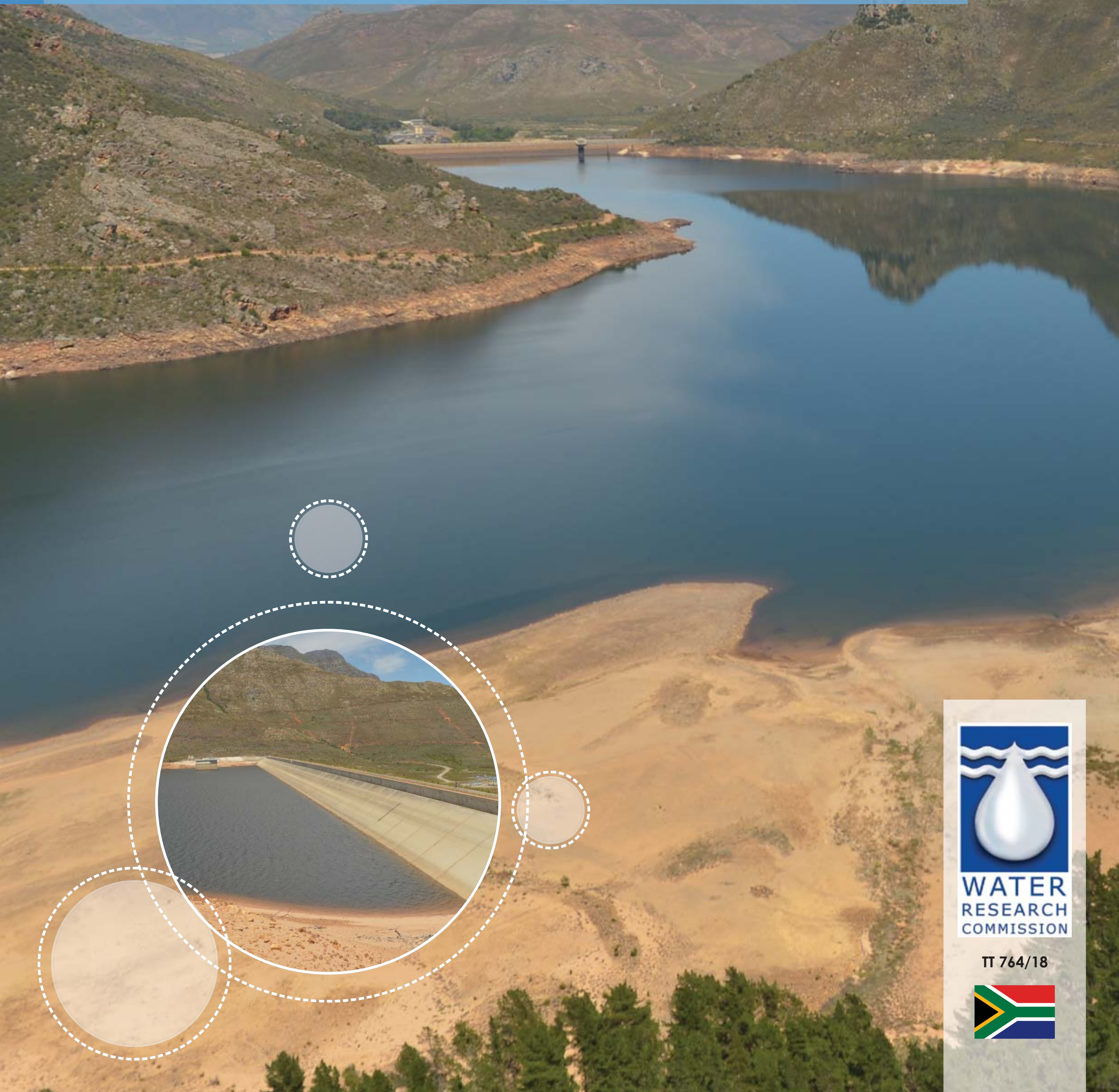
MANAGING WATER AS A CONSTRAINT TO DEVELOPMENT WITH DECISION-SUPPORT TOOLS THAT PROMOTE INTEGRATED PLANNING: THE CASE OF THE BERG WATER MANAGEMENT AREA

C Pengelly, H Seyler, N Fordyce, P Janse van Vuuren, M van der Walt, H van Zyl & J Kinghorn



WATER RESEARCH COMMISSION

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Managing Water as a Constraint to Development with Decision-Support Tools That Promote Integrated Planning: The Case of the Berg Water Management Area

C Pengelly, H Seyler, N Fordyce, P Janse van Vuuren, M van der Walt, H van Zyl & J Kinghorn

Report to the
Water Research Commission and **Western Cape Government**

by

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Various references to appendices appear in this report. Kindly note that these appendices do not form part of the report, but can be found on the GreenCape website at https://www.greencape.co.za/content/focusarea/water-for-sustainable-development. (To access, click on Appendices under the heading Project Documents on the opening page)

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Executive summary

There is increasing recognition that the combined effects of climate change, population growth and continued urbanisation are exerting pressure on limited water resources. At the same time, economic growth remains vital for alleviating poverty. Therefore, growth is required in spite of significant water resource constraints. At issue then is how to allocate water optimally to enable economic growth, while also ensuring that human needs are met and ecological systems maintained.

Understanding of the economic impacts of water access is limited, and there is a lack of tools available to address the trade-offs that may be required when allocating water in a water scarce system. This is needed in particular in “constrained catchments” where all readily available water is already allocated, such as the case of the Berg Water Management Area (WMA). In such catchments, future development requires additional water resources, either through the development of new resources or the reallocation from other users in the WMA.

This three-year study (Managing Water as a Constraint to Development with Decision-Support Tools That Promote Integrated Planning: The Case of the Berg Water Management Area) aimed to better integrate water into economic development planning, and vice versa. The project’s objectives included developing a guideline for a planning approach that recognised the cyclical interdependency of economics and water resources; conducting a cost-benefit analysis of economic developments and water resource interventions; building a spatial hydro-economic tool to manage regional allocations in constrained catchments; developing research products in close collaboration with decision-makers; implementing research outcomes to address current development challenges. These objectives have been achieved through developing actionable insights and tools for governmental decision-makers that link water as a resource and its availability to economic outcomes in terms of growth and job creation. The project structure was highly collaborative, lead by a sector development agency for the green economy (GreenCape) and utilising research generated by Masters students at the University of Cape Town (UCT) African Climate and Development Institute (ACDI) and adapting the approach and outputs to the evolving requirements of government stakeholders. The Berg WMA was selected as a case study area.

Analysis was done on the (potential for) integration between development planning, water allocation and water resource development processes, with an emphasis on enabling implementation of the findings. The analysis aimed to understand how decision support tools could add value to existing legislated processes by filling knowledge gaps or by providing a collaboration mechanism. This analysis highlighted how the Integrated Development Plan (IDP) is the key integrated planning tool, but that it is not taking water resource availability sufficiently into account. Furthermore, that the municipalities, which are also the Water Service Authorities (WSAs), do not have the capacity nor resources to develop their own local water resources, and are struggling to access water from the regional schemes, managed nationally by the Department of Water and Sanitation (DWS). In this context, provincial government has a critical coordinating and supporting role to play.

A regional hydro-economic GIS tool has been developed to understand how water scarcity may constrain development in local economies within the Berg WMA, currently and into the future, including due exogenous factors such as climate change and population growth. The study models future water demand, focusing on the years 2025 and 2040 to assess where demand may outstrip supply according to the current system yield. These projected demands link water usage to economic indicators (e.g. gross value add (GVA), jobs) to highlight where these constraints have the most significant economic implications, thereby allowing for the prioritisation of interventions to improve water supply to particular local economies. The results indicate that under all climate change models, irrigated agriculture will require more water to remain sustainable. However, at the same time, urban centres will demand increasingly more water. The water required for urban areas generates greater value to the regional economy, with the City of Cape Town continuing to dominate regional economic outcomes. However, when water is analysed as a constraint to the local economy, the West Coast municipalities of Swartland, Saldanha Bay and Bergrivier emerge as the municipalities where water is likely be to a significant constraint to future development (with substantial impact on the local economy and livelihoods), unless water supply augmentation options are developed urgently. However, arguably, the current drought in Western Cape has already illustrated the economic impacts of reduced water availability, as well as the need for diversified local water supply that is not solely reliant on surface water.

In the case of Saldanha Bay, where water is already a constraint to development, a Multi-Criteria Decision Analysis (MCDA) tool was developed that allows the municipality to prioritise new development applications on the basis of the socio-economic outcomes from the various projects in comparison to the water required, rather than just allocate water on a first-come-first-served basis. This tool allows for transparent and collaborative decision-making that assists the municipality in improving the livelihoods of the local community and increasing the productivity of water in the local economy.

The project outcomes have been shared with local stakeholders responsible for development planning and water management. The tools have been favourably received with provincial government departments declaring their intent to adopt them in 2018. The tools are also easily replicable for other regions in South Africa that face similar challenges and wish to better integrate their water resource and development planning. The project also highlighted gaps in the availability of data to be able to develop a fully-functional hydro-economic tool. These gaps include a sectoral breakdown of water usage in urban areas, multi-year agricultural revenue and production figures, and metered agricultural water usage.

Overall the project has been beneficial in helping drive a dialogue amongst a number of stakeholders of the importance of water for development. It has elevated the consideration of water within provincial government from an environmental concern to one that enables growth and jobs. It has also helped substantiate the need for urgent intervention in certain areas for supply augmentation.

However, the project findings highlight the need for further action:

- The absence of a regional water utility for the Berg WMA is hampering the development of water resources, particularly at a local level, and the creation of either a regional water utility or water board should be explored in an intergovernmental process that results in an implementation protocol. An implementation protocol will allow local, provincial and national government departments to practically coordinate the work required to set up a suitable regional entity.
- Coordinated planning for future water resource interventions for those WSAs supplied by the Western Cape Water Supply System (WCWSS) must be strengthened. A feasibility study is proposed to estimate the economies of scale and efficiencies that could be gained in combining regional and local water resource development schemes across the Berg WMA.
- A regional (or national) fund that WSAs can access for off-budget water resource infrastructure, which leverages private sector funds, should be explored
- All spheres of government need to be more cognisant of the local capabilities and water resource availability in the areas in which development is planned, crucially as it relates to the availability of water to support their development ambitions. If sufficient water is not available, then a careful consideration should be made about the suitability of a particular industry for the area (linked to its water intensity) versus the cost/benefit of developing new water resources.

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- Assessment of current and future water requirements in the Berg based on 'bottom-up' calculations of irrigation water requirements and collation of domestic water use datasets, and
- Assessment of the marginal cost of water in the agricultural sector in the Berg, respectively.

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List of acronyms

ACDI	African Climate and Development Initiative
BCC-CSM1-1	Beijing Climate Center Climate System Model
BFAP	Bureau for Food and Agricultural Policy
BGCMA	Breede-Gouritz Catchment Management Agency
BNU-ESM	Beijing Normal University Earth System Model
BRIP	Berg River Improvement Programme
CanESM2	Second generation Canadian Earth System Model
CBA	Cost-Benefit Analysis
CCT	City of Cape Town
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
CNRM-CM5	Centre National de Recherches Météorologiques' GCM
CSAG	Climate System and Analysis Group
CUC	Capital Unit Charge
DAFF	Department of Agriculture, Forestry and Fishing
DEA&DP	Department of Environmental Affairs and Development Planning of the Provincial Government of the Western Cape
DED&T	Department of Economic Development and Tourism of the Provincial Government of the Western Cape
DM	District municipality
DoA	Western Cape Provincial Department of Agriculture
DPLG	Department of Provincial and Local Government
DRDLR	Department of Rural Development and Land Reform
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EDP	Western Cape Economic Development Partnership
EIA	Environmental Impact Assessment
FGOALS-s2	Flexible Global Ocean-Atmosphere-Land System model, Spectral Version 2
FIBC	Future Infrastructure Build Charge
GA	General Authorisation
GCM	General Circulation Model
GDP	Gross Domestic Product
GFDL-ESM2G	National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory's Earth Systems General Model
GFDL-ESM2M	National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory's Earth Systems Modular Ocean Model
GIS	Geographic Information Systems

GS RSIF	Greater Saldanha Regional Spatial Implementation Framework
GVA	Gross Value Add
HDI	Historically Disadvantaged Individual
IBT	Inter-Basin Transfer
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
KZN	KwaZulu-Natal
LED	Local Economic Development
LM	Local municipality
LUPA	Land Use Planning Act
MCDA	Multi-Criteria Decision Analysis
MERO	Municipal Economic Review and Outlook
MIG	Municipal Infrastructure Grant
MIROC5	Model for Interdisciplinary Research on Climate and associate Earth System Models
MRI-CGCM3	Japanese Meteorological Research Institute's Coupled Global Climate Model
MTSF	Medium Term Strategic Framework
NDP	National Development Plan
NEMA	National Environmental Management Act
NPC	National Planning Commission
NWA	National Water Act
NWRS	National Water Resources Strategy
NWSMP	National Water and Sanitation Master Plan
PICC	Presidential Infrastructure Coordinating Commission
PSDF	Provincial Spatial Development Framework
RBIG	Regional Bulk Infrastructure Grant
ROA	Return-On-Assets
RQO	Resource Quality Objective
RSA	Republic of South Africa
RWU	Regional Water Utility
SATI	South African Table Grape Industry
SAWIS	South African Wine Industry Information and Systems
SBLM	Saldanha Bay Local Municipality
SDBIP	Service Delivery Budget Implementation Plan
SDF	Spatial Development Framework
SIP	Strategic Integrated Project
SPLUMA	Spatial Planning and Land-use Management Act
SWMP	Sustainable Water Management Plan
TCTA	Trans-Caledon Tunnel Authority
UCT	University of Cape Town
UWC	University of the Western Cape

V&V	Validation and Verification
WARMS	Water Authorisation and Registration Management System
WC/WDM	Water Conservation/Water Demand Management
WCDM	West Coast District Municipality
WCG	Western Cape Government
WCWSS	Western Cape Water Supply System
WMA	Water Management Area
WRC	Water Research Commission
WRCS	Water Resource Classification System
WRSM	Water Resource Simulation Model
WSA	Water Services Authority
WSDP	Water Services Development Plan
WSP	Water Services Provider
WTE	Water Trading Entity
WUL	Water Use License
WULA	Water Use License Application
WWAP	World Water Assessment Programme

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1. Introduction

1.1. Study Vision

Water resources planning and economic development planning need to acknowledge that the two factors are inter-dependent. Currently, each one is treated as an independent variable in the other.

1.2. Study Motivation

There is wide recognition that the combined effects of climate change, population growth and continued urbanisation are exerting pressure on limited water resources. By 2012, approximately half of the major South African supply schemes were already in a water balance deficit, requiring new water resources interventions to meet projected future demands. According to the Department of Water Affairs (DWA) (2013a), 55% of smaller schemes supplying settlement areas or towns are currently or will be in a water balance deficit before 2023. At the same time economic growth is vital to alleviate poverty, hence the large national drive to stimulate growth (NPC, 2011). Given that growth is required in the face of natural resource constraints, the Green Economy has been promoted most broadly as an approach to maintain growth whilst not depleting natural resources (WCG, 2013).

In terms of water resources and development, the Department of Water and Sanitation (DWS) has been careful to point out that whilst water is essential to development, its availability is not a driver to, nor constraint on, development (DWA, 2009; DWA, 2010). This position of DWS is based on the view that as much water can be made available as is required (via desalination for example). In the case of a catchment where all readily available water is allocated (referred to as a ‘constrained catchment’), future development requires additional water resources. This in turn requires new infrastructure, which comes at a cost. This cost would be borne in part by the future water users (people, economic developments), via capital levies or direct water charges. If the users considered part of the future economic development are unable to bear this cost, then the cost of provision of water becomes a constraint to economic development. Furthermore, the capacity to develop this infrastructure may not always be available locally and is therefore a stumbling block to many local municipalities. The ability of the users to carry the cost of this proposed water infrastructure needs to be taken into account in determining the viability of the considered future economic development (GreenCape, 2015). Furthermore, the security of available water resources will promote investment in a region, in the same way that uncertainty over future supplies, or the cost of ensuring water security, has in several cases dissuaded investment. There is an interdependency therefore between economic development and water resources, which needs to be taken into account in development planning (key intervention 1).

Given the potential constraint of (the cost of) water, allocation or access to water services in a constrained catchment should be towards those developments that maximise environmental and socio-economic benefits of the water used. Of course, economic benefit is challenging to quantify, and there are complex links to considerations of socio-environmental benefits for water use or allocation. But at the least, environ-socio-economic benefit considerations need to be incorporated in water allocation or access decisions to promote the ‘smartest’ use of water (key intervention 2). This is also promoted by DWA (2009).

It follows that in constrained catchments, there may simply not be ‘enough for all, forever’ and regional planning decisions between potentially competing development trajectories need to be taken (key intervention 3). For example, what is the impact on the economy of diverting more water towards agriculture in a bid to promote food security? Conversely, what is the impact on the food processing industry and on food security, of a decision to promote more economically lucrative uses of water than agriculture? What economic developments should be promoted regionally, and in what locations? In a perfect water market, market forces would dictate the access to water between competing users. However, water is identified as a basic human right in the South African Constitution giving priority to domestic use. Meeting the Ecological Reserve is also a priority as dictated by the National Water Act (Act 36 of 1998). Also, water's role in food security ensures that high priority is given to agricultural use. Therefore water allocation and access decisions have to be made while achieving sustainable environ-socio-economic growth. The need for sustainable growth requires that various uses of water be assessed for their local and regional costs and benefits.

1.3. Previous/Related Work

Driven by a similar motivation to that behind the key interventions highlighted above, a recent WRC project investigated the links between water resources and the economy in the Western Cape, and attempted to understand how water flows through the economy (Pegram and Baleta, 2013). The applicability of various tools for linking water and economics, such as virtual water and indices such as rand per drop, were assessed. The project unpacked and promoted some critical paradigm shifts required in order to assess water and economics as one linked package. Other researchers are also applying complex systems thinking approaches to try to unpack water resources planning and the inherently linked considerations such as economic development, and management of the water-energy-food nexus (such as Muller, 2013 and Palmer, 2014). Another research team completed a regional resource flow model to develop a baseline for the resource efficiency of the Western Cape economy, benchmark sectors and particular commodities in these, with the aim of identifying interventions to increase the resource efficiency of the various sectors and the economy as a whole (Janse van Vuuren & Pineo, 2014). These studies improve our current understanding of how water moves in the economy.

In addition, a model has been developed for demonstrating the importance of water in the South African economy, while providing a means for quantifying the impact of different water policy strategies and demand/supply scenarios (Conningarth Economists, 2012). The model allows comparison of the benefits of water use between various sectors using weighted average multipliers (GDP, number of employees, households) per Rand per m^3 water used, and also allows for growth scenario analysis and the aggregated effects of different policy interventions such as increasing water tariffs. However, this existing model does not take into consideration the full complexity of the system, to quantify trade-off or knock-on effects of different water uses. For example, whilst demonstrating that agriculture uses water less 'efficiently' than other sectors, the analysis does not take into consideration issues such as the value of food security and regional imbalances in the prevalence of poverty. The model also excludes the environmental costs or impacts of various proposed water uses or developments, and of various water resources interventions. In addition, the model does not consider the spatial relationships between economic growth and the variability of water availability and quality across the catchment. Finally, although the model considers economic indicators (GDP and jobs contribution at a macro-scale) it does not include social impact indicators such as changes in well-being.

As yet there are no known examples where planning that acknowledges the inter-dependency of water and economics (key intervention 1 above) has been implemented. There are also no known examples of cost-benefit analyses or socio economic-benefit of proposed developments, informing current decisions over proposed developments, prior to investing in them (key intervention 2 and 3 above).

1.4. Focus on Berg Water Management Area and Saldanha Bay

Whilst the interventions motivated above (key intervention 1, 2, 3) are theoretically relevant to any constrained catchment, there is an urgent need to implement these interventions to inform economic development decisions in the Saldanha Bay area, within the constrained catchment of the Berg River. The West Coast District Municipality (WCDM) is supplied by water from the Western Cape Water Supply System (WCWSS), via the Berg River and Misverstand Dam, and in turn supplies water to Saldanha

Bay Local Municipality (SBLM). The WCDM has exceeded its allocation since 2008 (DWS, 2015). At the regional catchment level, allocations from the WCWSS should weigh up the potentially competing demands of industrial development in Saldanha versus agriculture in the Middle and Upper Berg, versus domestic and industrial supply to the Cape Town metropolitan (Pegram and Baleta, 2013). Additional water resources need to be brought online for Saldanha's planned development, and have been investigated (WCDM, 2010), however are yet to be implemented largely due to financial challenges. SBLM has previously declined applications for large-scale access to water (forcing a proposed development to source their own water supplies) and made access dependent on SBLM developing new water resources. Economic growth in the region therefore might become constrained by the cost of and availability of water (GreenCape, 2015).

In baseline research (GreenCape, 2015) and a series of interviews with decision makers in economic development planning and water resources planning, the following challenges have been observed for Saldanha Bay:

- Water resources and economic development plans are generally each treated as independent variables in the planning of the other. One takes the other "into account" but does not consider the inter-dependency. This is entrenched by the planning protocols such as Integrated Development Plans, Water Services Development Plans, and Master Plans.
- This disconnect in the planning system has led to the current situation in which those responsible for water resources allocation assume that industries with high water demand should be ruled out for the area. However, consideration should be given to the possibility that economic productivity from these industries and future water users may outweigh the costs of the required water infrastructure. This can only be assessed if a systems approach to planning is implemented, and if the total socio-economic-environmental cost/benefit of development options or water resources allocations are assessed and used in decision-making.
- Some of those in the planning system recognise the current challenges and reflect that there is no current alternative. Projects are currently assessed on an individual basis (i.e. in an environmental impact assessment or a water use license application), rather than strategic assessments of development scenarios. Local-scale planning depends on Provincial Government for this strategic oversight role. At this level, the full spatial complexity of the linked socio-economic-resources system needs to be taken into account. However, there are currently no tools to assist in this assessment.

Palmer et al. (2014) noted similar challenges when unpacking the reasons for slow implementation of the National Water Act, and motivates that a new paradigm is required for water resources planning and associated development planning, which incorporates a linked systems approach to assess trade-offs between competing uses (Palmer et al., 2014).

1.5. Research aims and proposed tools

Based on the evolving vision and the challenges identified, the project proposed three potential solutions:

1. The development of a cost-benefit analysis of proposed economic developments, water allocations, and resource interventions (key intervention 2).
2. The development of a regional hydro-economic model (key intervention 3 above).
3. An investigation into the current state of water resources and economic development planning to guide the development of the tools (item 1 and 2 above) inform how best to implement the tools, to promote better integrated planning (address key intervention 1 above).

The 'solutions' are indirect measures that aim to alleviate the potential constraint from poor planning, and enable smarter decisions necessary with constrained resources. The project did not assess the various direct solutions available to alleviate water resource constraints in Saldanha and the Berg WMA, i.e. provision of new water resources.

The overarching intention of the project was to (through the tools to be developed, and through the process of their development) inform decision-making for economic development and water resources, promote or take steps towards change in the current approach to planning, and ensure research findings or proposed tools were implemented during the course of the project. There is a growing recognition that to achieve this intention, research must be co-created by those it is intended to benefit (i.e. in this case decision-makers), at all stages including even the inception of such research, to ensure it is fit for purpose and is implemented. As such, the project team fostered close working relationships with decision-makers, directly connecting them with academic research.

Although the proposed research responds to the challenges in Saldanha Bay and Berg WMA, these challenges and the proposed interventions listed above are common to other constrained catchments, hence the methods and lessons from this case study are transferable to other areas.

1.6. Study spatial boundaries and focus areas

The study area includes the (previous) Berg Water Management Area (WMA), shown in Figure 1. This WMA has since merged with the Olifants WMA to the north, and forms the Berg-Olifants WMA. However, in this document, the term Berg WMA is used and refers to the previous outline of the WMA. The Berg WMA comprises the Berg River catchment together with areas along the west coast including the Diep River catchment and the Greater Cape Town area.

The Berg WMA includes a number of local municipalities, as well as the City of Cape Town metro. See the map below that delineates the location of the municipalities within the WMA.

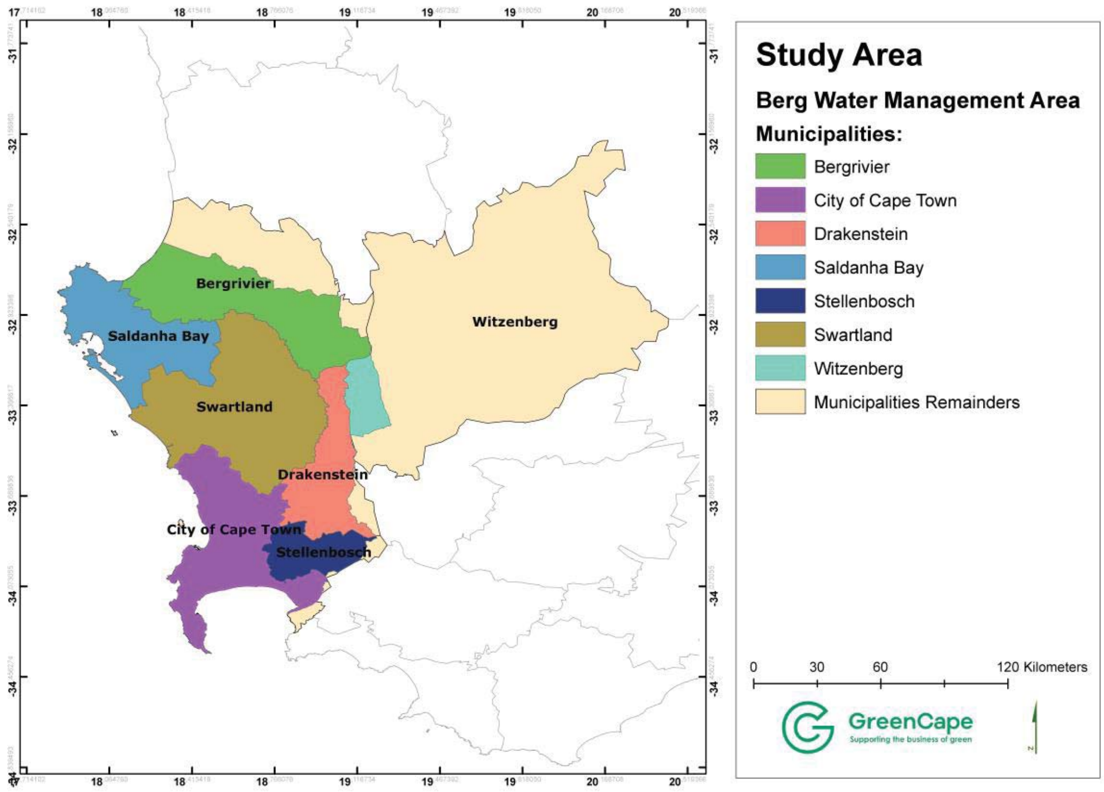

Figure 1: Berg Water Management Area including municipal boundaries

This region was the focus of the study, and wherever possible the boundary of the WMA was the extent of the study analysis. The exception to this was during some of the economic analysis of the local municipalities, where those municipalities fell across the boundary but where it was difficult to distinguish the specific economic outcomes for the proportion that fell within the WMA. Additionally, SBLM, was the focus for the "local tool" intervention, and many engagements[1] were held within the municipality to assist with the water constraints being experienced and the impact that this was having on the development potential of the area.

The analytical focus area of the study was largely concerned with the impact of water availability (i.e. not water quality) on the economic outcomes of the region (i.e. jobs and investment). The assessment of the planning systems looked into the intersection of development planning, water allocation and water resource infrastructural development. The economic analysis valued water on the basis of Gross Value Add (GVA) and employment. The calculation of water requirements was based on water access for production and human consumption. Therefore the impact of water availability on the environment was not included in the analysis.

1.7. Outline of this document

The document follows the following structure:

- Chapter 2 discusses the methodological approach to the study
- Chapter 3 provides background and context to the study area
- Chapter 4 analyses the planning and governance approaches to water allocation, water resources and economic development
- Chapter 5 discusses the role that water plays in the regional economy and provides some estimates of its value
- Chapter 6 estimates how much water is being used in the region, and forecasts how much will be required in 2025 and 2040, as well as highlighting the potential gaps in supply with the implications for development
- Chapter 7 discusses the tool that was developed for the SBLM to assist in prioritising water applications
- Chapter 8 summarises the key insights and findings from the study
- Chapter 9 provides recommendations for future research and the way forward
- Thereafter references are provided, as well as a number of appendices with details from the research

[1] For example, the project team assisted with the scoping of the "Water Exchange Network", regularly met with industry players to understand their water requirements and growth plans, and assisted the municipality as part of the municipality's "Smart Water Team".

2. Methodology

2.1. Project approach

The solutions developed on the project include two tools (a regional hydro-economic GIS model, and a local development prioritisation tool), and a governance assessment (or planning guidelines) to guide development and direct implementation of the two tools. Figure 2 shows the diagrammatic representation of the overall project structure:

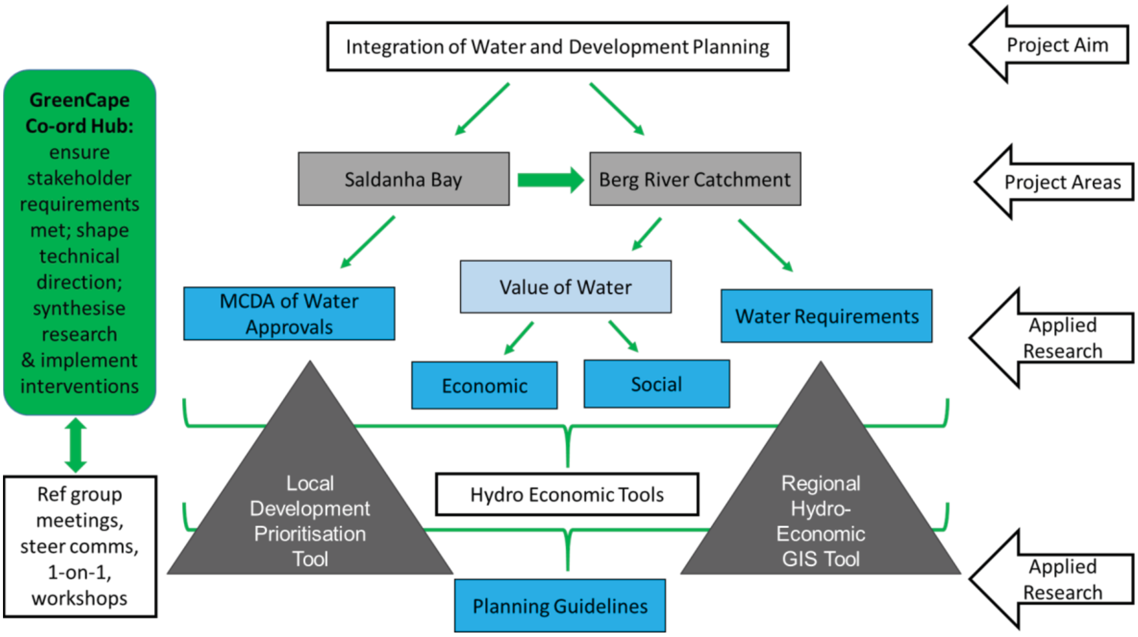

Figure 2: Project structure

The diagram illustrates how there were two distinct, yet related project areas: Saldanha Bay and the Berg River Catchment. There were a number of multi-disciplinary applied research studies that were consolidated into the Regional Hydro-Economic GIS tool – these were broadly split into estimating the total water requirements and then valuing those requirements. The Hydro-Economic tools were underpinned by the planning guidelines or governance research. GreenCape was positioned as the coordination hub.

2.2. Co-production with decision-makers

The overarching intention of the project was to (through the tools to be developed, and through the process of their development) inform decision-making for economic development and water resources, promote or take steps towards change in the current approach to planning, and ensure research findings or proposed tools were implemented during the course of the project. To achieve this aim, and ensure that the solutions meet the requirements of the decision-makers that will need to implement them, close collaboration and co-production with decision-makers was sought throughout the project. Formal workshops, smaller group meetings, and one-to-one meetings were held regularly. GreenCape also participates on several steering committees of similar projects which provided a platform for discussion and collaboration.

Following on from the scoping study, the proposal to the WRC for this project contained a problem definition and proposed solutions (outlined in section 1). Preliminary investigations into necessary datasets, and research into the proposed solutions, was also carried out during proposal phase. At the initiation of the project, a “user-needs workshop” was held to verify the problem definition, and shape solutions. This engagement led to the prioritisation of the challenges detailed in the problem definition, and shaping of proposed solutions, further data collation and tool development (further detailed in section 3.3). At routine interactions, the research was shared with decision-makers, and course-corrected where necessary, and the interactive cycle was therefore repeated several times (summarised in Figure 3). Continued interaction with decision-makers ensured that the project team remained informed of the problem landscape, as this changed significantly over the years since the proposal was written. In some cases, elements of the initial proposal were no longer valid, yet it was broad enough to allow the tools to be shaped accordingly. Particularly, the severity of the 2015-17 drought in the Western Cape certainly heightened interest in water, and provided GreenCape with additional platforms to disseminate research findings and foster implementation of the developed tools, although most decision-making during the period was being driven by the crisis and not longer-term planning.

GreenCape has supported decision makers in implementing the tools from this project through technical guidance and facilitation services. Implementing solutions and interventions was a continual process and was not reserved only for the end of the project.

In addition to closely involving decision-makers in the project, the research process itself represented a cross-sectoral collaboration between academic research housed at a university, consultants, a non-profit organisation, and (local, provincial, and national) government decision-makers.

Lessons learnt in the project process, and an appraisal of the successes of the project are included in section 8.3. In addition, a record of the liaison with decision-makers and research champions with whom the project has engaged with during the course is included in Appendix 1. Three annual workshops were held on the project, and their findings are integrated into the report in the relevant sections, with further details given in Appendices 2 and 3.

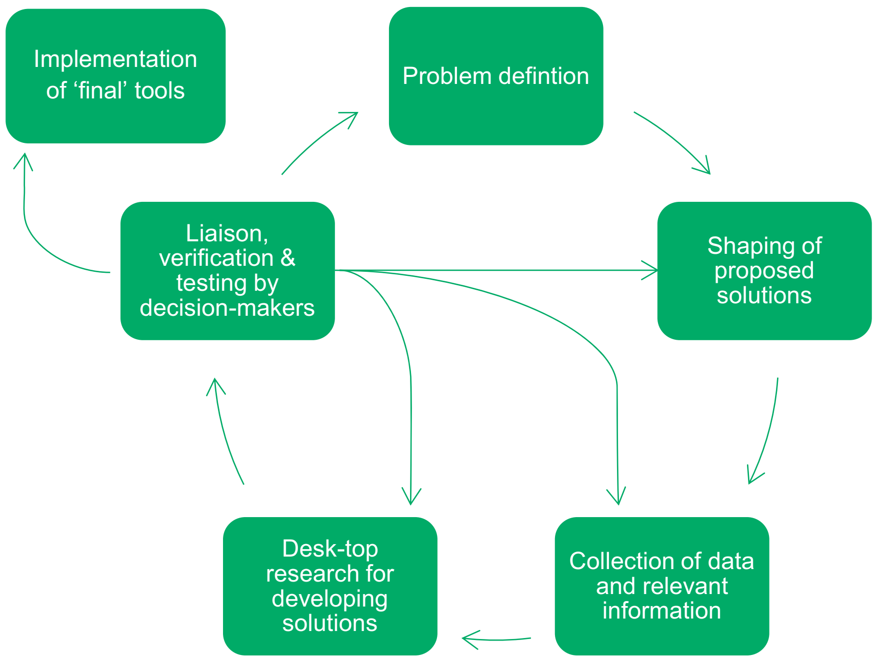

Figure 3: Framework for the iterative, co-development of solutions with decision-makers

3. Study Area Background and Challenges

3.1. Water resources in the Berg Water Management Area

The Department of Water and Sanitation (DWS) previously divided the country into 19 Water Management Areas (WMAs), each containing a large river system (DWAF, 2004a). The Berg River catchment supplies areas outside of its natural boundaries (Cape Town for example), and the boundary of the Berg WMA includes the supply area, and several smaller catchments. With the second revision of the National Water Resources Strategy (DWA, 2013) 19 WMAs were reduced to nine, through an amalgamation of areas. As such the Berg no longer constitutes an individual WMA, and is now part of the Berg-Olifants WMA, but is still referred to as such in this report.

The Berg WMA is a heavily utilised system. Through a set of six major dams (listed in Table 1), the Berg River supplies water to the majority of municipal demands (both domestic and industrial) as well as significant agricultural demands across the Berg WMA. The structure of the supply network, collectively termed the Western Cape Water Supply System (WCWSS, Figure 4), enables these dams to be operated in an integrated manner, maximizing efficiency. One of the dams (Theewaterskloof) is located in the neighbouring Breede River catchment, and contributes water to the Berg Catchment and the WCWSS via an inter-basin transfer. The DWS (2015a) points out that the total integrated system yield (at a 98% level of supply assurance for all user categories) is 570 million m^3/a. This figure is deduced from the maximum annual water requirements that the system can supply before the risk of curtailments become too great.

Table 1: Capacity and yield of the dams and system of the WCWSS (DWS, 2015a)

Dam	Capacity [million m^3]	Yield [million m^3/a]
Theewaterskloof Dam	432	219
Voëlvlei Dam	158	105
Wemmershoek Dam	58	54
Upper Steenbras Dam	30	40
Lower Steenbras Dam	34	
Berg River Dam	127	80
Palmiet		23
Compensation		38
Additional yield from integration		11
Total	**839**	**570**

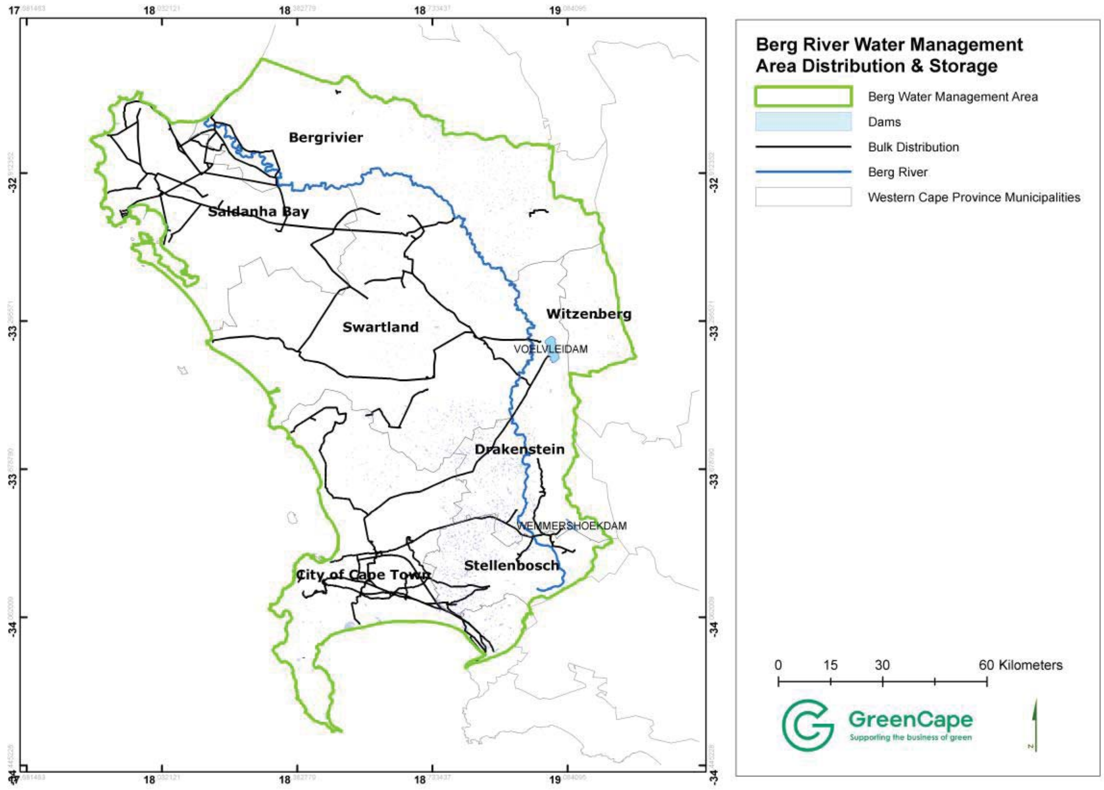

Figure 4: Western Cape Water Supply System network infrastructure

The WCWSS supplies raw water to domestic and industrial users (via municipal supply), and to agricultural users (via Water User Associations and irrigation boards). The major domestic and industrial user is the City of Cape Town, which then supplies to users within the Metropolitan area. The West Coast District Municipality (WCDM) also receives water from the WCWSS and operates smaller schemes to supply West Coast towns and industry, as does the Stellenbosch Local Municipality. The latest WCWSS consumption and allocation figures are from 2014/2015 and these reveal that this system was at that stage already over-allocated (i.e. that the water use authorisations exceeded the estimated system yield), however the usage was not yet exceeding the yield of the system:

Table 2: 2014/15 Consumption versus allocation million m^3/a (DWS, 2015a)

	Allocations	2014/15 Use
City of Cape Town	357.90	334.70
WCDM	22.80	27.73
Stellenbosch	3.00	4.19
Other urban/industrial	9.18	10.64
Agriculture (capped)	216.24	170.00 (estimated)
Total	**609.12**	**547.26**

The DWS planning scenario (based on high water requirement growth, 50% success of water conservation and water demand management measures and no impact of climate change) indicated that the WCWSS's water requirements would exceed the system yield in 2019[2]. The first possible supply augmentation scheme (Voëlvlei Augmentation Scheme) will increase the system yield by

[2] Sooner than previously thought due to decreased system yield

23 million m³/a and may come online in 2021 (due to the current drought, this scheme has been prioritised and may be online earlier than previously reported). However, as this brings the system yield to 605 million m³/a, the system will still be over-allocated. Thereafter a number of new supply schemes will need to be implemented in to meet the continued growth demands of the system. Feasibility studies are underway by the City of Cape Town (CoCT) for large-scale desalination, water reuse and groundwater use, and implementation of one of these schemes would have to commence imminently. Short-term schemes are being planned by the City of Cape Town that are effectively piloting the Table Mountain Aquifer Group and large-scale reuse schemes, yet also form part of the City's drought emergency supply schemes.

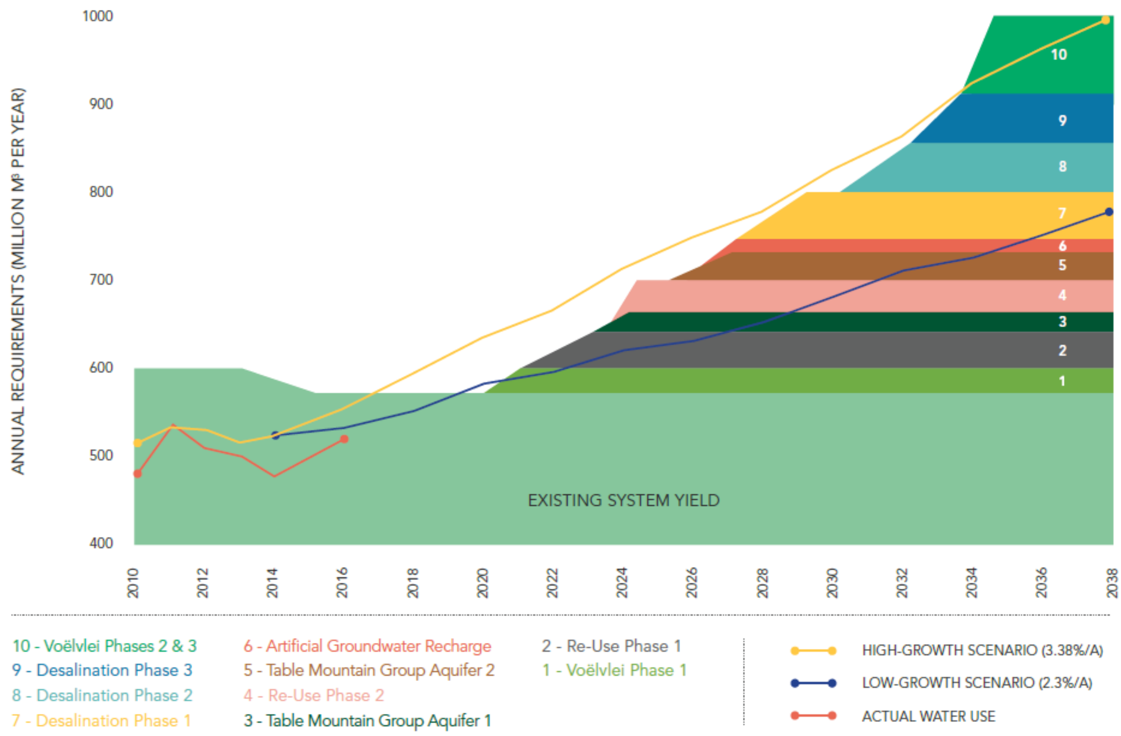

Figure 5: WCWSS reconciliation of supply and demand for the Planning Scenario (Redrawn from DWS, 2015a)

The WCWSS is therefore highly constrained according to existing allocations (which are undergoing a Validation and Verification process (see Box 1 in Chapter 4) and may therefore be updated), with a high reliance on surface water resource. New supply options largely rely on non-surface augmentation (excluding Voëlvlei) and are therefore expected to be far more expensive to develop than previously built dams.

3.2. Water resources in Saldanha Bay Local Municipality

The total allocation to the WCDM from the WCWSS is 22.80 million m³/a, of which 17.4 million m³/a is allocated from the Withoogte Scheme which supplies SBLM. WCDM can also extract 1.5 million m³/a from the Langebaan Road aquifer. The WCDM has exceeded its WCWSS allocation for the last 8 years, and Withoogte for the last five years (see Figure 6 below).

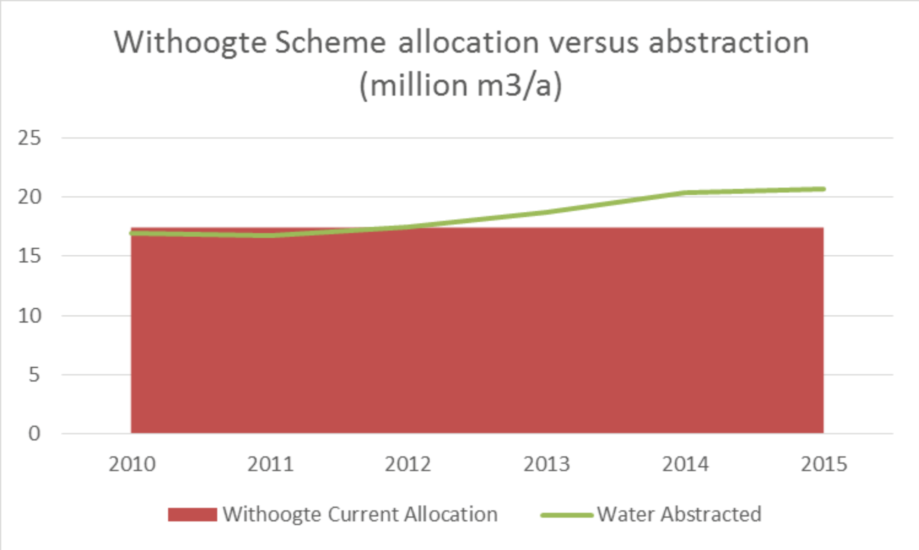

Figure 6: Abstraction versus allocation to the Withoogte Scheme from the WCWSS (DWS, 2015a)

The WCDM applied for a water use licence in 2011 that would increase the allocation from WCWSS to Withoogte, to 30.3 million m^3/a by 2033. However, this increased allocation is in competition with a similar application from the CoCT. This issue has not yet been resolved and the application request has not been approved nor denied by DWS[3]. However, a recommendation has been provided to DWS that the WCDM application is not awarded until other resource interventions are in place for Cape Town, i.e. in 2021 (DWS 2015a).

Table 3: Towns served by the Withoogte bulk scheme (DWS, 2015a)

Bulk System	Local Municipality	Towns
Withoogte	Saldanha Bay	Hopefield, Langebaan, Vredenberg, Saldanha, St Helena Bay
	Swartland	Koringberg, Morreesburg
	Bergrivier	Velddrif, Dwarskersbos

Of the approximately 21 million m^3/a of water utilised in the Withoogte scheme, around 13.5 million m^3/a is sold from the WCDM to the SBLM for distribution, the remainder being sold to other LMs from the Withoogte (or comprising losses).

Due to the delay in the increased allocation from the WCWSS, even if the WCDM application were to be approved in 2021, on the basis of existing abstraction rates and potential demand from new developments in the area, the increased supply from the WCWSS would not be sufficient to meet projected demand in SBLM (see Figure 7 below).

[3] As this study was going to print, confirmation was received by the WCDM that their licence application had been approved, but no further details were available to the project team

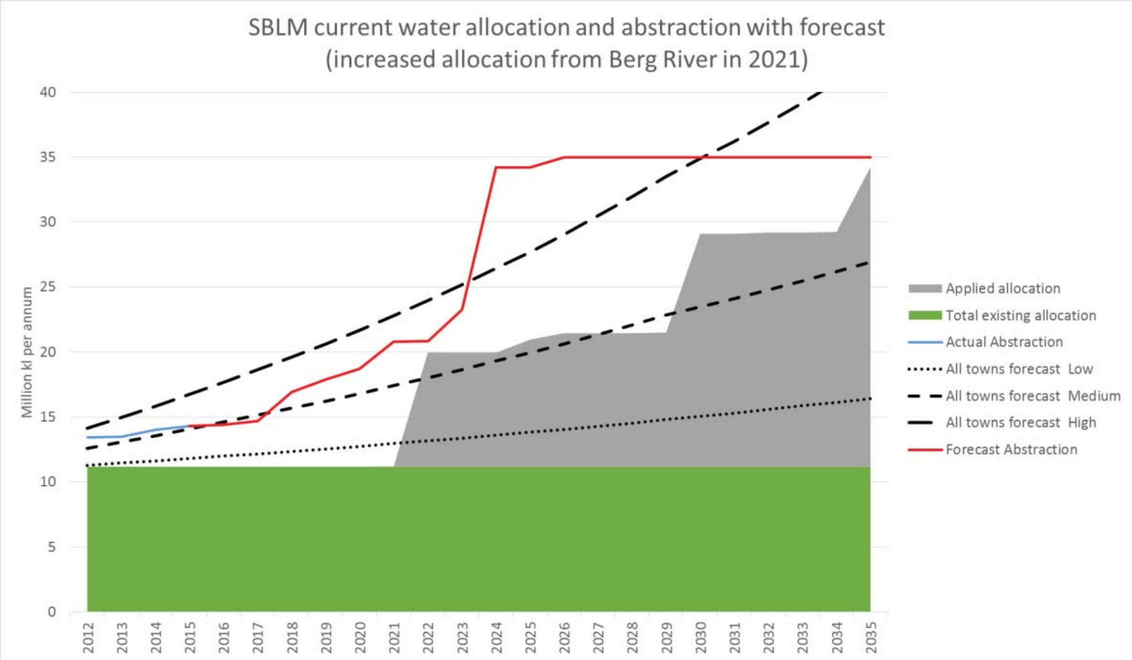

Figure 7: Projected SBLM water allocation and abstraction (DED&T, 2016; DWS, 2015a)

The situation highlights the precarious position of the SBLM: it is a relatively small user within a large scheme (in terms of volume used, population dependent on, and also GDP generated with this water), and dependent on decisions made upstream of it.

Besides increased allocation from the WCWSS, the WCDM, on behalf of the SBLM, has also pursued desalination as a water resource option. This option is favoured by the municipality over other local resource development options as it has the highest assurance of supply. The proposed project aimed to build a 25.5 ML/d by 2026 at a proposed cost of R450 million (Weslander, 2013) (current cost is estimated to be closer to R600 million). However the application to DWS for Regional Bulk Infrastructure Grant funding was not sufficient to cover the total cost of the project, and the municipality struggled to find funding for the shortfall. Additionally, DWS were concerned that desalination had been prematurely favoured without adequate appreciation of alternative sources, including increasing the supply from groundwater, and water reuse (GreenCape, 2015). The plan for this desalination plant has therefore been shelved for the time being.

It seems likely that SBLMs lack of water availability will continue for the coming short-term (four years) at the very least. Without a response forthcoming from DWS on the WCDMs water use license application for increased allocation from the WCWSS, there is a lack of certainty as the best way forward for assuring future supply. In the current drought environment, the need for increasing drought resilience through diversification of supply has also been highlighted and temporary local resources are being explored, including groundwater and reuse.

3.3. User Needs summary

The following six statements form a summary and grouping of the challenges listed in chapter 1, that were identified through engagement with decision makers during the scoping phase (GreenCape, 2015). They represent a mixture of challenges in water supply, and also challenges in coordinated development planning. There is overlap between each of them.

1. Water demand may outstrip supply in 2017-2018.

2. A misalignment in planning approaches, makes it difficult to strategically assess a set of development options, and to know whether there is sufficient water to support these.
3. There is no feedback loop between water demand, intervention cost, and whether the development can support the intervention cost, and ultimately the development approval.
4. Although work has been done on the economic productivity of various water uses or economic sectors, this had not yet been used to inform the allocation of water resources, nor in what development scenarios should be promoted for Saldanha.
5. Projects are awarded on project-by-project basis, without strategic oversight and quantification of competing resource demands/trade-offs. Tools to enable this are lacking.
6. The building block is missing: a coordinated picture/repository of planned development.

These identified challenges led to the key interventions (or solutions), contained within the proposal for this project, and summarised in chapter 1.2. At project inception, a half-day "user needs workshop" was held in June 2015. The workshop was externally facilitated and 29 participants attended.

The purpose of the workshop was to align proposed project solutions to the needs of those involved in water resources and economic development planning, and those impacted by this planning. The first aim of the workshop was to verify whether these challenges are relevant, critical, affecting development, and whether there were any missing. Once a collective picture of challenges could be established, the second aim of the workshop was to collect stakeholder feedback on the proposed solutions; to identify whether these solutions would add value, whether there is buy-in for them, shape them to be most relevant, and identify decision-makers who would be most likely to adopt the research outputs, and play key roles in the project process. The participants were asked:

1. (How) Are these challenges affecting you? Can you prioritise them?
2. Are there any key (water & economic development) challenges missing?

Participants responded to the prioritisation question by placing each challenge in their perceived relative order of importance (from 1 to 6 for 10 identified challenges, Figure 8). The results are shown in Figure 9.The key results of this exercise show:

- Although people considered it necessary to highlight four additional challenges, one of these received no priority "votes", and a further two received the fewest votes. This suggests the dominating challenges were captured by the scoping phase, listed as 1 to 6 above. Participants may have felt the need to raise issues that are linked, but these appear to not be central to the group present.
- The challenge that stakeholders feel is the most relevant, or biggest challenge for water resources and economic development in Saldanha[4], is that there is a misalignment in the planning approaches.
- The second biggest challenge for water resources and economic development in Saldanha, is that there is a lack of tools for strategic oversight, followed by the lack of feedback loop (between planned development, water demand, cost of water resources interventions, whether the development can afford this cost and whether development should proceed).

The prioritisation exercise confirmed the worth of developing tools that can better integrate water resources planning and economic development and assessing planning procedures in order that these tools can be implemented.

The following two questions were posed to the participants to direct their discussions on the proposed solutions:

- Would these solutions be effective for you?

[4] Saldanha Bay and its development future drove the motivation behind this study, and the focus on the Berg WMA emerged later as it was determined that Saldanha's future was intricately linked to the upstream water users in the remainder of the Berg WMA.

- Can you see a way to improve the proposed solution?

There was support from participants (at the workshop as well as at other initial presentations) for the proposed solutions.

A key theme from the user-needs workshop was the perceived limitation in understanding how a full range of planning ordinances, policy directives and local by-laws, all operating at slightly different scales and with different levels of authority, could be responsible for directing the water resource and economic development of Saldanha and the Berg WMA. Workshop participants highlighted the need for the project to begin by identifying the status quo of water resource and economic development planning. This status quo was considered necessary to also shape tool development further, and inform where how and by who the tools being developed could be implemented.

Figure 8: Stakeholders prioritising identified challenges (shown on white posters) through voting (coloured numbered notes) in June 2015

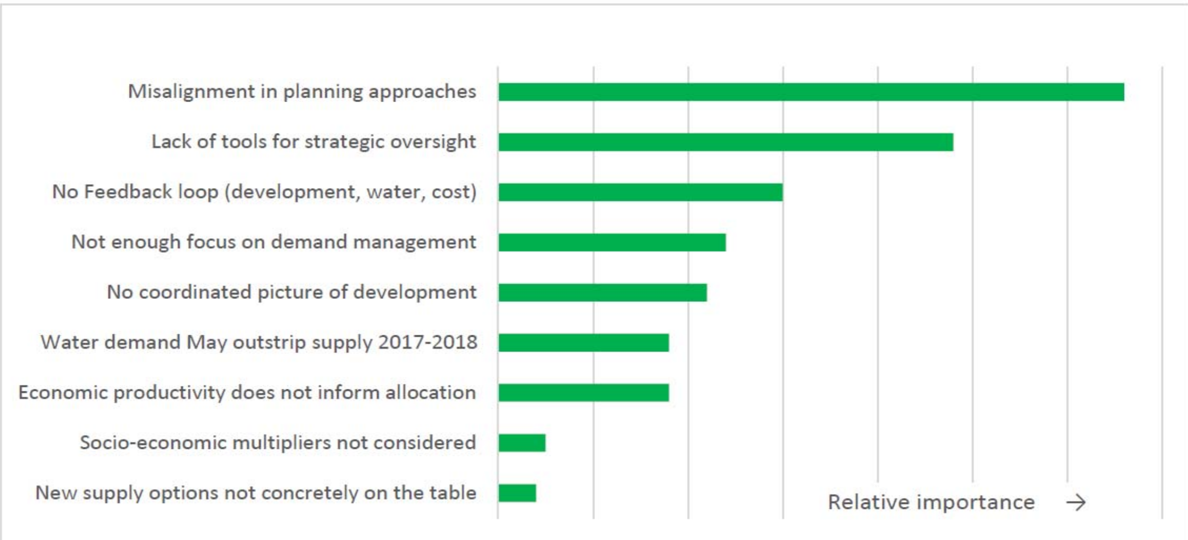

Figure 9: Stakeholder perspectives on the relative importance of challenges identified

The following chapter outlines the assessment undertaken of the planning approaches that led to the misalignment in Saldanha Bay and the Berg WMA.

4. Status quo of water resources and economic development planning

4.1. Introduction

Integrated (water resources and economic development) planning requires that: i) legislation and legislated planning processes support this integration; ii) that the necessary platforms are available (and functioning) to support information exchange and integration; and iii) that knowledge, data and information are available to support this integration. The user needs summary (section 3.3) highlights the key challenge for integrated development is a misalignment in planning, and a lack of tools. It therefore suggests that there are shortcomings in legislation, and in the various platforms for planning, as well as a lack of knowledge, data and information.

The legislation that controls the way in which water is accessed, economic development is planned, and water services and resources development is planned, was investigated. Current forums responsible for water resources and economic development planning were also assessed. The purpose of this assessment was:

- To deepen the understanding of the status quo for water resources and economic development planning, and thus understand the source of the challenges raised.
- To guide the development of the various tools,
- To identify where, how and by whom, the tools (and more broadly, the recommended approach to integrated water resources and economic development planning) should be used.

These investigations were carried out largely through review of relevant literature, policies and relevant legislation for water resources and economic development, and one-on-one discussion and workshops with people responsible for implementing the legislation or the forums. The planning processes outlined in Figure 10, Figure 11, and Figure 13, were drafted and presented at the second large workshop held on the project (June 2016). Stakeholders provided feedback on how the processes operate in legislation and in practice (where this differs). This section incorporates this feedback. Additional information on the second workshop is contained in Appendix 2

The planning process findings have been separated into perspectives and practices (section 4.2), current legislation (section 4.3) and current forums (section 4.4), and understandably there is overlap between these sections.

4.2. Perspectives and practices

The below set of perceptions and practices have been collated through one-on-one interviews, informal meetings and discussions, and annual project workshops with decision makers in economic development planning and water resources planning. Findings from this assessment expand on findings from the scoping phase appraisal of perspectives and practices water resources and economic development planning, outlined in section 1 (particularly section 1.2) and section 3 (particularly section 3.3).

The inter-dependence of water and economic development planning is not recognised in practice, controlled in part by legislated approaches. Water resources and economic development plans are generally each treated as independent variables in the planning of the other.

- High water-demand development is often planned without assessment of available water resources, or at least without assessment of the ability of the associated future water users to fund water resources development. For example;

- The establishment of the IDZ in Saldanha Bay assessed projected water requirements availability, and made the assumption that desalination of seawater was a potential resource and hence proceeded with the IDZ declaration. The water requirements of the IDZ itself is not significant, but as discussed in section 3.2, Saldanha Bay is already using more water than allocated, without clear plans for future supply. If desalination is going to be the approach pursued by the municipality to assure supply to the area, this would be a substantial cost for future water users.
- The WCG declared oil and gas and agri-processing as two of the priority areas for economic development under project Khulisa (WCG, 2015). However these are both water intense industries, effectively competing for water within the Berg WMA. There was inadequate appreciation of the need to develop regional water resources to support these industries, if they were to achieve their objectives of job and investment growth (WCG, 2015)

- On the other hand, water-intensive development is often disregarded under the assumption that it will not be feasible in a water-constrained area, again without assessment of the ability of the associated future users to fund water resources development. For example, DWS made comments at a GreenCape hosted a workshop in February 2014 (scoping phase, GreenCape 2015), that high water demand industries should be discouraged for Saldanha.
- Water resources development plans are based on broad assumptions of the annual growth in water requirements (as a percent) over the planning period (usually the coming 20-40 years). These water requirement growth percentages are generally developed through an assessment of previous water requirement growth trajectories, and take into consideration the general level of economic growth intended for a region, as documented in the Integrated Development Plans (IDPs). Water resources interventions are recommended to meet any future shortfalls, and costs provided. However, the IDPs do not outline specific private investments and developments that are possible for the municipality (often unknown), and are generated only on a 5-year basis. There are good reasons for these existing approaches, however, it results in situations where potentially unaffordable infrastructure is recommended (infrastructure that cannot be supported by the future users), or in a situation whereby future potential development is not provided for.
- Those responsible for water resources development planning reflect that there is a lack of information on economic development planning, and as such are forced to make broad assumptions for future water requirements.

The inter-dependence of water and economic development planning is recognised in perceptions to some degree, or at least by some individuals. However, incorporating the inter-dependence between water and economic development when implementing the required and legislated planning processes is a challenge, and a lack of tools prevent integrated analyses.

- Although work has been done on the potential future cost of water, and the cost per resource intervention or source of water (desalination, water re-use, etc.), and on the impact that this cost may have on certain economies (Conningarth Economists, 2012; DWS, 2015b; DWS, 2015a; WCDM 2010), there is no work that addresses the complete cycle for Saldanha: what are the potential developments, their water demand and the potential source, the potential cost of the provision of the necessary water, and the impact of that cost on the potential development.
- Projects are currently assessed on an individual basis (i.e. in an environmental impact assessment or a water use licence application), rather than strategic assessments of development scenarios. This is also a legislative requirement; if a water use licence application meets the required criteria it cannot be declined in favour of an application not yet submitted which may reflect development that is more socially-economically favourable. There does not appear to be an explicit feedback loop between the proposed economic developments, the associated water requirements, the cost of water resources intervention, and a strategic decision as to whether this proposed development, or group of developments, is therefore viable.

- Local-scale planning depends on provincial government for the strategic oversight role required to meet this integrated regional planning (the vision, key intervention 1, section 1.2). At this level, the full spatial complexity of the linked socio-economic-resources system needs to be taken into account. However, there are currently no tools to assist in this assessment.

4.3. Legislated planning processes

4.3.1. Water allocation

4.3.1.1. Overview

Figure 10 represents a flowchart illustrating how water is allocated for use as dictated by the National Water Act (NWA) (Act No. 36 of 1998, Section 21(a), taking water from a water resource).

The total water resource is determined through water resources yield models, and the allocable resource is what is remaining after legal obligations are met (left-hand side blue boxes in Figure 10). These obligations include water for the ecological reserve, water for strategic use (for example, electricity generation), international agreements and existing lawful use (light green boxes in Figure 10). Remaining water that is allocable by the DWS or Catchment Management Agency (CMA) includes all raw water resources (surface and groundwater) but excludes other sources such as the use of seawater (via desalination).

Whether the DWS/ CMA acts as the responsible authority for allocation of the remaining water depends on the catchment (responsible authority in dark grey in Figure 10). The NWA provides for a water to be allocated by the relevant CMA, but since only two are currently operational, the DWS remains the allocating authority in those catchments where CMAs are not yet established. This remains an uncertain situation as there are indications that no more CMAs will be declared, and that there will be a single, national CMA with regional/catchment offices that report to the single CMA – however this will require changes to legislation.

Aside from the initial legal obligations, all other allocations from DWS function as a licensing or authorisation processes, i.e. all taking of water from a water resource (i.e. direct users of raw water) apply to DWS (or the CMA) for a licence to abstract water (dark grey boxes in Figure 10). This includes water services authorities who must apply to DWS to abstract raw water, which they then provide to their municipal domestic or industrial users (light grey boxes in Figure 10). The process is controlled by Chapter 4 of the NWA. Water allocation priorities are dictated by Section 27 of the NWA, and are clearly mapped out in the second National Water Resources Strategy (NWRS) (DWA, 2013a), and will also be described in the relevant Catchment Management Strategy (CMS), where applicable. But it emerged through stakeholder engagement that these priorities were not used in practice, and that the operational aspects of awarding WULs do not easily allow for the realisation of these priorities.

The above description of Figure 10, and indeed the water use process described in the NWA, are all straightforward. However, potential water users have great uncertainty over the allocation process and the amount of water available for allocation. This uncertainty extends to within the (water and economics) planning sector, the uncertainty arises from several sources such as lack of information on how much water is available for allocation (and how this may change due to climate change), and are related to slow implementation of all aspects of the NWA. CMAs are not fully established, causing confusion, there is uncertainty over current water use, related to incomplete registration of existing lawful use, and the ecological reserve is in many cases not fully implemented, which would reduce the allocable resource once it is implemented. Some of these complications, that have relevance to integrating water resources planning and economic development planning, are described in further detail in section 4.3.1.2 and 4.3.1.3.

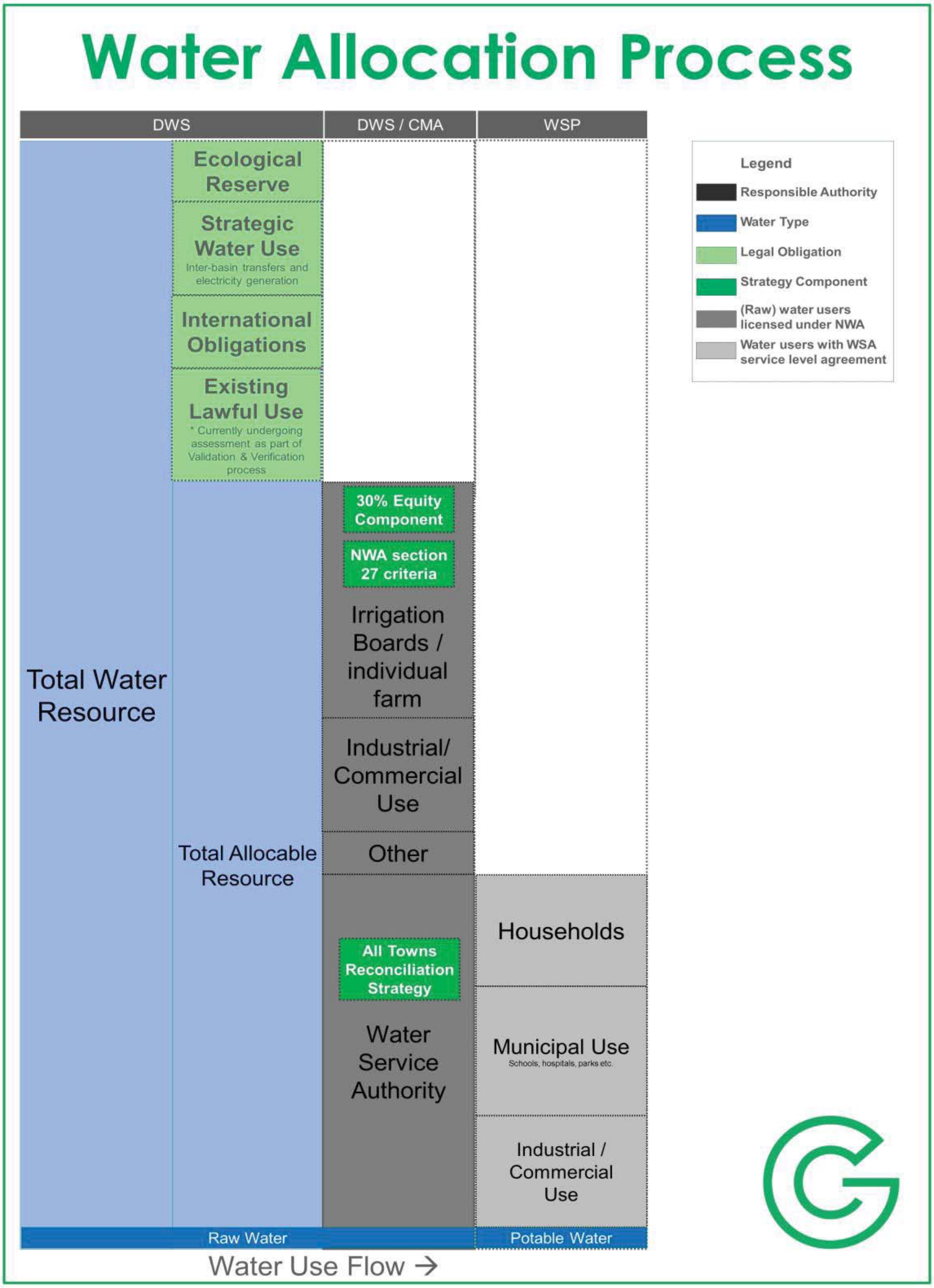

Figure 10: A flowchart of the water allocation process based on analysis of legislation and verification by stakeholders

4.3.1.2. Total Allocable Resource

The calculation of the total water resource is a technical process that utilizes hydrological and hydrogeological models, usually completed at primary catchment scale. The NWRS must establish water management areas, contain a water balance for each area, provide the minimum requirements for the reserve, set out actions to reconcile requirements and resources, set up principles regarding WC/WDM and determine the inter-relationships between institutions. Once the total water resource has been determined (through the NWRS), the NWA and the NWRS highlight binding legal allocations (priorities) that must be reserved from the total water resource (DWA, 2013a). These include:

- The Reserve
  - According to the NWA (Section 16), the highest priority is afforded to water for purposes of the reserve (RSA, 1998). The reserve has two components: basic human needs and ecological reserve. The first objective is to ensure that there is sufficient raw water available to provide for the basic water needs of people, currently determined as 25 litres per person per day. The second objective is to allow for the healthy ecological functioning of the aquatic ecosystems through the implementation of the ecological reserve (a technical process to determine the flow rate and quality required). These are the only two absolute rights contained within NWA. The reserve is determined (essentially a sign-off process) by the Minister. The placement of the Reserve above the Total Allocable Resource in Figure 10 refers to the non-negotiability of the implementation of the reserve before any allocations can be considered. However, the human reserve component is not actually reserved or set aside, and the ecological reserve is not currently implemented in all areas.
- International Agreements.
  - South Africa has committed to managing shared river basins in line with existing international agreements with the relevant riparian states. These include for example ensuring a particular flow transfers across borders. This is not relevant in the case of the Berg area as it does not share its river basin with any other countries.
- Strategic Water Use.
  - Strategic water use refers to water use that is strategically important to the national economy as per the NWA and includes water for inter-basin transfers (IBTs) and electricity generation. IBTs are relevant for the Berg insofar as the catchment receives IBTs from neighbouring catchments, but has not committed to transfers out of the catchment. Freshwater consumption for electricity generation is not significant within the Berg catchment, as Koeberg is largely reliant on seawater, and the net water consumption at Palmiet pumped storage scheme is low.
- Existing Lawful Use
  - The NWA recognises historical water use as existing lawful use for end users (Section 32). These lawful uses relate to (a) water used during an interval period between the first democratic election in 1994 and the commencement of the NWA in 1998 and (b) water used as a consequence of riparian rights granted to farmers in the Water Act 54 of 1956. (RSA, 1956). In terms of (a) with the passing of the NWA in 1998, existing lawful use of water was recognised and secured as a transitional measure until all users could be licensed under the same regime (RSA, 1998). As such, DWS are legally mandated to provide this water prior to determining the total allocable resource. However, DWS are in the process of addressing this and during a parliamentary portfolio meeting on the 2nd of November 2016, it was

emphasised that plans are in place to do away with this sunset clause[5] in an amendment of NWA. The validation and verification of the existing lawful use is currently being conducted in the Berg and should be completed by the end of 2017 (see Box 1). Following this process, DWS may implement compulsory licensing to initiate a reallocation of water for the Berg River catchment.

Once the above described legal obligations have been prioritised, the total allocable resource available to a CMA or regional DWS office for allocation should be determined. According to the NWA (RSA, 1998), the Minister is responsible for determining the quantity of water that the responsible authority may allocate, subject to the guiding 'priorities' of the NWRS. These 'priorities' simply inform the manner in which the CMA/DWS reviews water use license applications. In this sense, water allocation from the allocable resource functions as a licensing or authorisation process rather than as a process driven by strategic priorities. This understanding has been validated by a number of officials, including DWS regional office licensing officials and the Breede-Gouritz CMA (BGCMA). Priorities are only considered when competing applications are received and the key priority that governs that process is whether a minimum of 30% of the allocated water will go to, or benefit, historically disadvantaged people. It is not clear however, how completing applications from Water Service Authorities are compared, and there are competing applications for water from the Berg WMA between Water Service Authorities (DWS, 2015a).

There are three types of (or levels) of water authorisation: Schedule 1, General Authorisation, and Licences. Before applying for the relevant authorisation, the applicant will need to determine what category they fall into.

- Schedule 1 use refers to water for the purpose of household use only and is thereby assumed to be low (although no specific usage rate is applied to it, rather only the purpose of the water use). In this case, no application for a licence needs to be made, but Schedule 1 users are required to register with DWS to protect their interests.
- General authorisations (GA) were designed to lighten the administrative load of licensing, and are for volumes of water that fall within a range specified per quaternary catchment[6] by DWS. In known areas of water stress, the general authorization may be set extremely low to enforce more users to require a full assessment that is required for licensing. The user thereby does not apply for a (full) licence but must register their water usage under the general authorisation category.
- Water uses not falling into Schedule 1 or GA require a license, acquired through a water use license application (WULA) process. The application is assessed by DWS regional office (for the Berg), but signed off by the minister (i.e. national office). This transfers to the relevant CMA once they are up and running. Presently, the BGCMA and the Inkomati CMA are the only two in operation in South Africa. The Berg-Olifants is a Proto-CMA so this responsibility will transfer to the CMA once it has been fully established and the responsibility to issue licences delegated from minister to CMA (if indeed this process is completed).

"Considerations" for the issuing of GAs and WULs are listed in Section 27 of the NWA, yet these are not provided in section 27 in a prioritized order. The need to redress the results of past racial and gender discrimination is listed as a consideration however no guidance is available in the NWA or NWRS on how this is defined or implemented. The BGCMA has implemented this criterion through requiring all applicants to have a minimum of 30% equity share for HDIs (*pers comm*, Breede-Gouritz CMA, 12 October 2016). This has, however, led to legal disputes in other areas.

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[5] A sunset clause refers to a piece of legislation that has an expiry date associated with it. In the case of existing lawful use recognised during the 'qualifying period', this right will be lost following the completion of the validation and verification process and compulsory licensing.

[6] The limits for GA in the Western Cape are displayed here: http://mgo.ms/s/ll4ph

A recent appeal court case of *Makhanya v Goede Wellington Boerdery (Pty) Ltd*,[7] considered the prioritisation of the considerations under section 27 of the NWA. The applicant, Goede Wellington Boerdery, was refused a licence for the transfer of water rights from a neighbouring farm on the basis that they had not met the equity consideration in terms of the criteria laid out in section 27 of the NWA. The court ruled that the transfer of water rights is possible, that an equal consideration of various factors must take place in the consideration of any application for the transfer of water rights, and that no single factor (out of those considerations listed in NWA Section 27) may be afforded preference or carry a heavier weight than any other factor in such consideration. The judgement confirms that, although empowerment is an important factor in the consideration of licenses, it is not the sole factor to be considered and that a balance must be struck between all relevant considerations as prescribed by NWA in the assessment of any application. The High Court, and later also the Appeal Court, found that the DWS and the Water Tribunal misinterpreted the provisions of section 27(1) of the NWA by regarding the redress factor (section 27(1)(b)) as a prerequisite for the approval of a licence application. The court confirmed that “all relevant factors”; must be taken into account for the approval of a license, and although the Department has a discretion, it is still required to maintain a balance in its decision making.

One of the key components of a Catchment Management Strategy (CMS) is the development of its water allocation principles for the catchment, taking into account the NWA S27. The CMS for the Berg-Olifants is still to be developed and will be completed once (or if) the CMA has been established.

Although the NWA, NWRS and potentially CMS provides a strong set of principles and guidelines to guide the allocation process, a key finding of this study has revealed that, in practice, these principles are not influential in the allocation process. Given allocation is managed with a licensing process, DWS (or the responsible authority) must authorise a water use if it meets the licensing requirements. DWS has no reason (and no mandate) to withhold an authorisation on the hope (or even knowledge) that a more socially or economically productive use of the perhaps constrained water resource is applied for at a later date.

[7] Available at https://cer.org.za/wp-content/uploads/2012/12/Goede-Wellington-SCA-2012-205.pdf accessed 1 September 2017

Box 1: Validation and Verification Process and Compulsory Licensing

The DWS is in the process of validation and verification of water users in the Berg-Olifants Water Management Area to ensure that all available water is accounted for. According to Regulation 1352, a person who uses water as contemplated in Section 21 of the NWA must register the water use when called upon by the responsible authority to do so. The registration process requires that all water uses, regardless of the pre-existing legal status thereof (i.e. already licensed), must register. Water users in the Berg-Olifants WMA were asked to register their water usage, during the qualifying period. This usage is then being reviewed by the DWS through the process of validation and verification. Validation aims to confirm of the extent of water use (who, where, how much & what for?) that took place during the qualifying period, to determine the extent of the present water use, and thirdly, to determine the lawfulness of the uses. Therefore, registering your water use does not guarantee that it is accurate or lawful. Verification refers to a process that determines whether the water use identified in the validation process was lawful – it confirms whether any previous laws would have authorised the use or limited the use in the Qualifying Period.

Once the validation and verification process is completed, DWS may initiate the compulsory licensing process which will enable them to reallocate water. Reallocation is a likely scenario for the Berg WMA: The on-going Validation and Verification (V&V) process by DWS hopes to discover that there is additional water to allocate as they suspect that registered water use is higher than actual water use. Furthermore, once the V&V process is completed, and a sunset clause is removed from the National Water Act that provides farmers with automatic riparian rights, DWS may institute compulsory licensing in order to reallocate water across the region for equity purposes.

4.3.1.3. Water Services Authority Supply

In the same manner as individual applicants, Water Service Authorities (WSA), which are almost always municipalities (or water boards in other parts of the country), must apply for abstraction of raw water from a water resource from the CMA/DWS. In turn, the WSA will have an agreement with a Water Services Provider (WSP), often simply another department at the municipality, who will treat raw water and distribute potable water to individual applicants under a service level agreement (Figure 10). Roles and responsibilities of WSA and WSP are further outlined in Box 1. However, water resources such as seawater (via desalination), and use of treated effluent, are not directly allocated by DWS given its mandate to manage fresh water. The release of water to a watercourse, from a wastewater treatment works, is licensed by DWS as one of 12 types of uses of water that are regulated (along with taking from a water resource). But the allocation of the treated effluent resource (who it goes to and in what quantity) is not. In the case of desalination, DWS may only be involved in terms requests for infrastructure funding, approval of any discharge, but not the quantification and allocation of the available resource. So, in addition to the water resources managed on a regional scale by the CMA/DWS, the WSA may also have access to water resources that are not allocated by DWS.

Applications by the WSA to DWS/CMA for additional water allocations are considered against the same section 27 criteria, plus the manner in which the WSA has managed any existing water allocations. Applications by a WSA for water from DWS/CMA have to be in alignment with the recommendations and forecasts in the All Towns Reconciliation Strategy Study[8]. However, if plans have been made for the development of a town/area above and beyond what is reflected in the All Towns Strategy, then the WSA will struggle to gain approval for increased allocation (Thompson et al., 2015).

[8] The All Towns Strategy Study is a nationwide DWS project to forecast water requirements and supply in all South African towns and villages (outside of the major water supply systems which have more in depth reconciliation studies), and make recommendations on reconciliation of demand and supply, to ensure sufficient water supplies into the future.

The individual water users that require water services will include household users and larger industrial users within the municipality, who for whatever reason, prefer to use municipal supply water rather than abstract raw water. (Most users are connected to the municipal supply in Saldanha Bay, due to the lack of local surface water resources.) Larger users, particularly industrial or commercial users on greenfield or unserviced sites, will need to apply to the WSA for access to water services. The basis on which this access is granted is determined by the Water Services Act (RSA, 1997, chapter 1, section 8), which largely includes the practical considerations of supplying the water, along with the "socio-economic and conservation benefits that may be achieved by providing the water services in question".

GreenCape's scoping study (2015) highlighted that connections to water services are granted on a first-come-first-served basis by the SBLM (and in essence, so are WULs if all necessary requirements are met in the application, section 4.3.1.2). Although both SBLM and DWS acknowledge that this is not an ideal situation, there are few alternatives in absence of better information.

4.3.2. Development planning process

4.3.2.1. The IDP and SDF

Figure 11 illustrates the development planning process. The primary planning processes occur at the local municipal level, through the Integrated Development Plan (IDP) (Figure 12). The IDP is, simply put, a coordination and amalgamation of sector development plans which must reflect:

a) the municipal council's vision for the long-term development of the municipality with special emphasis on the municipality's most critical development and internal transformation needs;
b) an assessment of the existing level of development in the municipality, which must include an identification of communities which do not have access to basic municipal services;
c) the council and private sector's development priorities and objectives for the council's elected term, including its local economic development aims and its internal transformation needs;
d) the council's development strategies which must be aligned with any national or provincial sectoral plans and planning requirements binding on the municipality in terms of legislation;
e) a spatial development framework which must include the provision of basic guidelines for a land use management system for the municipality.

However, the overall development planning process is structured in a tiered manner which reflects the different government spheres (see Figure 11 and Figure 12). In this regard, a local municipality (LM) IDP has several planning processes above it that it is required to take into account. From the top (in terms of hierarchy and spatial area of interest), the National Development Plan (NDP), established by the national planning committee, has documented Vision 2030 that is intended to shape all development in the country with the central aim to eliminate poverty and reduce inequality by 2030 (NPC, 2011). This includes effective management of water resources and services to support and promote a strong economy and healthy environment, effective water planning that cuts across different economic sectors and spheres of government and reliable water supplies for urban and industrial centres with increasingly efficient agricultural water use (NPC, 2011).

The aims and vision of the NDP are implemented through a 5-yearly plan developed by Cabinet: the Medium Term Strategic Framework (MTSF). The MTSF articulates Government's commitment to implementing the NDP and delivering on its electoral mandate as well as its constitutional and statutory obligations (RSA, 2014). The priorities identified in the latest MTSF (2014-2019) are being incorporated into the plans and programmes of national and provincial departments, municipalities and public entities.

The NDP incorporates a National Infrastructure Development Plan 2012, with a series of ambitious and far-reaching initiatives envisaged to transform South Africa's economic landscape, to virtually eliminate unemployment and improve the delivery of basic services. This plan listed 18 Strategic Integrated

Projects (SIPs) which have been developed and approved by Cabinet and the Presidential Infrastructure Coordinating Commission (PICC) to support economic development. The identified projects will provide new infrastructure, assist in terms of rehabilitating and upgrading existing infrastructure and will also play a crucial role in facilitating the regional integration for African co-operation and economic development on the African continent. This plan has relevance in areas where a SIP is located, of which Saldanha is one (SIP5: Saldanha-Northern Cape corridor development, strengthening marine support capacity for oil and gas and through the expansion of iron ore mining production, integrated rail and port expansion).

At provincial level, Provincial Government develops a Provincial Strategic Framework that guides all activity by Province, all focus areas and all projects completed. The local level IDP needs to fit into, and correlate with, all of these broader-scale plans “above” it in the hierarchy presented in Figure 11. A LM IDP includes all the projects/interventions which the LM plans to undertake. The IDP can list private developments although it seldom does so for future development projects. Furthermore, an IDP is also completed at district municipality (DM) level. According to the Municipal Structures Amendment Act (RSA, 2003), a DM is responsible for developing an IDP for the DM as a whole, including a framework for IDPs of all local municipalities in the area of the DM. The DMs IDP is primarily aimed at coordinating development across the borders of the LMs within its jurisdiction, ensuring alignment with provincial and national strategic plans and supporting LMs where capacity is weak. **Whilst this tiered approach does well to guide the development planning process on a variety of spatial scales, a challenge exists in dealing with the slow trickle down of information from higher level planning processes to the LM IDP. Processes need to be aligned more timeously.**

The Constitution stipulates that local government is responsible for the provision of water supply and sanitation services, hence to operate as the water services authority and water services provider unless this is outsourced under contract to a water board (RSA, 1996). To this end, the IDP is the primary planning tool within which any water infrastructure interventions would have to be outlined. The budget planning for the LM and the IDP go hand-in-hand, i.e. projects within the IDP are voted for at council level, and the required budget is set aside. Typically a 12-month process is required for the completion of an IDP (see Table 5), and the required content is set out in the Municipal Systems Act (RSA, 2000).

The level of detail contained within development plans differs at the different levels. Local-scale planning is more detail specific whilst national scale planning has a greater strategic focus, although will name individual projects where these are of national significance. For example, the national spatial development framework includes mentioning of Saldanha Port because it is of national importance.

The Spatial Development Framework is a sector plan that is regarded as the key input to the IDP, and often elevated to the same importance as an IDP (demonstrated in Figure 11 and Figure 12). The Provincial Spatial Development Framework (PSDF; Figure 11 and Figure 12) aims to spatialize core projects, promote biodiversity, guide land use, guide bulk infrastructure development, serve as a manual for municipal planning, create integrated land management areas, facilitate cross-boundary collaboration, guide sustainable development initiatives, guide allocation of government funds and optimise benefits of private sector investment.[9] This is in contrast with a more detail orientated LM SDF. The PSDF is guided by the Provincial Growth and Development Strategy (PGDS, Figure 12).

The LM Spatial Development Framework (SDF) is a development plan focused on the spatial planning in the LM’s area of jurisdiction. It identifies land suitable for future development projects that are described within the IDP, as well as identifying changes on the urban edge. It also gives a localised spatial dimension to development principles, objectives and projects and forms the basis for the local government’s land use management system (DPLG, 2000). The development of an SDF is regulated

[9] See video on PSDF at http://northerncapepsdf.co.za/

through the Spatial Planning and Land-use Management Act (SPLUMA) (RSA, 2013). SDFs are completed at LM, DM, provincial and national level. Furthermore, the Western Cape Provincial Government has recently initiated regional SDFs, at levels smaller than provincial scale.

The National Environmental Management Act, Act 107 of 1998 (NEMA) allows for the development of a national environmental management framework. In the same way as multi-scaled SDFs, this has a provincial and local government equivalent (see Figure 11 and Figure 12). The regional environmental management framework is then incorporated into the regional SDF. The process is important as it a key link between (environmental, spatial, integrated) development planning, and whether a private sector project initiates: the project will only be awarded an EIA if it is aligned with the various environmental management plans. The plans will also dictate the content of the EIA.

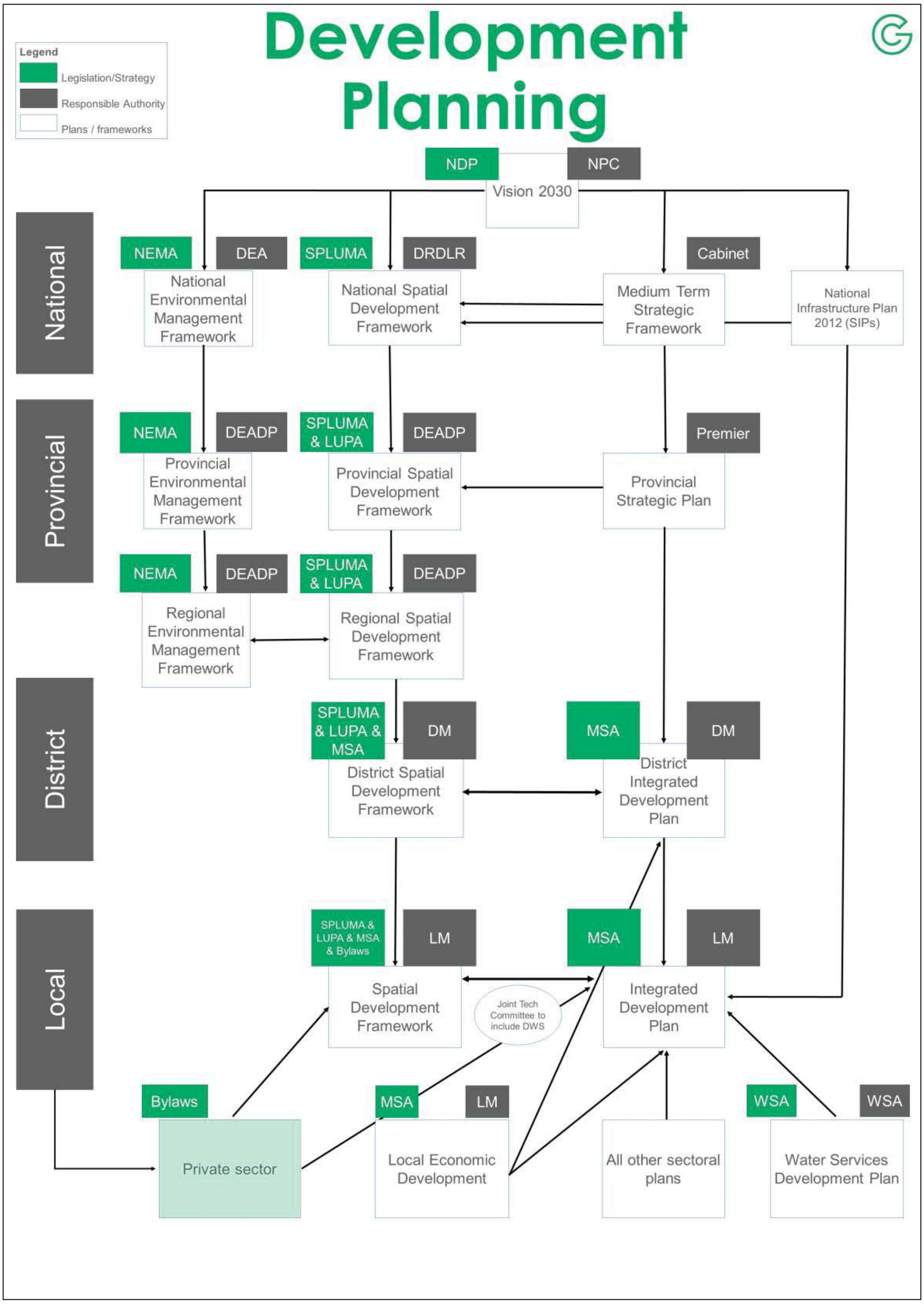


Figure 11: A flowchart of the development planning process based on assessment of legislation and discussion with stakeholders

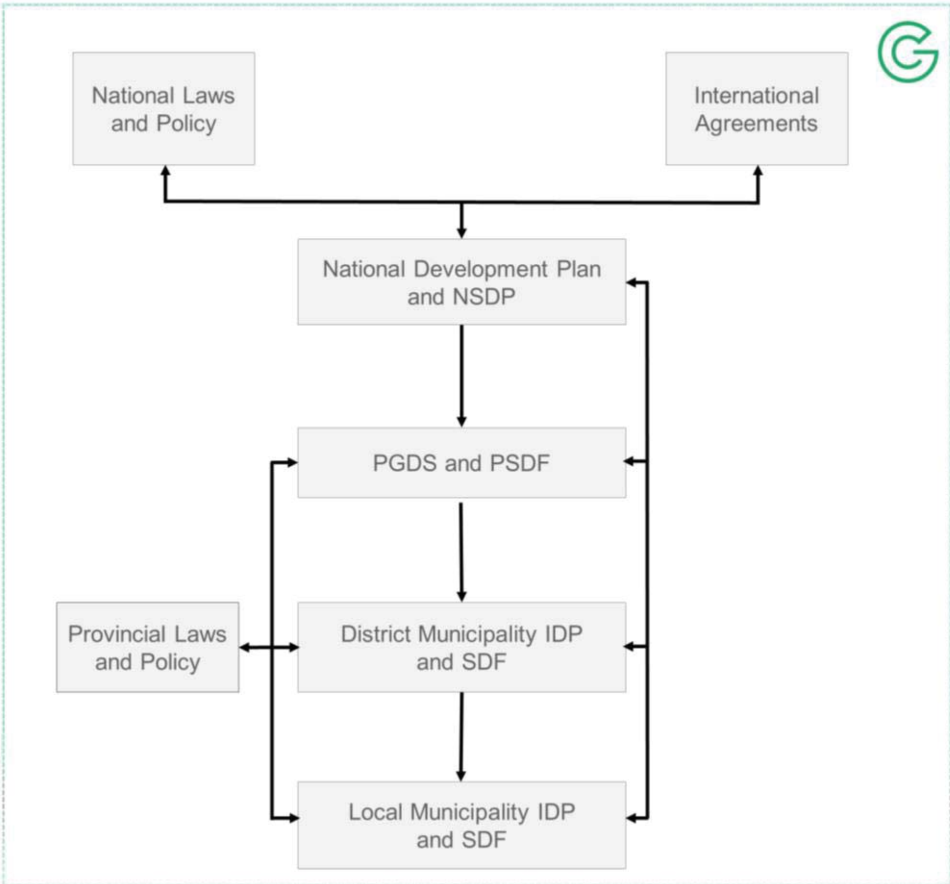


Figure 12: Structure of key plans working within government (adapted from DRDLR, 2012)

Table 4: Generic IDP process (adapted from DRDLR, 2012). The dark green block indicates the point at which sector development plans are incorporated into the IDP

IDP Process	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Preparation												
Analysis												
Strategies												
Project												
Integration												
Approval												
Implementation												

4.3.2.2. Water (and other inputs) in the IDP process

A fundamental feature of the IDP process is the integration of all sector plans into the IDP document (dark green box Table 5). This includes the integration of the Water *Services* Development Plan (WSDP) as the key plan for water *services* in the municipality. The compilation of Water Services Development Plans (WSDP), by Water Services Authorities, is a planning requirement laid out in the Water Services Act (RSA, 1997). In the event of the Water Service Authority covering more than one local municipality, each local municipality should be represented in the planning team for the Water

Services Development Plan to ensure mutual alignment of the WSDP and the water-related projects of the IDP (Haigh et al., 2008).

Sectoral departments/agencies are responsible for checking the alignment of the IDP with the relevant sector's plans and priorities during its drafting, while the national sector agencies should provide a framework for the development of the sector plans. **Insights from many officials suggest that this often functions purely as a legislative requirement and there is insufficient time to ensure meaningful commentary and input is given. One challenge, highlighted by government officials during the 2016 workshop, relates to the different timescales of the IDP and WSDP. An IDP only functions in five-year intervals whereas a WSDP is generally in place for 20-30 year intervals (with an implementation plan for the coming five years). An alignment of these two planning processes is challenging and officials generally call for a repetition of WSDP information in the IDPs**.

More significantly, the WSDP relates mostly to infrastructure and water services needs. They do not, generally, include detailed consideration of future water resource or supply interventions. These considerations are sometimes addressed in other planning documents of the LM or DM such as water master plans, or only addressed by DWS, for example in the All Towns Strategy Study. There is no explicit requirement for the reconciliation interventions listed in the All Towns Strategy Study to be included in the WSDP, nor in the IDP. Typically the IDP will simply include a recognition of currently available water resources, and potential future water availability, by repeating information that may be available in the WSDP or other documents. This demonstrates the challenge originally noticed; that water and economics are treated as independent variables to be taken into account in the planning of the other, rather than recognising the two are intrinsically linked (section 1.2). During the 2016 workshop, it was proposed that the Catchment Management Strategy (CMS) be included as one of the sector plans input to the IDP since water resource to support future water supply interventions are not currently adequately considered in the WSDP. However, the CMS does not address local supply augmentation problems, so this remains a problem.

The Local Economic Development (LED) plan is another sector plan required as input into the IDP process and it is an approach towards economic development which allows and encourages local people to work together to achieve sustainable economic growth and development thereby bringing economic benefits and improved quality of life for all residents in a local municipal area. The LED plan is intended to maximise the economic potential of all municipal localities throughout the country and, to enhance the resilience of the macroeconomic growth through increased local economic growth, employment creation and development initiatives within the context of sustainable development. The "local" in economic development points to the fact that the political jurisdiction at a local level is often the most appropriate place for economic intervention as it carries alongside it the accountability and legitimacy of a democratically elected body. The LM is a key player in shaping the local economy and should formulate policies and provide the infrastructure that fosters economic growth (DPLG, 2000).

The private sector (from households to businesses) is also a key consideration within the LM IDP. The private sector provides input to the IDP and SDF carried out at LM level through the stakeholder participation processes. They are also subject to the output of these plans. Development applications from the private sector to the LM that are not in line with the SDF and IDP will not be approved or require additional levies for infrastructure development. Participants at the 2016 workshop highlighted the need to promote increased communication, integration and coordination between the private sector and local government, specifically because the private sector felt it had significant insight to private developments that would impact the area. The current status quo is that the private sector is generally unwilling to disclose specific development plans, to protect market competitiveness, and also due to related impacts on land use and property prices. **The LM is only consulted once permissions or expansion authorisation are needed. This situation is sub-optimal as if the LM is aware of future industrial**

development plans, it can factor in municipal services and associated projects accordingly, and industry could play a key role in economic and social development. If better transparency could be promoted, it was felt that the LM could put together a more informed IDP that is considerate of industry's needs. **This broadly demonstrates a recurring issue with the IDPs, specifically that the depth of commentary given during the participation and input process, is typically rushed and more legally obligatory, rather than promoting detailed, useful contributions.** This problem has been stressed an issue both internally (i.e. from governmental departments) and externally through the private sector.

In summary, development planning currently functions in a top-down manner. Overarching development goals are set at national level and inform planning at lower levels but are not necessarily compatible with LMs' available resources, budgets and capacity. The IDP, which at a LM level is generally seen as the primary planning tool of a local municipality, is not timeously informed by higher level documents and does not feedback to them. Contributions to the IDPs are also often rushed and serve to tick a legislative requirement but lack meaningful contributions from both government and the private sector. The IDP is also the touch point between development and water resources planning, through the integration of the WSDP as a sector plan, but does not adequately consider future water resource availability and the link to development.

4.3.3. Water Services and Resources Development Process

4.3.3.1. Water Resource Development

A review of the processes involved in water supply augmentation decisions, at both a resources and services level is necessary for a complete view of economic development and water resources planning. Figure 13 depicts a summary of the water resources and services development process.

Roles and responsibilities of DWS and WSAs
A Water Services Authority (WSA) is responsible for all planning necessary to ensure sufficient water is available to users, i.e. all elements of water resources planning for municipal supply (Box 1), with support from DWS. In the case of regional schemes that supply more than one WSA (which were historically generally established by DWS), DWS is responsible for oversight and coordination of this planning, however relies on the input from WSAs to coordinate requirements between the various users of the regional schemes.

Soon after the establishment of the NWA (1998), DWS begun the process of quantification of available water resources, first with the Internal Strategic Perspectives (i.e. DWAF, 2004), then with the Water Availability Assessment Studies (i.e. DWAF, 2008), both of which were projects completed across the country separated into individual projects per water management area (some were grouped). In parallel, in the mid-2000s DWS's Directorate of National Water Resources Planning was aware that the water requirements in the major metropolitan areas and major schemes were soon to outstrip availability and that the country's development priorities necessitated increases in supply in most areas. In response, the DWS initiated the reconciliation strategies for all the major schemes in order to guide the necessary water resources planning (i.e. DWAF, 2007), although it is ultimately the responsibility of the WSAs using the major schemes to ensure supply. In a reconciliation strategy, available water supplies are compared to current and projected future water requirements. Where there are shortfalls between future water requirements and currently available supplies, water resource interventions are proposed (along with necessary actions, i.e. presented as a strategy), to reconcile supply and demand, such as demand reduction and increasing availability.

The DWS then initiated the 'All Towns Reconciliation Strategy study' which included the development of water reconciliation strategies for towns, villages and clusters of villages (i.e. all population that is or should be served by a WSA) in 2008, concluding the first phase in 2011. The project was intended to provide DWS with oversight of and guidance for the LMs in their planning of water resources interventions. The DWS has therefore completed reconciliation strategies at a local, regional and national level. These strategies vary in complexity, depending on the geographic focus and complexity of the water supply scheme being assessed.

The gaps between DWS and WSAs

Whilst it is the responsibility of the WSA to provide water resources, the DWS has (as outlined above) acted in a guiding and advisory capacity in the generation of reconciliation strategies, for regional schemes and local water resources. However in some cases, WSAs continue to look to DWS for water resources planning support, focussing their sights on services provision only. The following challenges are listed in the NWRS2 with respect to managing regional water infrastructure and supporting local government in the delivery of water services:

- "Weak performance in the management of water supply and sanitation services by many municipalities, which compromises services;
- Unclear responsibilities for water resources development at the local and regional level, and for regional bulk services outside of the existing water board service areas; and
- Governance and performance-related problems within some of the existing water boards" (DWA, 2013a, pg. 59).

In response to these challenges, Regional Water Utilities have been proposed and will be created from the 12 existing water boards (further described below), to manage regional water resources and regional bulk water and wastewater infrastructure in terms of a mandate from the DWS.(DWA, 2013a; DWA, 2014). However, to date, little progress has been made with regards to the establishment of a Regional Water Utility in the Berg WMA.

Box 1: Responsibilities of Water Services Authority and Water Services Provider (quoted from Riemann et al., 2011, pg. 9)

Duties of Water Services Authorities

Water Services Authorities have the following primary responsibilities:

Realisation of the right to access to basic water services: ensuring progressive realisation of the right to basic water services, subject to available resources (that is, extension of services), the provision of effective and efficient ongoing services (through performance management, by-laws) and sustainability (through financial planning, tariffs, service level choices, environmental monitoring).

Planning: preparing water services development plans (integrated financial, institutional, social, technical and environmental planning) to progressively ensure efficient, affordable, economical and sustainable access to water.

Selection of water services providers: selection, procurement and contracting water services providers (including itself).

Regulation: of water service provision and water services providers (by-laws, contract regulation, monitoring, performance management).

Communication: consumer education and communication (health and hygiene promotion, water conservation and demand management, information sharing, communication and consumer charters).

Duties of Water Services Providers

The main duty of water services providers is to provide water services in accordance with the Constitution, the Water Services Act and the by-laws of the water services authority, and in terms of any specific conditions set by the water services authority in a contract. A water services provider must publish a consumer charter which:

- is consistent with by-laws and other regulations;
- is approved by the water services authority; and
- includes the duties and responsibilities of both the WSP and the consumer, including conditions of supply of water services and payment conditions.

Financial support for water resources development at WSAs

In order to coordinate water resources investment requirements from WSAs, the DWS proposed the initiation of a National Water Sector Infrastructure Investment Framework; part of the National Water Investment Framework (DWS, 2013a). The National Water Investment Framework was intended to document the costs and financing options of the entire water sector from source to tap to waste and back to the source, and include the investment requirements of DWS, CMAs, water boards, WSAs and WSPs (DWA, 2013a). Infrastructure requirements proven in the All Towns Reconciliation Strategies, and the recommendations in the reconciliation strategies for the larger schemes, were to be included in the Infrastructure Investment Framework (DWA, 2013a). A presentation to Parliament in 2015 provided an update on progress made by DWS on the investment framework and included costs for the national water resource development and municipal water services development (DWS, 2015c). This update revealed that funding had been increased by R13 billion/year but that there was still a significant funding shortfall for water and sanitation infrastructure of R35 billion/year. The National Water Investment Framework was intended to inform a Water Investment Strategy, followed by a Water Investment Plan (DWS, 2015c). The current (2017) status of the investment framework is not known.

The DWS has recently (mid-2017) launched the National Water and Sanitation Master Plan (NWSMP), whose aims are similar to the National Water Investment Framework, and presumably are replacing it. The NWSMP cites un-coordinated planning and delays in infrastructure development and inadequate financing of water resources as water sector challenges to which the NWSMP plans to respond (among others). The NWSMP intends to guide, integrate, and facilitate:

- Infrastructure development, refurbishment, operation & maintenance, fighting Non-Revenue Water;
- Institutional arrangements & roles/ responsibilities; and
- Informs prioritisation or criteria of infrastructure development (amongst others). (DWS 2017b)

The NWSMP is planned for completion by mid-2018. In the immediate absence of the Water Master Plan, the process by which water resource infrastructure requirements are prioritised by the Minister is not clear. However, once the infrastructure need has been established, the Minister of Water and Sanitation determines whether the project is classified as social and economic stimulus infrastructure or commercial infrastructure, or both. Social infrastructure supplies the basic water requirements of municipal water users in rural areas and economic stimulus infrastructure promotes economic development where there are no current users or where the users can't afford the supply (DWS, 2015b). Both are hereafter referred to as social infrastructure. Commercial infrastructure is seen as commercially viable infrastructure. The distinction of the project or infrastructure as social or commercial is at the discretion of the Minister. Typically, social infrastructure is funded on-budget from the fiscus with charges being set to recover operational and nominal asset costs, while the latter is funded using commercial off-budget finance with charges being set to recover the full financial cost of operation and debt repayment (Pegasys, 2012). There are cases where infrastructure is determined to be a mix of the two, with the infrastructure being funded on-budget but where commercial users are charged full costs or where the social component within commercial projects is funded by the State (DWS, 2015b). Feedback from the 2016 workshop (Appendix 1) highlighted that access to funding has proved complicated for projects which comprise both social and commercial classification. For example, the WCDM application for funding to DWS for a desalination plant was deemed to be partially social and therefore grant funding for part of the infrastructure investment was approved, with the remainder of the funding (R200 million of R450 million) to be raised by the municipality (*personal communication*, Minnaar, 2016). The municipality had not planned for such a large capital investment (hence no capital investment tariffs were collected) and did not have the funding to cover the commercial component of the plant and there was resistance from local industry who saw this as too expensive. Finding funding for new infrastructure is frequently a challenge in municipalities when considering that maintaining and rehabilitating existing infrastructure is already under-funded. **Access to funding is further complicated due to the capacity required to raise off-budget finance often being greater than that which is available at the LM.**

The entities responsible for the development of the infrastructure are split according to whether the project is considered on or off-budget. The Water Trading Entity (WTE) functions within the administration of DWS and is responsible for the development of new on-budget infrastructure, amongst other water resources and infrastructure management responsibilities (DWA, 2013b). However, it has been acknowledged that the WTE is not the most appropriate or efficient institutional arrangement for managing DWS's water infrastructure and an alternative model has been proposed, with a dedicated organisation focused on national water resources infrastructure (DWA, 2013a). It is not clear if the institutional framework for this proposed new agency has progressed or has been postponed (*personal communication,* Bosman, 2016).

The Trans-Caledon Tunnel Authority (TCTA) is a public entity responsible for the development off-budget bulk raw water infrastructure development, specializing in project finance, implementation and liability management (DWA, 2013b). TCTA is mandated to raise funds from commercial domestic and international funders. TCTA generally develops infrastructure that is commercially viable and the full cost of the investment is recouped through the revenue from water sales over a twenty-year period. The Berg Water Project (the Berg River Dam) was funded off-budget by TCTA and financing raised from ABSA Bank, Development Bank of South Africa and the European Investment Bank (Pegasys, 2012).

Additionally, the new raw water pricing strategy (DWS, 2015b) proposes a change to the manner in which revenue for on-budget infrastructure is generated – from a Return-On-Assets (ROA) approach to a Future Infrastructure Build Charge (FIBC). The FIBC will be a determined on a national basis (DWS, 2015b) as opposed to the scheme-specific ROA. The FIBC will support the development of social infrastructure and "provide for the costs of investigation, planning, design, construction and pre-financing of new infrastructure and the betterment of already existing infrastructure" (DWS, 2015b:19). FIBC will be paid by municipal, industrial/mining and high assurance use categories only. Agriculture's infrastructure tariffs, are still capped.

The Capital Unit Charge (CUC) is used to generate revenue for commercial infrastructure and will continue to operate according to the existing 2007 pricing strategy. The CUC is scheme-specific and calculated on water used, not necessarily on water provided into the scheme. The CUC will provide for the debt service requirements on the project, once the financial viability of the project has been established with the water users. All water users supplied from the scheme, with the exception of the social component, will be liable for the CUC (DWS, 2015a). The CUC ceases once the debt has been repaid, and thereafter will attract FIBCs. The pricing strategy therefore provides for the raising of revenue for the development of water resources through appropriate raw water tariffs, however an existing challenge with the on-budget and off-budget schemes is that there is a funding gap between the DWS funded on-budget developments and the larger, TCTA financed off-budget development projects. The difficulty experienced by a WSA in raising financing for the non-grant component of a water project (typically partially funded by RBIG) is a "funding gap", i.e. there is funding available for local water resource development or infrastructure, but it will likely need to be raised from commercial sources or development finance institutions. If the WSA can't raise this due to their lack of credit-worthiness or ability to raise tariffs, then the project will not happen. This is the case in SBLM. To this end, Regional Water Utilities (RWUs) have been proposed and will be created from the 12 existing water boards with the mandate to fill this 'gap' (DWA, 2013a; DWA, 2014).

The mandate of RWUs will be expanded to include the development and management of regional water resources, regional bulk water services and regional wastewater infrastructure. They will be responsible for the financing, development, management, operation and maintenance of regional bulk water infrastructure in an efficient and effective manner to meet the social and economic development needs of current and future users to achieve the objectives of integrated water resources management. The RWUs will also play a strong secondary role of supporting municipalities by providing water services on their behalf to users or by providing services directly to municipalities on a contractual basis, provided this does not detract from their ability to fulfil their primary functions. In contracting with WSAs to provide affordable and sustainable water services in accordance with S78 of the Municipal Systems Act (RSA, 1997), RWUs will be able to complement local government capacity through the benefits of economies of scale by integrating risk management and by leveraging finance for commercial water supply projects (DWA, 2014).

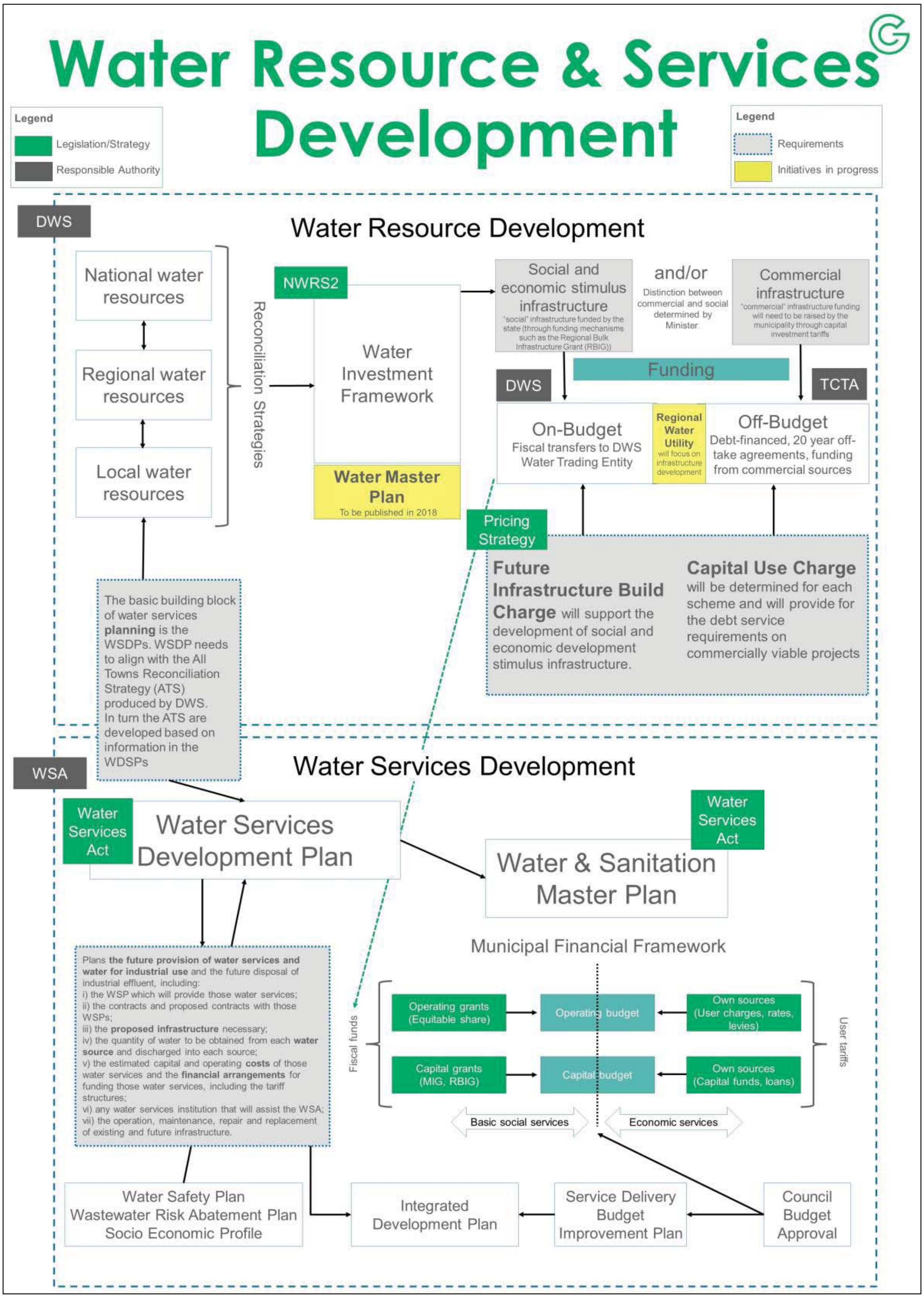


Figure 13: A flowchart of the water resources and services development process based on assessment of legislation and discussion with stakeholders

4.3.3.2. Water Services Development

Water services are developed by WSAs, typically municipalities. Their legislative mandate is the Water Services Act (RSA, 1997). The WSAs are responsible for preparing a Water Services Development Plan (WSDP) and ensuring its implementation. The Service Delivery Budget Implementation Plan (SDBIP) ensures that funding from the IDP is channelled towards the implementation of the WSDP (illustrated in Figure 13). The WSDP must provide information on the "future provision of water services and water for industrial use" including details on "the proposed infrastructure necessary", "the water sources to be used and the quantity of water to be obtained from and discharged into each source" and "the estimated capital and operating costs of those water services and the financial arrangements for funding those water services, including the tariff structures" (Water Services Act, RSA, 1997). The WSDP must therefore have a good degree of alignment with the regional or bulk water resources development planning process, where relevant, and catchment management strategies. As per the NWRS2 (DWS, 2013a), it is the responsibility of local government, to align their functions to water resource management functions and institutions. This includes monitoring all relevant plans to inform their planning, and the alignment of this planning with the availability of water resources, water supplies and bulk or regional infrastructure plans. A sub-section of the WSDP; the Water and Sanitation Master Plan plays a key role in determining the feasibility of water services infrastructure.

Alignment between DWS and the WSA becomes critical when financing of the water services infrastructure is to be approved as part of a Council Budget adoption. The WSDP is a sector report included in the IDP and approval of the WSDP plans are reliant on their inclusion in the IDP. Grant funding from the state, as noted above, is only relevant for infrastructure that fulfils a social objective. **These grants may be sourced from the Treasury's equitable share (for operating grants) or Municipal Infrastructure Grant (MIG) for capital funding (amongst other capital grant mechanisms). However, if the infrastructure is not classified as social and does not qualify for grant funding, the municipality will need to generate revenue for the infrastructure through user tariffs. These could be through user charges, rates levies, capital funds or loans. The development of local sources of water (groundwater, reclaimed water or desalinated water) may need to be partially financed by the municipality where a component of the infrastructure is deemed to be commercial.**

4.4. Key forums for integrated water resources and economic development

4.4.1. Overview

One key outcome from the local prioritisation tool (chapter 7), is that it brought government officials from a variety of departments within the SBLM together to discuss and consider which key variables need to be considered (at any given time) within the MCDA tool. The tool was developed with the target of implementation within a single municipality, and the tool promotes cooperative governance and integrated planning.

A 'regional tool' has been created with the aim of providing the information required to make integrated water resources and development planning decisions (chapter 6). The 'tool' is a series of data and maps which allows planners to forecast different scenarios and make decisions through a comparative analysis of the outcomes. The development of the tool was guided by project findings and stakeholder engagement as the project progressed. The emphasis in the investigation of forums, was to determine where, how and by whom, this tool could be used to inform greater integrated planning. **A key finding from the analysis of legislation, and the enquiry of perceptions, is that the DWS (or any DWS-led platforms) is not the appropriate body to lead the kind of integrated planning being recommended by this project** (section 4.5). Continued insights suggested that provincial government have a key role to play in supporting local municipalities and are the most appropriate house for strategic oversight of water resources and development planning (section 4.5). A focus was therefore placed on forums that have diverse, well-represented stakeholders, meet regularly, include water resource and development planning (at least each in part) and which are preferably chaired by the provincial government. Whereas findings in section 4.3 are largely relevant nationally, with local examples, the assessment of the forums operating for integrated water resources and development planning is based on local (Berg WMA) information, with local relevance.

Table 5 contains details of forums identified as most relevant for integrated water resources and economic development planning (and therefore the potential implementation of tools/approaches developed in this project) in the Berg WMA.

In addition to those listed in Table 5, the steering committee for the current DWS project for the Classification of Water Resource and establishment of Resource Quality Objectives (RQOs) for the Berg River was established in November 2016. The steering committee consists of a number of role-players from various provincial and local government organisations (including, but not limited to, representatives from DWS, DRDLR, DEADP, DOA, CCT and numerous district and local municipalities), conservation authorities (Cape Nature) and non-governmental organisations. It is anticipated that the project will be completed towards the end of 2018 at which point the established (and gazetted) RQOs and Management Classes will be incorporated into the CMS for the Berg-Olifants CMA.

Given the overall aim and intention of the Water Resource Classification System (WRCS) process (Dollar et al., 2010, Box 2), the current DWS project in the Berg, and the steering committee for the project, has the potential to provide a vehicle and platform for integrated water resources planning and economic development. The WRCS process intends to determine the intended development trajectory and corresponding condition of water resources, based on the economic, social and environmental cost/ benefit of the various development and conservation scenarios. The process requires that trade-offs between development (increased use of water resources) and condition of water resources (ecological functioning) be quantified. The binding nature of the RQOs therefore has potential implications for development in the area in terms of both (a) access to water resources and (b) environmental impacts on the water resources.

However, the process is likely to lack the granularity in detail to fully translate to tangible (go / no go) impacts on particular developments. The process is also driven from DWS and set according to the gazetted process for establishing the Management Class and RQOs, with relatively little potential for participatory engagement. The RQOs will likely only impact on the targets particular developments will need to meet in their effluent discharges, for example. Nevertheless, increased involvement from DEADP (the spatial planning department and environmental authorisation) is required, in order fully understand potential development implications and provide feedback on where development is already planned.

The analysis has led to a recommendation of the provincial government's Sustainable Water Management Plan (SWMP) as the "best fit" existing forum to implement the regional tool, and adopt the integrated planning promoted here. Hence, additional detail is given on the SWMP in section 4.4.2.

Table 5: Characteristics of key water and planning forums in the Berg

Forum	Convening Institution	Stakeholders	Principle Focus Areas and Mandate	Frequency	Other Comments
Berg River Partnership (BRP)	DWS	DWS, DEADP, BRMIB, CWDM, DLG, Drakenstein Municipality, Stellenbosch Municipality, WCDM, Witzenberg Municipality, Cape Nature, Stellenbosch University, UCT, UWC, GreenCape, Casidra, WWF, Living Lands, Fruit Look, Private Land-owners	Predominantly focused on water quality and ecological restoration. The forum also presumably serves as a stakeholder coordinating forum.	Quarterly	Last met in October 2015; forum has been reviewed in latter half of 2017
Berg River Improvement Plan	DEADP	DEADP, DWS, DEDAT, Cape Nature, DoA, DLG	Focused on establishing a water stewardship programme for the Berg River with emphasis on ecological restoration, water quality and agriculture	Quarterly Meetings	Similar forum currently being created for the Breede River. “BRIP 2”
Western Cape Sustainable Water Management Plan (SWMP)	DEADP	DEADP, DWS, DEDAT, GreenCape, Municipalities, DOA, Irrigation Boards, Isidima	Broad mandate which includes most issues relating to water – conservation, management, education, info sharing, etc.	Quarterly Meetings	Consultants appointed by DEADP to review mandate and goals
WC/WSS Steering Committee	DWS	DWS (head and regional offices), DoA, CoCT, WSPs and WUAs. District and Local Municipalities, BGCMA	Coordination of the implementation of the water resources interventions within the reconciliation strategy for WCWSS	Bi-annual Meetings	Last met in March 2016 and no longer meeting; contract for the support for the continuation of the strategy has lapsed.
Premiers Coordinating Forum	Western Cape Premier’s Office	Premier, MECs, Director-General, Heads of Department, Mayors and municipal Managers	Promoting cooperative governance between provincial government and municipalities to ensure integrated, effective and efficient service delivery	Quarterly	High level but also deals with a range of topics, typically those which are most pressing and topical
Provincial Liaison Committee	DWS	Provincial heads of department from DEADP and regional heads from DWS	Focus on cooperative governance, one environmental policy and conflict resolution	Quarterly	Seems to have gone stagnant and has not met recently
Municipal Planning Heads Forum	DEADP	DEADP, DOA, DRDLR, SALGA	Principal focus is on legislative and land-use planning issues relating to the LUPA.	Quarterly	Water not currently a key discussion point in this forum

Box 2: Water Resource Classification System and Resource Quality Objectives for the Berg River

The NWA sets out to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled, in a manner that promotes equitability, efficiency and sustainability for present and future generations. To this end, the Act prescribes a series of measures which are intended to ensure comprehensive protection of water resources so that they can be used sustainably. These measures are to be developed progressively within the context of the NWRS2 and catchment management strategies (DWS, 2017a). In particular, Chapter 3 of the NWA provides for:

1. The development of a Water Resources Classification System (the WRCS)
2. The setting of a Management Class and Resource Quality Objectives (RQOs)
3. Determination of the Reserve

Water resources are categorized according to specific classes that represent a management vision of a particular catchment. This is done analysing the current state of the water resource and defining the ecological, social and economic aspects that are dependent on the resource. The implementation of the WRCS therefore requires an assessment of the costs and benefits associated with utilization versus protection of a water resource. The WRCS defines three water resource classes, reflecting a gradual shift from resources that will be minimally used, to resources that are heavily used. Water resources must be classified into one of the following classes:

Class I water resource: is one which is minimally used and the overall ecological condition of that water resource is minimally altered from its pre-development condition.
Class II water resource: is one which is moderately used and the overall ecological condition of that water resource is moderately altered from its pre-development condition.
Class III water resource: is one which is heavily used and the overall ecological condition of that water resource is significantly altered from its pre-development condition

The classification of water resources represents the first stage in the protection process and will result in the determination of the quantity and quality of water required for ecosystem functioning (the Reserve) as well as maintaining economic activity that relies on a particular water resource.

The RQOs capture the established Management Class of the classification system and the ecological needs of the Reserve, representing this as measurable management goals that give direction to resource managers as to how the resource needs to be managed (DWS, 2017a). RQOs describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota. These RQOs are essentially narrative and qualitative and are aligned with the vision for the resource. Because RQOs are descriptive, and generally easy to understand, they are also meaningful to stakeholders, as well as the responsible managers, and give direction for whatever action is necessary to achieve the vision for the resource. These RQOs are gazetted and are thus supported by law.

4.4.2. Western Cape Sustainable Water Management Plan

The Sustainable Water Management Plan (SWMP) for the Western Cape Province was developed following the recommendations made at the DWS-coordinated Water Indaba held in Cape Town during November 2009. Its development was undertaken collaboratively by the Western Cape Government and the then National Department of Water Affairs: Bellville Regional Office. The SWMP recommended short (1-5 years), medium (6-15 years) and long-term (+16 years) actions and projects towards achieving integrated and sustainable management of water in the Western Cape (DEADP, 2012).

One of the actions in the original plan, was the establishment of a steering committee to oversee the continued implementation of these actions and projects, beyond the initial development of the plan.

The overall aim of the SWMP is to guide sustainable water management in the Province towards meeting the growth and development needs of the region, without compromising ecological integrity. Four strategic goals form the cornerstone of the SWMP, and therefore also guide the mandate of the steering committee (Table 6). Goals 1 and 2 are of key interest in the context of this project, as they relate directly to the key challenges that this project is seeking to address.

Table 6: Strategic Goals of the SWMP

Goal	Description
Goal 1	Ensure effective co-operative governance and institutional planning for sustainable water management
Goal 2	Ensure the sustainability of water resources for growth and development
Goal 3	Ensure the integrity and sustainability of socio-ecological systems
Goal 4	Ensure effective and appropriate information management reporting and awareness-raising of sustainable water management

At the start of 2017, the SWMP commenced with a strategic review process. This is a requirement of the SWMP – specifically that the relevance of its mandate and strategic goals are reviewed every five years. The review, sub-contracted from DEADP to a consultant service provider, has provided a unique opportunity to re-evaluate priority areas requiring renewed focus and an opportunity for some of the key finding from this study to be incorporated into the review process. Many of the findings in this project have been echoed during the review of the SWMP mandate. **Amongst the key insights in the SWMP review has been the recognition for the importance yet inadequacies of the IDP in local water resources development planning, a recognition of the potential role of provincial government in providing support to LMs, and recognition of an urgent need to promote deeper integrated planning moving forwards.**

During the SWMP review, a workshop was held in which stakeholders were asked to "vote" for key goals and objectives requiring priority action moving forwards (i.e. to be incorporated into the SWMP mandate). The overwhelming majority of stakeholders voted for objectives listed under goal 1 – Cooperative governance and planning (Figure 14). Within this, the objective which received the most votes was Objective 1.3 – Integrate sustainable water management with planning and ecological sustainability.

Given the mandate of the SWMP (and particular the first two of its four strategic goals), its wide range of stakeholders, its regular quarterly meetings and the initial outcomes from the review process it is currently undergoing, it appears to be the most appropriate forum to address the misalignment of planning approaches, for potential implementation of the regional tool developed here, and more broadly, the forum to lead integrated water resources and development planning in the Berg.

This recommendation was discussed with stakeholders at the third project workshop in June 2017 (Appendix 2). Members from the DEADP and stakeholders of the SWMP gave general support for the presented conclusion: that the WCG's SWMP forum is a good vehicle to take on the integrated water and economic development coordination that is being recommended by the project (further details in Appendix 2). It was noted that the SWMP has been lacking a focus on the planning and development aspects of coordinated water resources planning. As this is within WCG's mandate, the involvement of the correct people and information from spatial, economic, and development planning, with those involved in water, must be realised. However, it was noted that the SWMP needs to improve working relations with other key role players such as the Local Municipalities (LMs) and Department of Water and Sanitation (DWS), to ensure that the recommendations for integrated water and economic development are translated into authorisation decisions Indeed, the tools were seen as having the potential to play an important role in facilitating greater integrated planning for the region.

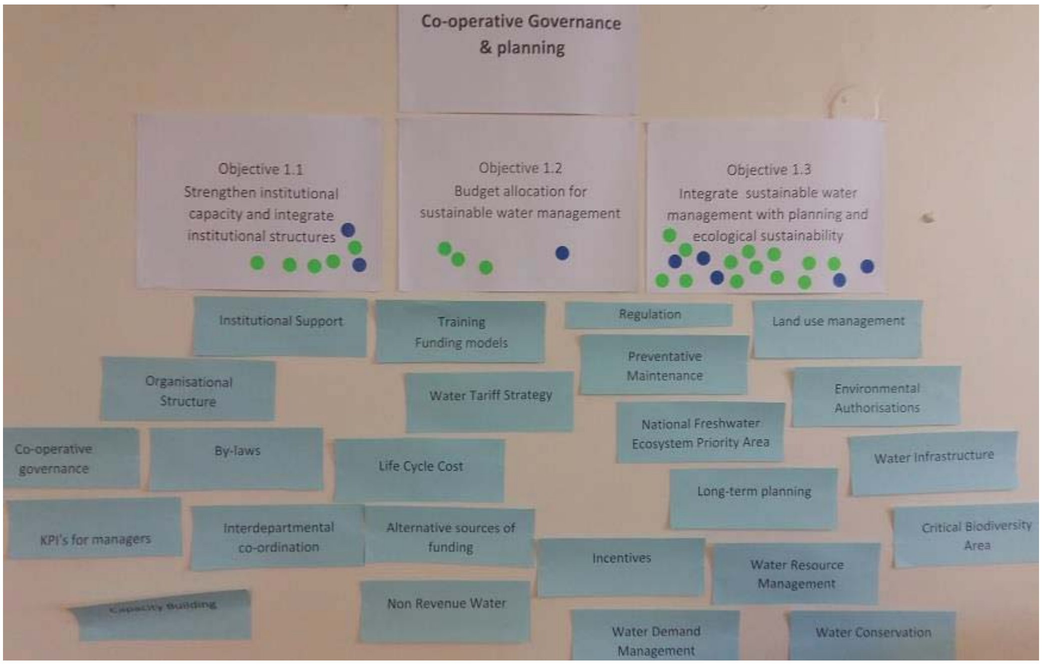


Figure 14: Image of prioritised objectives (under "cooperative governance and planning") as voted for by stakeholders during the SWMP mandate review workshop (May 2017)

4.5. Insights

Currently, the economic impact of water resource decisions, and the water resource implications of economic decisions, are not fully considered. Water is taken into account in economic planning (and vice versa), but generally as independent variables rather than accommodating the co-dependence of water and economics (chapter 1, chapter 3, and section 4.2). Optimally integrating water resources and economic development planning would see

i) available resources allocated for optimal benefit, including consideration of economic development and job creation;
ii) the economic benefit and water intensity of different water uses informing development decisions;
iii) the ability of future development to fund water resources interventions taken into account in the viability of interventions; and
iv) overall water resources challenges are taken into account in regional development decisions.

Documenting the processes of water allocation, development planning and water services and resources development, and discussing these with stakeholders (workshop 2), provided key insights into water and development integration points, gaps and opportunities.

What is needed to realise integrated planning is largely provided for in legislation. In principle, economic development is detailed as part of the preparation for an IDP, and can then be shared with those preparing the WSDP such that future developments are catered for. The WSDP is required to include necessary planning for future water resources. The WSDP is then reflected in IDP and required interventions are budgeted. The provincial government oversees the development of IDPs, and is responsible for ensuring cross-boundary integration. The CMS outlines water resource availability in the region and should also be taken into account in the WSDP and hence IDP process (and vice versa, the necessary development should inform resource planning in the CMS). Furthermore, there is widespread recognition that water is a key (and limiting) resource for economic development and, given this status, it poses an inherent risk to the economic development agenda. It is also widely recognised that there are touch points, particularly through local IDPs and regional SDFs, where the potential exists for greater integrated planning that identifies imminent development plans and objectives and aligns these with sustainable water resource planning.

However, there are significant shortcomings in the processes resulting in them falling short of potential. Not all private developments are known during the development of an IDP, which can lead to a situation where the LM is incapable of providing water resources to development. More fundamentally, in most cases the WSDP is failing in its consideration of water resources and only considers service requirements, thereby assuming an increase in the resource supplying that service is feasible. The Berg-Olifants CMA is not established, hence there is no CMS to support the IDP and WSDP process. Contributions to the IDPs, including provincial oversight, are also often rushed and serve to tick a legislative requirement, but lack meaning from both government and the private sector.

When this project commenced, the working assumption was that the point of impact, to ensure more strategic use of water in terms of economic development, was via the water allocation process itself. However, the analysis of the variables that are prioritised when it comes to water allocation (the use of the word 'prioritised' in this context proved to be a misnomer), and the insights from workshop 2, show that, notwithstanding some predefined legal obligations, water allocation functions as a licensing or authorisation process. If a water use licence application meets the necessary application requirements, and there is water available to allocate, the application is passed. The DWS has no scope (in their mandate) to, for example, wait for other potentially more economically beneficial uses of the same (limited) water resource and allocate water to this later application. Further, there is no scope for DWS to influence the kind of applications that will be submitted (unless the NWA was amended). The DWS (or any DWS-led platform) is therefore not the appropriate body to lead the kind of integrated planning being recommended by this project.

On a local scale (and where water resources are local), it is the responsibility of a LM to ensure economic planning in the IDP is in line with water resources planning contained in the WSDP (given the role of a WSA). The reality however is that LMs are generally not capacitated to plan accordingly. The WSAs are generally under-performing in terms of water resources planning, and over-relying on DWS to provide this role, which it provides only for regional schemes. Where adequate plans are made by WSAs, implementation slows due to hurdles such as financing. In the Berg WMA, as with many other areas, water resources are shared between many LMs, DMs and a metropolitan municipality. Because of the regional nature of the scheme, DWS therefore does coordinate planning for water resources interventions to reconcile future demand on the WCWSS. However, clearly this coordination is also insufficient at the level required, given competing applications have been submitted from various WSAs using the WCWSS, which DWS has been recommended to urgently address (DWS, 2015a).

The various assessments demonstrate that provincial government is the most appropriate body to provide this strategic oversight and integration role. Provincial government has the potential to identify and recognise threats to development plans as a consequence of (water) resource constraints, and provide support to LMs – both in terms of appealing for funding from national government for local water resource development and by providing capacity and support in driving these processes (and in the necessary water resources assessment). Related to this, the analysis led to a recommendation that the provincial government's Sustainable Water Management Plan (SWMP) is the "best fit" existing forum to promote the strategic planning promoted here. This oversight role should not only focus on LMs requiring capacity support. The water resources needs and development within CoCT must also be considered by the provincial government, in terms of implications for the province. Economies of scale are not currently being adequately considered between WSAs within the Berg to prioritise the most appropriate water resources infrastructure, prior to the related WULAs being submitted to DWS for their consideration. For example, perhaps a desalination plant in CoCT should be built larger to relieve more of CoCTs demand on the Berg, enabling higher use from the WCWSS in WCDM.

The analysis of legislation, supported by stakeholder engagement, highlights there is no clear mandate for the necessary support to local government to fulfil water resources development. The 'best fit' may sit with the department of local government, and Provincial Treasury. It has been suggested that this provincial oversight and support to LMs will be easier when SPLUMA and LUPA are fully implemented. Fundamentally however, tension remains between DWS and WCG over mandate in water resources, and is routinely evident in meetings or workshops with the two present. Although there have been attempts to resolve this at a high level, tension remains.

4.6. Way forward

These insights and recommendations are summarised as the way forward below:

- The WSAs in the Berg WMA require support for water resources planning, and in the absence of a Regional Water Utility or water board (both of which should be explored as possible avenues to resolve this issue) this support is best provided by WCG. However, tension remains with DWS regarding WCG's involvement in water resources. A facilitated discussion over mandate and the potential for the formation of a separate entity (such as a water board) is recommended between WCG and DWS. It is recommended that the discussion be held at the highest level, and is facilitated by experienced external strategic planners.
- In order for WSAs to perform better in terms of water resources planning, water resources planning must be strengthened in the WSDP process, and as such, water resources planning strengthened in IDP. It is recommended that provincial government, (through the SWMP and other mechanisms), oversees the water resources planned at LM level in WSDPs, coordinating these between neighbouring LMs / DMs.
- A gap exists in the support to LMs in the preparation of project finance applications to DWS (and other funding mechanisms, including commercial financiers), and WCG should explore the options in terms of providing support to LMs for these applications and/or the establishment of a regional water fund to assist in the financing of water resource infrastructure.
- It is recommended that WCG use the outputs of the regional tool to guide them in their assistance to the LMs, in terms of appropriate development trajectories to promote in their IDPs
- Coordinated planning for future water resources interventions for those WSAs supplied by the WCWSS must be strengthened. Competing applications are evidence that coordination is lacking. Economies of scale should be considered between WSAs within the Berg to prioritise the most appropriate (cost effective and resource efficient when considering the whole) water resources infrastructure, prior to the related WULAs being submitted to DWS for their consideration. Achieving this does not necessarily require an additional or separate study to be conducted (by DWS or WCG), it rather requires coordination, conversation, a platform, and information sharing.

5. Value of water to the regional and municipal economies

5.1. Introduction

The development of a regional hydro-economic model was proposed key intervention 3 of the project (see Chapter 1). Formal definitions for hydro-economic models are provided in Box 4 below.

Box 4: Formal definitions of hydro-economic models

> "Hydro-economic models represent spatially distributed water resource systems, infrastructure, management options and economic values **in an integrated manner**." (Harou et al., 2009)
>
> "Hydro-economic models are based on detailed representation of the river system linked to relevant economic production activities in the basin through appropriate demand functions. The demand functions depend on exogenous input-output parameters of the economic production process and reflect, at best, a partial economic equilibrium system of demand and supply equations." (Kimaite, 2011)

During the course of the project, it was established, and confirmed through consultation with various experts and stakeholders, that a hydro-economic model as formally defined could not be fully realised during this study, primarily due to data constraints.

Instead of a full hydro-economic model, it was proposed that a simpler regional hydro-economic geographic information systems (GIS) model be developed. This model would have two main components: (1) the value of water both in economic and social terms, and (2) water requirements linked to the various economic activities. This information would then be provided in a spatially explicit manner (GIS) for a particular region – in this case the Berg WMA. Despite not being as comprehensive or dynamic as the models implied in the formal definitions of hydro-economic models (Box 4), this approach would enable a consideration of the trade-offs of different water uses (and hence potential allocations), as both the economic and social value that the water generates and the amount that is required to generate this value can be considered in conjunction. A schematic representation of the model components is provided in Figure 15.

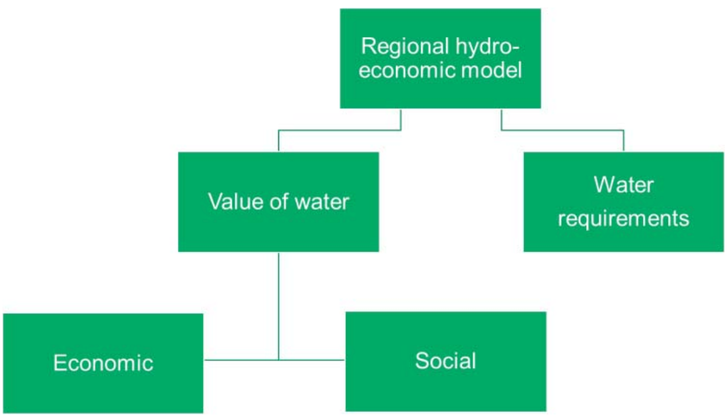


Figure 15: Regional hydro-economic model components

This chapter presents methodologies for the estimation of the economic and social value of water to the regional and municipal economies. The estimation of water requirements is considered in the next chapter (Chapter 6), which also integrates the value of water estimates from this chapter in order to provide a simplified regional hydro-economic model.

As highlighted in Chapter 4, access to water is a basic human right and water is reserved for the environmental functioning of a river ecosystem (i.e. the ecological reserve). Water is also a key input into the production of goods and services that generate economic value. The objective of water management is to ensure optimum, long-term, environmentally sustainable social and economic benefit for society (DWA, 2013a). Water allocation is complicated by the fact that water functions as a connected system. As the system is connected, upstream extractions have implications downstream. This highlights the need for a spatial, systemic view to ensure that there is sufficient water to meet the various needs in various areas and provides the motivation for the geographically explicit approach presented in Chapter 6.

This chapter considers different approaches to estimating the sectoral value of water, utilising the agriculture sector as a case study (section 5.2). Agriculture is a highly water-intense industry, and one for which the availability of water is directly linked to economic outcomes (either through irrigation and/or rainfall). It is also likely to be impacted by climate change and in highly-contested regions there may be conflict between agricultural and urban water users. Therefore agriculture provides an interesting case study to illustrate trade-offs between different water users and the subsequent impact on economic and social outcomes. The estimation of the value of water for the agricultural sector was thus the focus of one of the Master's studies funded through this project (Muller, 2017) and formed the foundation for the work on the sectoral value of water presented here.

5.2. Sectoral value of water: agricultural sector case study

Drawing on economic theory and practice, there would be two approaches to estimate the value of water for different sectors, namely marginal values and average values. These approaches, their application and their benefits/drawbacks for the purpose of a regional hydro-economic model are considered below. Depending on the approach used, different values could be obtained for the sectoral value of water. For the case of agriculture, previous studies have estimated the economic value of agricultural water to be R0-R27.95 per m^3 – substantially less than the economic value of water for non-agricultural sectors, i.e. R2.40-R340.57 per m^3 (Muller, 2017 p7-8).[10]

The differences between marginal and average values from a theoretical point of view are discussed in section 5.2.1, with the estimations of the marginal and average economic value of water for agriculture detailed thereafter. The benefits and disadvantages of these approaches for the purpose of estimating the value of water for the simplified regional hydro-economic model are also presented. An approach to estimating the social value of water on a sectoral basis is presented in section 5.2.2.

5.2.1. Marginal and average values

Water does not function in an open, free market, but rather its price and its allocation (or quantity by user) is set institutionally – in part to ensure that the basic human right of access to sufficient water is met. As the price of water does not reflect the value of water, it cannot be utilised to inform allocation decisions. Therefore, the value of water needs to be calculated in order to advise an allocation decision. As indicated, this can be done either through marginal or average values. The marginal value represents the value of one more additional unit, in this case another unit of water. The average value, in contrast, is simply the total value divided by the total number of units.

[10] However, it is important to consider that agriculture receives raw water and not potable water, so, in practice, the cost of supplying agricultural water is lower than the cost of providing water to households and industry.

What differentiates the marginal from the average value is that the value changes as the quantity used changes. The first unit of water allocated usually has a substantial impact, but this value diminishes as the quantity increases. Whereas, the first unit of water, when valued as an average value, would provide equal value to the final unit of water used.

Based on neo-classical economic theory, the theoretical ideal approach to inform allocation decisions would be where the marginal (additional) cost to the user of accessing a unit of water is equal to marginal (additional) value or benefit gained.[11] In an open, free water market, the price of water would reflect the marginal value and additional water would be purchased until the marginal value that is derived from the use of water is equal to the price.

Average values, in contrast, would simply consider the value generated per unit of water without a consideration of whether additional water would increase value. The average value just provides a general indication of how much value a sector has generated with its allocation. It may be that there is insufficient demand for a sector's product and increasing the water allocation to that sector will result in no increase in value. Using the average value to inform allocation is thus not ideal as it does not consider the impact an additional value will have, just what impact such an allocation has had in the past.

5.2.1.1. Marginal value of agricultural water

Muller (2017) estimated the marginal value of agricultural water using a complex econometric model (Tobit regression analysis[12]). As no field-level water usage data was available, the analysis was done using representative farms. These were generated utilising municipal level production and income data from the agricultural census. Census data from different years (1993, 2002 and 2007) was used to create a panel database that could indicate changes in agriculture over time, which is fundamental to estimating marginal value. This was combined with information on water use per crop and soil fertility per region (see Muller (2017) for details).

Muller found that the marginal value of water for agricultural products varied significantly by crop, from R0.14 per m^3 for wheat to R4.84 per m^3 for peaches (see Table 1 in Appendix 4) for full details). The marginal value of water also varied significantly by region and soil fertility. This is clearly illustrated for the case of table grapes for which the marginal value varied from R0.11 per m^3 to R6.66 per m^3 by region and R2.96 to R5.76 per m^3 according to soil fertility. However, the data constraints (i.e. absence of field-level data and age of date set[13]) meant that these marginal values at best reflect short-term marginal returns (marginal returns change as output changes). The limitations of this approach is compounded by the fact that many of the agricultural markets are international, or export facing, and thus their returns are often determined by what is happening elsewhere in the world. This makes an estimation that only considers a short-term (i.e. one season's impacts) of limited use when one wishes to consider the trade-offs between (allocation of water to) different crops in the longer term. While a theoretically sound approach, the reality is that decision makers often do not have access to marginal cost and benefit values and the lengthy process to get these numbers limit their usefulness to decision makers. The limitations of this approach in the estimation of the value of water based in marginal values

[11] Why the marginal cost being equal to marginal benefit is considered the ideal allocation level is best explained by considering when this is not the case. When the marginal benefit is greater than the marginal cost, then there is more benefit than cost and the economy could be better off from increasing the allocation. When the marginal benefit is less than the marginal cost, the economy would have been better off if this allocation had not been done and then ideally less water would be allocated. Note that this assumes there are no external costs or benefits from the product, i.e. no market imperfections.

[12] This model considers farmer behaviour in two steps. In the first step, the farmer choses whether to produce a certain crop on the farm. In the second step, the farmer chooses what share of the farm is used for the crops that have been chosen.

[13] The most recent data points for production and income from an agricultural census is for 2007, i.e. the data is 10 years old and much is expected to have changed in terms of production and income in the last 10 years.

was confirmed when participants at the third workshop stated that these estimates were not useful for long-term allocation decisions (Appendix 3)

5.2.1.2. Average value of agricultural water

The average value from different crops was considered to inform decisions about the possible benefit from (both existing and potentially new) water allocations. It was anticipated that these estimations could be more defensible than marginal values, since more recent data is available to decision-makers in South Africa, typically from industry associations. In addition, the average values are more stable over time and thus better suited to longer-term decision making.

In the case of the Berg WMA, there was the additional advantage of being able to generate spatial explicit information by utilising "fly-over data", i.e. agricultural census data gathered through aerial photography to identify crop production at a field level and made publicly available in GIS format (DoA, 2013). Considering water use spatially is important as water resources and water utilisation are highly spatially dependent (as confirmed, for example, by the variation in the marginal value of water in different regions in the previous section). As only one year's detailed field-level data for agriculture is available from the DoA GIS dataset, it is currently not possible to consider marginal value of water[14] using this information, but as additional years of data become available, this may be a useful avenue for extension of the work in future.

The average value of water was calculated as the value of the crops generated per hectare, regardless of destination market, i.e. as the field level data did not distinguish between intended market, the value of crops in different markets was ignored and the total value generated per crop was divided by the total hectares planted. However, the value in different markets can vary greatly. For example, apricots for export fetch R12,210 per tonne compared to R5,629 per tonne in local markets (Hortgro, 2012). Using the average value would thus mean that individual fields would be incorrectly valued. If specific regions have production that is more export (local) focussed, the approach would under (over) estimate the value that agriculture adds to the region. The assumption of the average value is also expected to be inaccurate for perennials, that only produce after a number of years, as the age of the crops is also not considered. This would mean that fields that are under establishment and not producing any crops are still given the average production value. This would again have a regional impact if a specific region has a significant share of newly established perennial crops by over-valuing the value that this region adds to the economy. However, over time, the perennials will produce and provide economic benefits and some export orientated producers may be forced to sell their produce locally in certain years. Over the longer term the value generated would align more with the average values that are generated, rather than the marginal values which are per definition more short term.

To estimate the average value that irrigated crops generated, a number of databases had to be consulted as no single database contained information on the value of all crops grown in the region. The primary data source was industry associations (data for 2011), followed by government reports, and then international reports and sector-specific reports. For a full list of data sources see Table 2 in Appendix 4.

The Western Cape flyover data provides field-level data that can be mapped and presented at different levels of resolution, from the individual field to the entire study area. Utilising this data in conjunction with the average value of crops, the value that agriculture contributes to different regions can be calculated. Figure 17 illustrates how the value of irrigated agriculture is distributed in the Berg WMA. The map highlights the fact that high-value irrigated crops have a concentration of value in Swartland, Stellenbosch and Drakenstein. This concentration of value is due to a large number of high-value fields, primarily stone fruit and wine grapes, occurring the region. This is reflected in the fact that 77% of the

[14] As estimates of marginal value require changes over time to estimate.

irrigated crops in the Berg WMA by area are grapes and 10% are stone fruit (DoA, 2013). It is important to note that the estimated value is based on average value per crop which is then mapped onto the fields. The results of the average value per crop by municipality is detailed in Appendix 4, Tables 3 and 4 and summarised in Figure 16 below. These values can then be linked to water use as demonstrated in Chapter 6 to form a broader hydro-economic model that provides the “value of water per drop”.

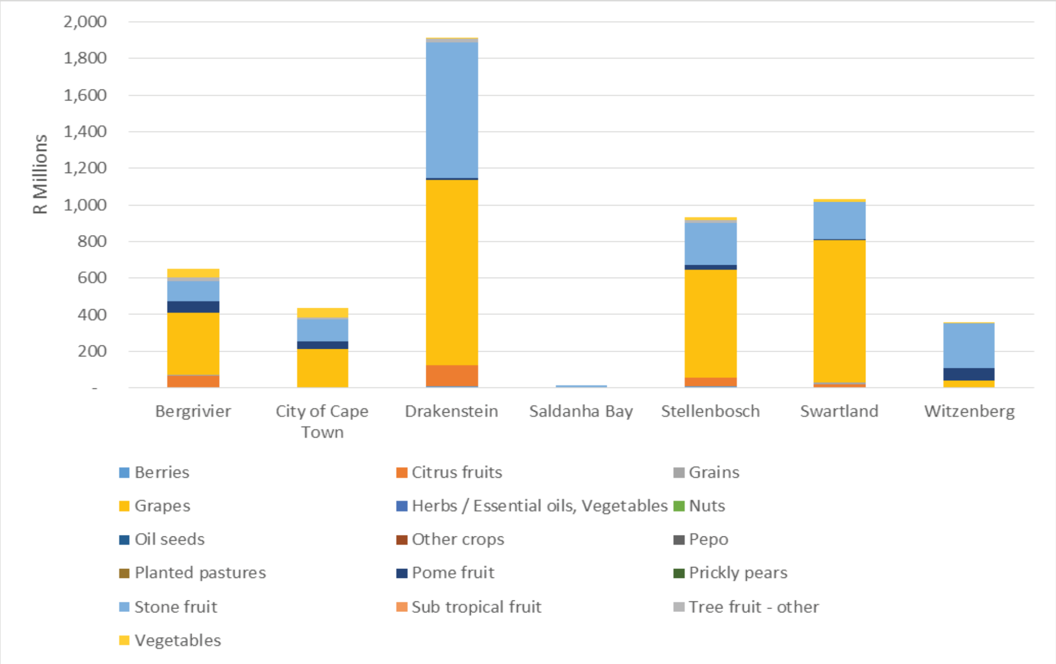


Figure 16: Average value of irrigated agriculture per year by municipality in the Berg WMA (R millions)

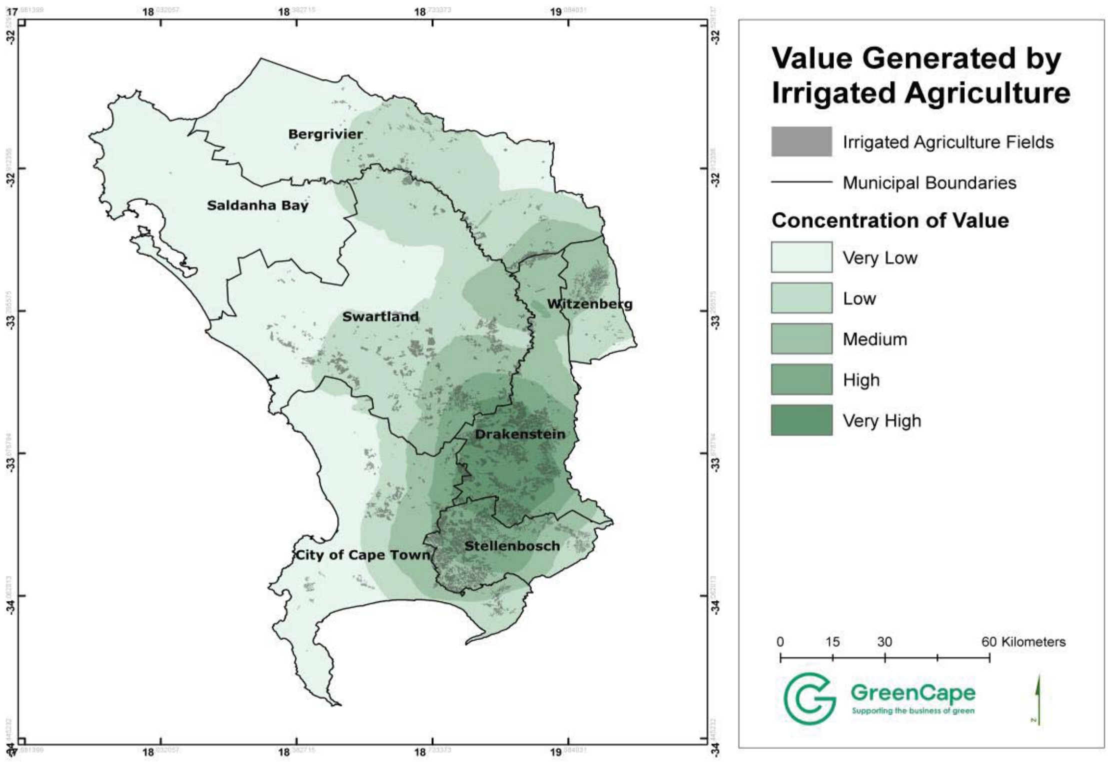


Figure 17: Value from irrigated agriculture in Berg Water Management Area

5.2.2. Social value of water: employment in agriculture

Water is key input into the production of goods and services that generate economic value. Labour is another key input to production. South Africa struggles with substantial unemployment – the expanded national unemployment rate was 36,4% in the first quarter of 2017 (StatsSA, 2017). Employment is thus a fundamental social issue in South Africa that can be indirectly linked to water use. Employment was thus proposed as an indicator of the social value of water use at a sectoral level. This section presents a number of alternative approaches to estimating job creation in the agricultural sector in different regions and for different commodities.

When considering economic value per drop, agriculture performs relatively poorly compared to other sectors. At a regional level, agriculture contributes only 2% of GVA in the Berg WMA, while utilising a substantial proportion of the available water in the region. However, this analysis does not take into account the value that agricultural water use generates in terms of social value. The agriculture sector's contribution to employment is especially relevant as it employs a significant share of low-skilled labour.

To illustrate the importance of employment by the agriculture sector, employment was estimated using employment multipliers reported by Bureau for Food and Agricultural Policy (BFAB) in conjunction with the "fly-over data" to develop bottom-up employment estimates (BFAP, 2011 & DoA, 2013, respectively). This "bottom-up estimate" is compared to the estimates for employment in agriculture developed by Quantec at the municipal level. This comparison is presented in Table 7 below[15].

The bottom-up estimates produce a significantly larger employment number than the regionalised official statistics. This higher estimate is likely due to the significant seasonal component to agricultural employment and the undercounting of informal employment (in official statistics). Informal and seasonal agricultural employment is significant in the agriculture sector and notoriously difficult to estimate. The only exception, in this case, is Saldanha Bay Municipality, which has a lower bottom-up estimate. The majority of the crops grown in Saldanha Bay have low employment multipliers.[16] The Saldanha Bay exception also gives weight to the seasonal labour argument, as the crops in the region are mostly field crops which have a lower seasonal labour component.

Table 7: Employment in agriculture for municipalities in study area in 2011

Municipality	Quantec estimates**	Bottom-up estimate*
Bergrivier	8 104	20 497
City of Cape Town	14 039	13 335
Drakenstein	11 335	35 106
Saldanha Bay	1 582	978
Stellenbosch	6 380	31 948
Swartland	7 767	27 626
Witzenberg	15 649	38 589
Total municipalities in Berg WMA	**64 856**	**168 079**

* Author's calculations using BFAP (2011) in conjunction with DoA (2013) considering dryland and irrigated agriculture in the entire municipal boundaries (not exclusively the Berg WMA).

** Regional standardised employment data from Quantec (2016b)

[15] When no crop specific data was available, the minimum value of similar crops was utilised in an attempt to keep the bottom-up estimates conservative. The assumptions made to make the BFAP multipliers comprehensive are laid out in Table 3 in Appendix 4.

[16] 99.7% of the crops by in the Saldanha Bay Municipality, by area, are field crops which have a multiplier of 0.01 jobs per hectare compared to the multiplier range of 0.75-3 jobs per hectare for fruit.

Agriculture clearly contributes significantly to employment in the rural municipalities, contributing up to 37% of employment in Bergrivier Municipality in 2011 (Quantec, 2016b). The importance of differentiating the impact for different regions (municipalities) is emphasised by the fact that overall agriculture only contributes only 4% of employment in the entire region (Quantec, 2016b).

At a sectoral/commodity level, the bottom-up estimates were compared to commodity level job estimates by DWS (2017a). This comparison is presented in Table 8. Note that the estimates by DWS are based only on irrigated agriculture within the Berg WMA, and the bottom up estimates displayed below are similarly calculated (hence the change in estimates from the Table 7 above)

Table 8: Employment estimates for irrigated crops in the Berg WMA

Crop	DWS estimate (2017a)	Bottom-up estimate
Grapes – wine	9,039	93,156
Grapes – table	3,736	
Pome Fruit	1,283	1,936
Stone Fruit	3,629	8,120
Citrus / sub tropical fruit	989	1,642
Tree Fruit Other	1,140	1,753
Berries	229	855
Grains	88	27
Planted Pasture	103	8
Vegetables	526	1,906
Nuts & oil seeds	1	5
Other	-	35
Grand Total	**20,762**	**109,444**

The jobs from the fruit sector are significantly larger than those calculated by DWS (2017a). To examine the validity of these estimates, they are compared to employment statistics recorded by the industry associations Hortgro (2012) and South African Wine Industry Information and Systems (SAWIS, 2015) in Table 9. These estimates still seem to indicate a slight over-estimation in spite of assumptions erring on the lower side (unknown crops and crops without their own estimates use a minimum of that crop type). This higher estimate may be due to the high amount of seasonal work that this sector utilises. For example, the South African Table Grape Industry (SATI) (2012) estimates employing 42,505 seasonal and 10,628 permanent employees, i.e. nearly four seasonal employees for each permanent employee. The seasonal nature of work could account for this difference.

Table 9: Comparison of fruit sector employment estimates

		Industry association estimates				Bottom-up estimates	
Category	Fruit	South African Employment	WC share	Western Cape employment		Western Cape employment	% of industry estimate
Pome fruit	Apples	27 493	79%	21 782	34 278	40 613	118%
	Pears	14 604	86%	12 496			
Stone Fruit	Peaches & nectarines	12 253	88%	10 841	20 804	28 405	137%
	Plums	6 717	95%	6 352			
	Apricots	3 819	95%	3 610			
Grapes	Dry grapes	39 125	44%	17 301	191 385	196 301	103%
	Table grapes*	10 628*	62%	6 591			
	Wine grapes**	-	-	167 494			
Other	Citrus	-	-	-	-	12 120	
	Subtropical fruit	-	-	-	-	319	
	Other tree fruit	-	-	-	-	3 223	

Industry estimates are Hortgro (2012) except for table grapes* which is based on SATI (2012) and only presents permanent employment (excludes 42 505 seasonal workers) and wine grapes** which is based on SAWIS (2015) estimate.

Given the consistently higher employment estimates, the BFAP multipliers were compared to the jobs estimated through "pseudo multipliers" based on the industry association data. The pseudo multipliers were calculated by dividing the employment the industry association recorded divided by the total hectares the associations recorded. The results, shown in Table 10, indicate that the BFAP multipliers do not seem to be significantly over-stating the employment levels, although they may contain a component of double counting as labour moves with the seasons. However, the assumption that wine grapes have a similar labour multiplier to table/dry (raisin) grapes may be problematic since wine grape production is able to undertake a greater amount of mechanisation than table grapes.

Table 10: Labour multiplier comparison (jobs/hectare)

Fruit	HORTGRO	BFAP
Apples	1.25	1.25
Grapes (dry & table)	1.59	1.62
Pears	1.26	1.26
Peaches & nectarines	1.47	1.2 / 1.25
Plums	1.43	1.46
Apricots	1.10	-

The labour estimates and multipliers presented here indicate that for agriculture the social value of water, through the provision of employment, is substantial and may be under-estimated in official estimates. That said, the amount of uncertainty around the estimates suggests the need to be conservative, so as not to overstate the social value/job creation from agriculture. However, the availability of water has been emphasised by agricultural producers as a constraint to increased production. Therefore, despite the limitations, the average economic value in Rand and labour multiplier calculations give an indication of what additional value could be unlocked and which crops would potentially generate more value than others.

Overall, however, both the marginal and average sector-based approaches to the estimation of the economic value of water and the average sector-based approach to the estimation of the social value of water presented here are limited, primarily due to a lack of data and hence uncertainty in estimates.

It is thus argued that these approaches cannot at this stage be applied with a high degree of confidence in the development of a hydro-economic model to support decision making for water allocation. An alternative approach to the assessment of the economic and social value of water at a regional and municipal level is thus proposed. The proposed approach is based on understanding the water intensity of regional and municipal economies, and the associated risk and hence resilience of these economies to changing water availability.

5.3. Water intensity of regional and municipal economies

5.3.1. Proposed approach to understanding value of water

The calculation of the value of water at a municipal and regional level is facilitated by the fact that municipalities are typically water service authorities (WSA) and that data on water usage, economic activity, social conditions, etc. are collected at a municipal level. However, while statistics collected at a municipal level may be done in sub-categories differentiating different economic sectors, water use categories are not consistently applied by municipalities. This makes water use comparisons between sectors in different municipalities difficult. This inconsistency is present in the case of the municipalities in the Berg WMA, but all the municipalities in the area do, at a minimum, distinguish between residential and other sectors.[17]

While water use can thus not necessarily be clearly linked to different industrial or commercial sectors, the value that local economies can attribute to companies that utilise significant amounts of water can be examined. Examining the economic value and jobs that relate to sectors that have a high water intensity or medium water intensity without considering the actual water that these industries utilise in detail gives an indication of local economies' reliance on water to provide economic growth and job opportunities. This analysis allows municipalities to consider how resilient their economies are to possible changes in water availability.

5.3.2. Application to Berg WMA

For the municipalities in the Berg WMA, sectors were categorised according to their water intensity using the classification of the United Nations World Water Assessment Programme (WWAP, 2016) categorising them as low, medium[18] or highly[19] water intense. GVA and employment data were then sourced from Quantec (2016). This is the same data that is used to inform the annual Municipal Economic Review and Outlook (MERO) reports produced by the Provincial Treasure of the Western Cape. MERO reports are intended to be a toolkit to facilitate decision making by municipalities, government departments, public entities, businesses as well as national and international organisations interested in investing in the Western Cape. To ensure that data was comparable, data for the entire municipalities that fall within the Berg MMA were utilised, even when a share of the municipality fell outside of the study area. This was considered more appropriate than limiting the consideration to only the Berg WMA portions only, as it is expected that municipal level decisions would usually be made considering the entire municipality.

The contribution of sectors to the local municipalities' GVA and employment was analysed for the entire Berg WMA in Figure 18 (refer to Tables 7-10 in Appendix 4 for details). This shows that the 10% of economic value (GVA) is contributed by heavily water intense sectors (including agriculture) with 19% of GVA generated by moderately water intense sectors and the remaining 71% attributable to low water

[17] The detailed water use is discussed in detail in section 6.3.

[18] "Sectors that are moderately water-dependent can be defined as those that do not require access to significant quantities of water resources to realize most of their activities, but for which water is nonetheless a necessary component in part(s) of their value chains." WWAP, 2016

[19] "Sectors that are heavily water-dependent can be defined as those requiring a significant quantity of water resources as a major and necessary input to their activities and/or production processes." WWAP, 2016

intense sectors. Considering the entire region, the risk of a decrease in water available for agriculture would seem to have a limited impact on the region's economy. However, this is due to the fact that the highly urbanised Cape Town Municipality dominates the region's economy, contributing 84% of the GVA of the municipalities that fall within the Berg Water Management Area.

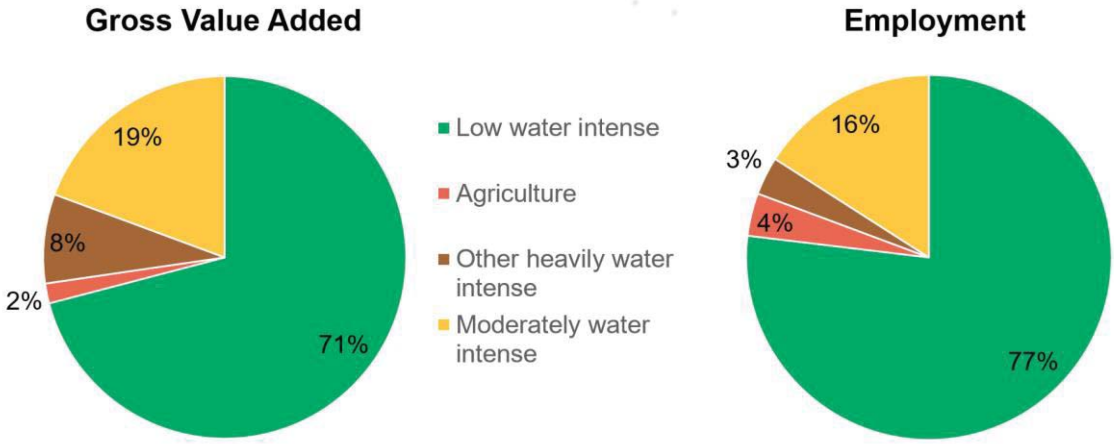


Figure 18: Gross value added and employment by water intensity of sectors in the municipalities in the Berg Water Management Area[20]

The water intensity of the local economies in the region varies significantly, as shown in Figure 18. The importance of agriculture for certain municipal economies becomes evident when the municipalities are considered separately. This is most evident for the Bergrivier Municipality, where agriculture provides 37% of employment. The significance of agriculture as a provider of employment in the region may be even higher if the bottom-up estimates utilising the relatively recent DoA (2013) fly-over data in conjunction with employment multipliers from BFAP (2011) are utilised (i.e. the estimates presented in Table 7).

The difference in water intensity of municipalities outside Cape Town differs significantly between municipalities. The variation in water intensity could be attributed in part to variation in agriculture, with GVA for agriculture ranging from 3% in Saldanha Bay to 22% in Bergrivier. The variation in heavily-water-intense sectors is also notable, varying from as little as 7% in Cape Town (or 9% outside Cape Town in Drakenstein and Stellenbosch) to as much as 21% in Swartland. The employment impacts are also important and largely track those of the GVA, with agriculture's labour-intensity evident from in its greater contribution to employment. Water availability is expected to change as a result of climate change (considered in section 6.5). The consideration of the value of industry linked to different water intensities thus helps to identify where a decrease in water availability would be of greatest risk to the local economy.

[20] Authors' calculations utilising Quantec (2016) data and WWAP (2016) definitions. Agriculture is also a heavily water intense sector. Refer to tables 7-10 in Appendix 4.

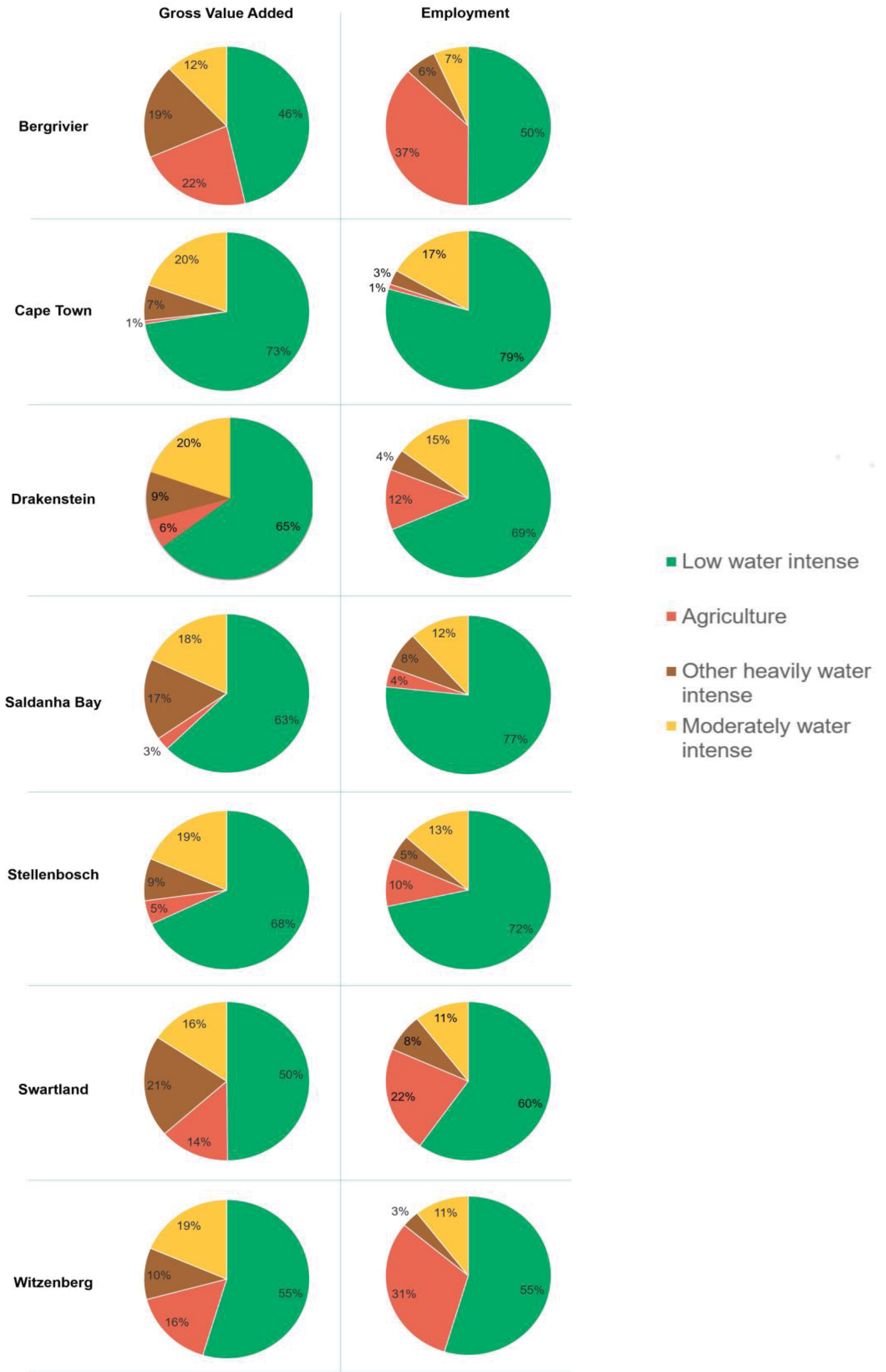


Figure 19: Gross value added and employment by water intensity of sectors in the municipalities in Berg WMA

5.3.3. Economic value of water at a municipal level

The economic value of water at the municipal scale was simply split into two categories: irrigated agriculture and everything else (otherwise referred to as urban). The calculation of irrigated agriculture has been discussed in the previous sections, and importantly, these values are directly linked to the fields in which the crops are grown. Therefore, it is possible to clearly determine how much value was generated within the WMA boundary. The non-agricultural (urban) value calculations utilised the data from Quantec (2016) on GVA and employment estimates for the entire municipality (excluding agriculture). For those municipalities that partially fall outside the WMA, the proportion of the municipality that fell within the WMA was assumed to be consistent with the proportion of the economy that had generated the economic outcomes from the water accessed within the WMA. For each municipality, these values were then divided by the amount of water that the municipal economy used (a detailed description of how these volumes were calculated is included in chapter 6).

Table 11: Average value of agriculture and urban water in municipalities

Municipality	Value or GVA (R millions)		Value R per m^3	
	Irrigated agriculture	**Urban**	**Irrigated agriculture**	**Urban**
Bergrivier	653	2,828	16.12	1,114
City of Cape Town	436	350,207	11.02	1,018
Drakenstein	1,909	17,177	13.03	912
Saldanha Bay	14	7,418	31.60	525
Stellenbosch	931	12,778	9.21	934
Swartland	1,030	5,840	8.76	1,004
Witzenberg	355	6,488	15.43	996
Berg WMA	**5,327**	**402,735**	**11.37**	**993**

The value of urban water seems to be highly consistent with the average value being R993 /m^3 except in the case of Saldanha Bay that has a substantially lower value of R525 /m^3. This is most likely due to Saldanha Bay supporting water-intense industry (steel manufacturing and fisheries) that significantly increases water usage while not increasing GVA to the same extent. Similarly, the average value of irrigated water is consistent across the region, with Saldanha as an outlier, likely due to the crops grown there: largely winter grains which require little water but still contribute economically.

It is clear that that 1 m^3 of agricultural water adds significantly less to the local economies than the value from non-agricultural water, but there are a number of caveats to this observation. Firstly, urban water is mostly potable water, while agricultural water is raw water and there are significant costs involved in taking raw water to a potable level. This analysis does not take into account the value that is generated by agricultural produce further down the value chain. Importantly, water is a binding constraint to more production in agriculture, while for other parts of the economy, this is not necessarily the case.

5.3.4. Social value of water at a municipal level

Access to water is enshrined as a basic human right in the South African Constitution and also emphasised in United Nations member states' Sustainable Development Goal (SDG) 6 'Water and sanitation for all'. This is relevant at the municipal level as municipalities are responsible for the provision of these services to households. It is proposed that, at a municipal level, indicators linked to achieving SDG 6 be used to assist in informing allocation decisions. This has been demonstrated in the case of the Berg WMA by Cole (2017). A number of indicators were selected. The indicators for access to water, access to sanitation and quality of water are shown in Table 12.

Table 12: Proposed indicators for SDG 6.1, 6.2 and 6.3 in Berg WMA

Municipality	1. Water access		2. Sanitation		3. Water quality	
	Piped water within 200 m of dwelling (%)	Piped water in dwelling (%)	Access to ventilated pit latrines or better (%)	Access to flush toilets (%)	Drinking water quality: Blue Drop Score (%)	Wastewater quality: Critical Risk Rating (CRR / CRR_{max}) (%)
Bergrivier	99	82	91	90	64	55
City of Cape Town	95	79	93	92	96	49
Drakenstein	99	81	95	94	72	56
Saldanha Bay	99	85	96	96	69	58
Stellenbosch	98	77	91	91	80	80
Swartland	99	79	92	91	74	64
Witzenberg	99	71	93	92	96	39
Berg WMA	**97**	**79**	**93**	**92**	**93**	**57**
South Africa (average)	83	46	70	57	80	72
Source: Cole 2017						

The analysis highlights that, although water access is not yet universal, the region is performing above the South African average on most counts. There were only two areas where performance was below the South African mean. These are linked to the two water quality measures, namely Blue Drop score and Critical Risk Rating. The Blue Drop system considers the performance of water service authorities and their providers via a standardised scorecard. In the Berg WMA, four municipalities performed below the South African average namely: Bergrivier, Saldanha Bay, Swartland and Drakenstein. For the Critical Risk Rating on wastewater treatment, Stellenbosch is the only municipality that has a higher risk that the South African average. So, in summary, the region performs well in terms of provision of basic services (water and sanitation), but the water quality in the region can be improved. The fact that provision is near universal suggests that the priority of water allocation for human consumption has largely been reached, but still requires some work. It does however allow some consideration of allocation criteria lower on the National Water Resources Strategy (NWRS2) (DWA, 2013a) priority list, such as job creation.

To assist in determining the social value of water, it is proposed that an estimate of "jobs per drop" (in real terms "jobs per m^3") be used. To demonstrate this in the case of the Berg WMA, the Quantec (2016) employment estimates for non-agriculture sectors were considered in conjunction with the water use estimates (as detailed in Chapter 6) to calculate the job per drop for non-agriculture sectors by municipality. The agricultural job estimates were generated utilising the BFAP job multipliers, as previously discussed, and then also by irrigated agricultural water use (detailed in Chapter 6). These estimates are shown in Table 13. It is clear that agricultural sector delivers substantially lower jobs per drop than the non-agricultural sectors. Again, there is a high degree of conformity between the average values, with the exception of Saldanha Bay, in which lower jobs are generated in agriculture and non-agriculture on average. This can be explained by the crops grown in Saldanha, largely winter grains, which are highly mechanised with low employment multipliers. The low job intensity for non-agricultural production in Saldanha is likely due to the water-intense manufacturing industries that do not generate proportionally the same number of jobs.

Table 13: Total employment and "job per drop" for agriculture and non-agriculture sectors in the municipalities of the Berg WMA

Municipality	Employment (number)		Jobs per drop (jobs per million m^3)	
	Agriculture	Non-agriculture	Agriculture	Non-agriculture
Bergrivier	6,115	13,825	151	5,446
City of Cape Town	11,340	1,393,581	286	4,050
Drakenstein	33,261	80,833	227	4,290
Saldanha Bay	25	38,007	56	2,692
Stellenbosch	29,265	58,430	290	4,269
Swartland	25,054	28,050	213	4,822
Witzenberg	4,383	34,368	191	5,278
Berg WMA	**109,444**	**1,647,094**	**234**	**4,201**

It is clear that the non-agriculture sector is the largest employer in all the regions and generally has an overall lower water consumption in municipalities outside of the City of Cape Town. The non-agriculture sector thus results in significantly more jobs per drop. However, the non-agriculture sector includes a wide range of sectors with varying water intensities and it does not necessarily hold that the job per drop would be higher for all non-agricultural sectors. Given the inconsistent reporting of urban water usage (in terms of sectoral consumption), a more detailed consideration of the jobs per drop for different sectors cannot be considered at this stage. However, this would be a valuable avenue for further research to determine the social value of water.

5.4. Conclusions

A hydro-economic model was proposed as a means to integrate the allocation of water with its economic and social outcomes. Although, the marginal value of water is far more preferable means of estimating this value as it more accurately links the benefit that can be accrued to changing water allocations, data constraints only allowed for an average value estimation. The analysis of the average value of water in the study area is in alignment with other similar studies, notably that water utilised for agricultural production produces less value than water used in urban sectors. This is reflected in both employment and GVA. However, this value is not equally distributed across the region, with the type of crops grown determining some of this difference. A structural analysis of the water intensity of an economy was also conducted in order to understand how resilient it is to water shocks and constraints. This also revealed that local economies in the region have highly varied water intensities. The combination of the value of water used and the intensity of this water use is important to consider. A reduction in water supply to a largely agricultural economy, will not have the regional economic impacts that the same proportional reduction would have for a largely tertiary economy, like the City of Cape Town, however, the local impacts would be felt severely. Chapter 6 discusses how water requirements for the region were calculated and then integrates these requirements with the values discussed in this section, with the understanding that prioritising water supply to different regions should not only be based on the total value that this water enables, but also on the relative impact of the water on the local economy.

6. Regional hydro-economic GIS model

6.1. Introduction

In order to better understand how water availability may impact on a local economy's growth prospects within the Berg WMA, a regional hydro-economic GIS model[21] was developed. The spatial visualisation of water allocation, overlaid with its economic value (as determined in Chapter 5) provides decision-makers with a clearer view of where water is most likely to be a constraint to growth, while the comparative value of the water assists in prioritising efforts to close the supply gap.

The volumetric estimation[22] of water requirements or consumption was broken into two categories: irrigated agriculture, and urban and industrial use. Dry-land agriculture was not considered in this study as the analysis focuses on water supply, i.e. water that can be captured, stored and supplied to end users. Who receives this water supply is institutionally determined and subject to the National Water Act (amongst other legislation), whereas the water that falls onto rainfall-fed agriculture is not under the control of the government. Climate change may have an economic impact on dry-land agriculture (and therefore the local economy), but this would not be accounted for in this study that focusses on understanding how water demands from different sectors of the economy may be best realised through different allocation scenarios or supply schemes.

Water consumed by irrigated agriculture is not currently measured, and the existing database of Water Authorisation and Registration Management System (WARMS) is acknowledged to be inaccurate (DWA, 2006) as it is based on a self-registered volume that may not always be precisely estimated. Furthermore, the practical application of WARMS in geospatial maps has found the location of many of the farms to be incorrect (i.e. the recorded GPS coordinates indicate some farms as being located in the ocean). Therefore WARMS was not considered an appropriate means of estimating irrigated agricultural demand, however, the total regional requirements were summed and provided a validation check for the bottom-up calculations.

DWS is currently conducting a Validation and Verification process in the Berg WMA (refer to Box 1 in Chapter 4) that will provide an estimate of existing irrigated water consumption. This process is not yet completed, and will likely be finalised towards the end of 2018. If this data is made publically available, it will be invaluable in quantifying the approximate consumption of agricultural users in the region. However, in the absence of this data, a methodology was developed to estimate irrigated agricultural requirements (section 6.2).

The calculation of urban water requirements was relatively straight-forward as town-level usage records are available, as described in section 6.3. Combined, this allows forecasts to be generated for water requirements in 2025 and 2040 utilising assumptions for climate change and urban growth due to population growth (see section 6.4). The final step in section 6.5 involves combining the value of water estimates generated in Chapter 5 with the future water requirements to understand how a lack of water may result in constraints to the economy.

6.2. Estimating irrigated agriculture water requirements

With the increasing availability of spatial and ancillary data, modelling water requirements both temporally as well as spatially is becoming more and more accessible (Aspinall & Pearson, 2000; Arnold & Fohrer, 2005; Serra et al., 2016). Water requirement simulations are useful for investigating the

[21] Substantial sections of this chapter are derived from the Masters study that was funded as part of this project (Van der Walt, 2017). The methodology employed and data sources used were developed as a collaborative project team effort.
[22] Water requirements/usage are expressed as cubic metres or m^3 per year unless otherwise indicated

relationship between irrigation management practices and irrigation demand, as well as to predict future demand with the use of data produced by climate modelling (Arnold & Fohrer, 2005; Leenhardt et al., 2004; Thomas, 2008).

Crop water requirements can be estimated using a variety of methods. These methods normally rely on a combination of datasets including data describing local climate conditions over a period of time, such as daily minimum and maximum temperatures, rainfall volume and intensity, relative humidity, hours of sunlight and average wind speed, and data pertaining to specific crops and cultivation methods, such as planting date, length of growth stages, irrigation method, leaf area index, rooting depth and planting density. Other data often used includes soil type, soil layer water holding capacity, soil layer depth, surface soil albedo, and susceptibility to saline build-up and nitrogen leaching (Jensen, 1973; Jensen et al., 1990).

This study models irrigation water requirements simply, using time-series monthly climate data in conjunction with crop factors. Soil water balance is done to the extent of estimating a moisture deficit resulting from plant evapotranspiration-reduced soil moisture, replenished only by effective rainfall and irrigation. No salinity control or other processes are included in the analysis. Focus was placed only on the water lost through evapotranspiration processes, taking into account rainwater that entered the soil and was thereby made available to the plant.

A polygon feature class dataset containing field boundaries surveyed by remote sensing (DoA, 2013) was used as a basis for the calculation of irrigation demand. The dataset also provided important attribute data pertaining to each field's irrigation regime and crop types. From this data dry-land fields could be identified and removed as their consumption of green water would not be considered in this study.

Monthly cumulative effective rainfall over the period between 1979 and 2013 was obtained in the form of a grid of 0.5 x 0.5 degrees. Downscaled precipitation data was available but was not used due to limitations in the ability of downscaling methodology to accurately portray daily rainfall variability (Wilby & Wigley, 1997). Monthly reference evapotranspiration, calculated by the Penman-Monteith method, was taken from the WRC's 2007 Agrohydrological Atlas. This data was used to extract monthly effective rainfall and to calculate monthly reference crop evapotranspiration rates per field.

In order to investigate the potential range of future irrigation water requirements, mean daily temperature and effective rainfall data from several General Circulation Models (GCMs) were investigated. Observed data from 1979 to 2014 was analysed and compared with data from eleven of the twenty climate models that formed part of the fifth phase of the Climate Model Intercomparison Project (CMIP5) (Li, 2014; Ji et al., 2014; Chylek et al., 2011; Voldoire et al., 2013; Bao et al., 2013; Watanabe et al., 2010; Watanabe et al., 2011; Yukimoto et al., 2012; Taylor et al., 2012) over the same period to identify models representing drier, wetter and more temperate trends over the study area.

The following models were evaluated: the Beijing Climate Center Climate System Model (BCC-CSM1-1), the Beijing Normal University Earth System Model (BNU-ESM), the second generation Canadian Earth System Model (CanESM2), the Centre National de Recherches Météorologiques' GCM (CNRM-CM5), the Flexible Global Ocean-Atmosphere-Land System model, Spectral Version 2 (FGOALS-s2), the National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory's Earth Systems Models with General and Modular Ocean Models (GFDL-ESM2G, GFDL-ESM2M), the Model for Interdisciplinary Research on Climate and associate Earth System Models (MIROC5, MIROC-ESM, MIROC-ESM-CHEM), as well as the Japanese Meteorological Research Institute's Coupled Global Climate Model (MRI-CGCM3)

6.2.1. Current irrigated water requirements

6.2.1.1. Methodology

In order to map irrigated agriculture in a manner consistent with the land use mapping approach taken for delineating urban water use zones, a polygon feature class dataset from the 2013 Flyover agriculture survey was obtained, defining the borders of all cultivated fields in the study area. The dataset was converted into a raster grid coincident with the national land use dataset used previously, with matching spatial extent and cell sizes, such that the cells within each dataset would be conterminous.

The resulting agriculture raster grid was then converted to a points feature class producing an array of points, each located at the centre of a grid cell. Attributes defining the field identification number, predominant crop type, irrigation method and total field size in hectares were then assigned to each point based on the properties of the field on which it was overlaid.

Monthly irrigation requirements were calculated at a field level using Penman-Monteith reference crop evapotranspiration values based on a 50-year climate dataset (Schulze et al., 2007), locally and internationally derived crop coefficients spanning sixteen different crop categories (see Table 16 below), and effective rainfall calculations.

The Penman-Monteith formula can be summarised as follows (Monteith, 1965):

$$ET_{om} = \frac{\Delta R_n + (e_a - e_d) \times \frac{\rho \times c_p}{r_a}}{\lambda\left(\Delta + \gamma \times \left(1 + \frac{r_s}{r_a}\right)\right)} \qquad (1)$$

where ET_{om} is the reference evapotranspiration value for a given month, R_n is net radiation (W/m^2), ρ is air density, c_p is the specific heat of air, r_s is net resistance to diffusion through the surfaces of leaves and soil (s/m), r_a is the net resistance to diffusion through the air from the surface to the height of the measuring instruments (s/m), γ is the hygrometric constant, $\Delta = de/dT$, e_a is saturated vapour pressure at air temperature, and e_d is the mean vapour pressure. This method is generally considered to be quite accurate, although r_s may become less accurate when a large region is considered, or if vegetation is diverse or distributed in an uneven manner (Kneale, 1991).

The Penman-Monteith method of estimating reference crop evaporation has become the *de facto* international standard. Once this data was extracted from the agro-hydrological atlas (Schulze et al., 2007) at a field level, crop-specific evapotranspiration levels were determined using an adapted formula from Allen et al. (1998):

$$ET_m = K_c \times ET_{om} \qquad (2)$$

where ET_m is the monthly evapotranspiration value calculated by multiplying the reference evapotranspiration value for a given month, ET_{om} (mm/day) by the crop coefficient for the corresponding crop and season, K_c (Table 16) (Mekonnen & Hoekstra, 2011). From this simplified equation the potential amount of water that could be taken up and released by a plant may be calculated for each month. Table 14 lists the crop coefficients used in this study.

Table 14: Seasonal time-averaged crop coefficients (Kc) for each irrigated crop type

Crop Types:	Reference Crop Coefficient (K_c)				Reference:
	Summer Dec-Feb:	Autumn Mar-May:	Winter Jun-Aug:	Spring Sept-Nov:	
Berries	0.8	0.33	0.2	1	SAPWAT4 (WRC, 2016)
Citrus fruits	0.80	1.28	0.79	0.62	Green and Moreshet (1979)
Grains	-	-	0.92	0.25	Allen et al. (1998)
Grapes	0.95	0.55	-	0.59	SAPWAT (WRC, 2016)
Herbs/Essential oils	0.75	-	-	1.15	Allen et al. (1998)
Nuts	1.10	0.65	0.50	1.10	Allen et al. (1998)
Oil seeds	0.35	-	-	1.15	Allen et al. (1998)
Other crops	0.35	-	-	1.15	Allen et al. (1998)
Pepo	0.75	-	-	1.05	Allen et al. (1998)
Planted pastures	1.25	1.05	0.90	1.06	Allen et al. (1998)
Pome fruit	0.77	0.72	0.19	0.46	Taylor & Gush (2014)
Prickly pears	0.47	0.47	0.47	0.47	Allen et al. (1998)
Stone fruit	0.85	0.28	-	0.72	SAPWAT (WRC, 2016)
Sub-tropical fruit	0.80	0.70	0.40	0.70	Allen et al. (1998)
Tree fruit – other	1	0.5	0.35	0.65	Allen et al. (1998)
Vegetables	0.75	-	-	1.15	Allen et al. (1998)

Crop coefficients were based on three-monthly seasons, and as they were derived from a number of sources, were adapted to seasons by time-averaging. One of the most important crops in the Berg WMA is grapes. The crop coefficients for grapes were captured from SAPWAT4 (WRC, 2016) with the following parameters:

- Plant date: 1 September
- Bud Break: Early Spring
- Climate: Dry/Cold

Table 15: SAPWAT4 Wine Grape growing season and corresponding crop coefficients

	Initial	Developing	Mid	Late	Total days
Days per period					
K_{cb} by growth period	0.15	0.95	0.95	0.15	

$K_c = K_e + K_{cb}$ where K_c is the crop coefficient applied, K_e is the soil evaporation coefficient and K_{cb} is basal crop coefficient. The K_e value was found to have little impact on the overall annual irrigation estimates, as the soil type only appeared to have effect in the start of the season (see Figure 20 below), so when crop coefficients from SAPWAT were utilised, K_{cb} was considered analogous to K_c.

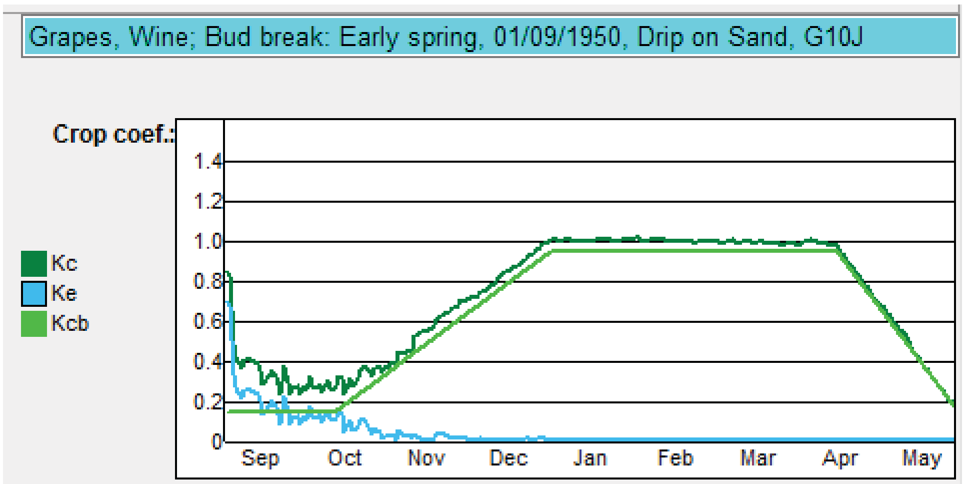


Figure 20: Screenshot from SAPWAT4 (WRC, 2016) of wine grape irrigation estimate

The days of each growing period were overlaid with the corresponding season, where the days did not exactly correspond to the season boundaries, the coefficients were proportionally calculated:

Table 16: SAPWAT4 Wine grape crop coefficients by season

Season	Spring			Summer			Autumn			Winter		
Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Monthly K_{cb}	0.15	0.68	0.95	0.95	0.95	0.95	0.95	0.55	0.15			
Seasonal K_{cb}	0.59			0.95			0.55			-		

Effective rainfall (*ER*) was calculated using the U.S. Bureau of Reclamation Method (Stamm, 1967) (Table 17) and treated as a displacing factor in irrigation demand.

Table 17: Effective rainfall estimates based on accumulated rainfall using the U.S. Department of Reclamation Method (Adapted from Adnan & Khan, 2009)

Precipitation Increment Range (mm)	Percentage of Rainfall Considered Effective	Effective Precipitation Accumulated Range (mm)
0.0-25.4	90-100	22.9-25.4
25.4-50.8	85-95	44.4-49.5
50.8-76.2	75-90	63.5-72.4
76.2-101.6	50-80	76.2-92.7
101.6-127.0	30-60	83.8-107.9
127.0-152.4	10-40	86.4-118.1
> 152.4	0-10	86.4-120.6

The difference between the monthly effective rainfall (ER_m) and the monthly evapotranspiration (ET_m) represents the moisture deficit to be covered by irrigation, which is then converted into monthly irrigation requirement:

$$I_m = 100(\frac{10\mathrm{A}((ET_m - ER_m)}{EF}),\ I_m > 0 \qquad (3)$$

where I_m is the monthly irrigation requirement, *A* is the field are in hectares, and *EF* the irrigation efficiency (Table 18). Negative values were treated as zero irrigation requirements as it was assumed that plants cannot utilise water beyond the point at which potential evapotranspiration is reached.

Table 18: Irrigation types found in the study area with relative efficiencies (DoA, 2013 & Ascough & Kiker, 2002)

Irrigation Type	Efficiency %	Number of fields	Hectares
Dragline irrigation	75	1	9
Drip irrigation	85	27,240	69,804
Flood irrigation	65	1	16
Floppy irrigation	85	1	2
Pivot irrigation	85	210	4,084
Sprinkler irrigation	75	339	994
Total		**27,792**	**74,910**

6.2.1.2. GIS Model

Once the monthly irrigation requirement for each field in the 2013 agriculture census flyover dataset had been calculated in Excel, the field polygons were converted to grid-based cells, coincident on the land use grid used for the spatial delineation of urban water use. A per-cell irrigation requirement was then calculated per field. Once the per-cell values were calculated for irrigated land uses, each point was assigned a water requirements value based on its land use type and location (see the PAST[23] attribute field in Table 19).

Table 19: Irrigation requirements database sample

FIELD_ID	18260	42201	112516
FARM_ID	576	38735	49597
MUNIC	Swartland	Stellenbosch	Drakenstein
DISTRICT	West Coast	Cape Winelands	Cape Winelands
CATNAME	Viti	Viti	Viti
AREAHA	3.52	1.14	0.65
CAPDATE	22-10-13	May / June / July 2013	May / June / July 2013
CROPS	Wine grapes	Wine grapes	Table grapes
CR_DETAIL	Wine grapes (3.52)	Wine grapes (1.14)	Table grapes (0.65)
CR_SUM	Grapes	Grapes	Grapes
DRY_IRR	Irrigated	Irrigated	Irrigated
IRR_TYPE	Drip irrigation	Drip irrigation	Drip irrigation
PAST	23684.0	6538.0	4261.0

The irrigation water requirements database outputs are linked to the Western Cape Flyover polygon shapefile through a process called "Join" within ESRI ArcGIS which joins a layer to another layer or table based on a common field. The records in the Join Table are matched to the records in the input Layer Name. A match is made when the input join field and output join field values are equal. The common field used for this matching was the Field ID, present in both databases.

[23] PAST simply refers to estimates of irrigation requirements on the basis of historical climatic conditions

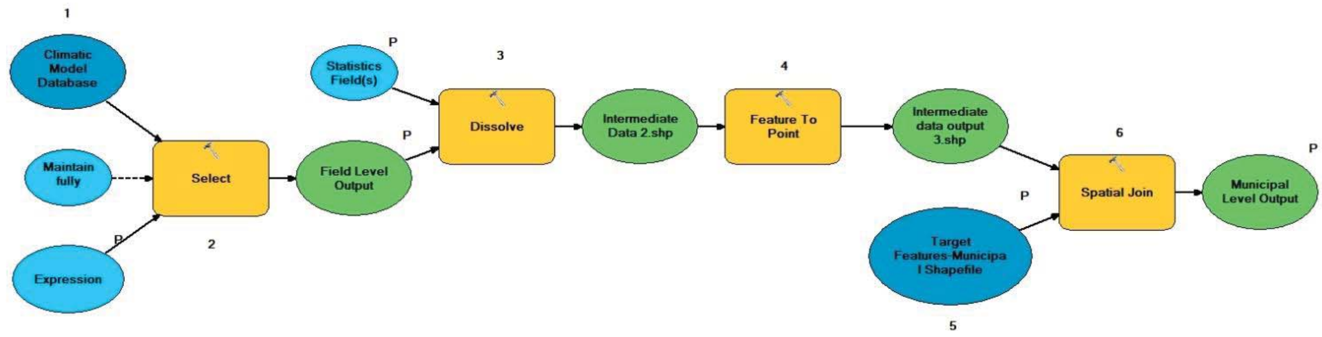


Figure 21: Overview of irrigated water requirements GIS model

After the Join has been completed one is left with an irrigation water requirements database (1) in the form of a shapefile. Particular municipalities or the entire WMA can be selected for visual analysis in Step 2, as seen above.

A shapefile is created at a field level and added to the display. Data is then dissolved[24] in order to conduct a spatial join to the municipal shapefile. As part of the dissolve process (3), the aggregated features can also include summaries of any of the attributes present in the input features (refer to Table 19 above). For instance, the total water requirements of a particular municipality selected in step 1 is summed to give the total irrigation water requirement for the selected municipality.

The polygon shapefile is then converted to a point feature class (4, 5) to assist in the spatial join operation in step 6 of the process. This is necessary as the polygons can overlap into more than one municipality at a time.

The final step in the process is a spatial join (6) to the surveyor general municipal shapefile (5). A spatial join involves matching rows from the Join Features to the Target Features based on their relative spatial locations. By default, all attributes of the join features are appended to attributes of the target features and copied over to the output feature class, which is the municipal layer.

The outputs of this process produces shapefiles that can be utilised in a GIS environment for visual analysis as well as further database queries.

[24] In GIS, dissolve is one of the data management tools used for generalizing features. It is a process in which a new map feature is created by merging adjacent polygons, lines, or regions that have a common value for a specified attribute.

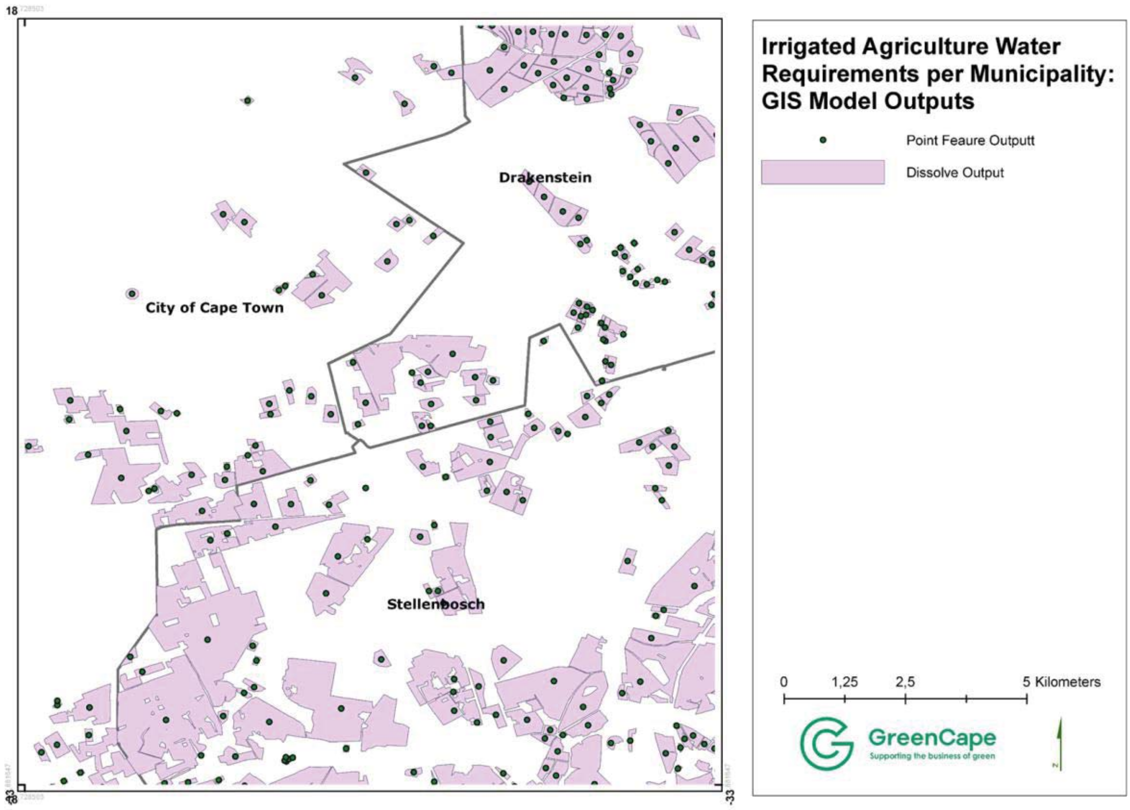


Figure 22: Screenshot of shapefile outputs for irrigated fields

6.2.1.3. Results

The results from the bottom-up estimations of irrigated water requirements are summarised in Appendix 5 and in Figure 23 below:

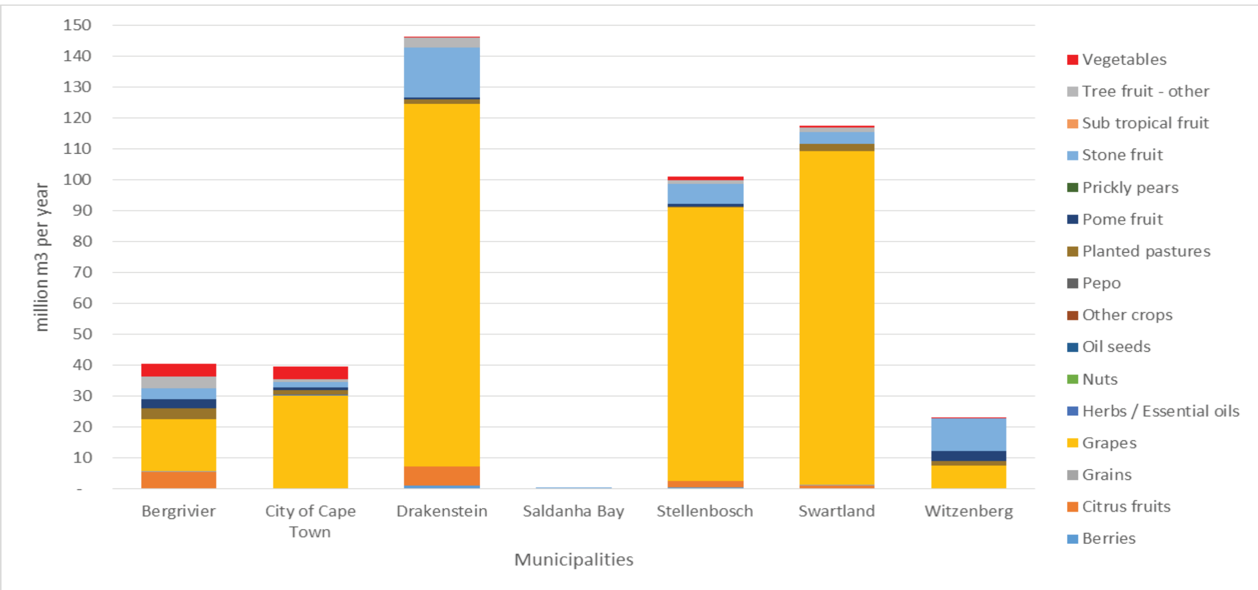


Figure 23: Irrigated agriculture water requirements per year in the Berg WMA

This graph (Figure 23) illustrates how grapes, largely wine grapes, consume most of the irrigated water in the region – estimated at approximately 79%. Drakenstein, Swartland and Stellenbosch are the largest irrigated agricultural water consumers and these are predominantly wine growing regions. The map below (Figure 24) also illustrates the variability of irrigated water requirements by municipality across the WMA

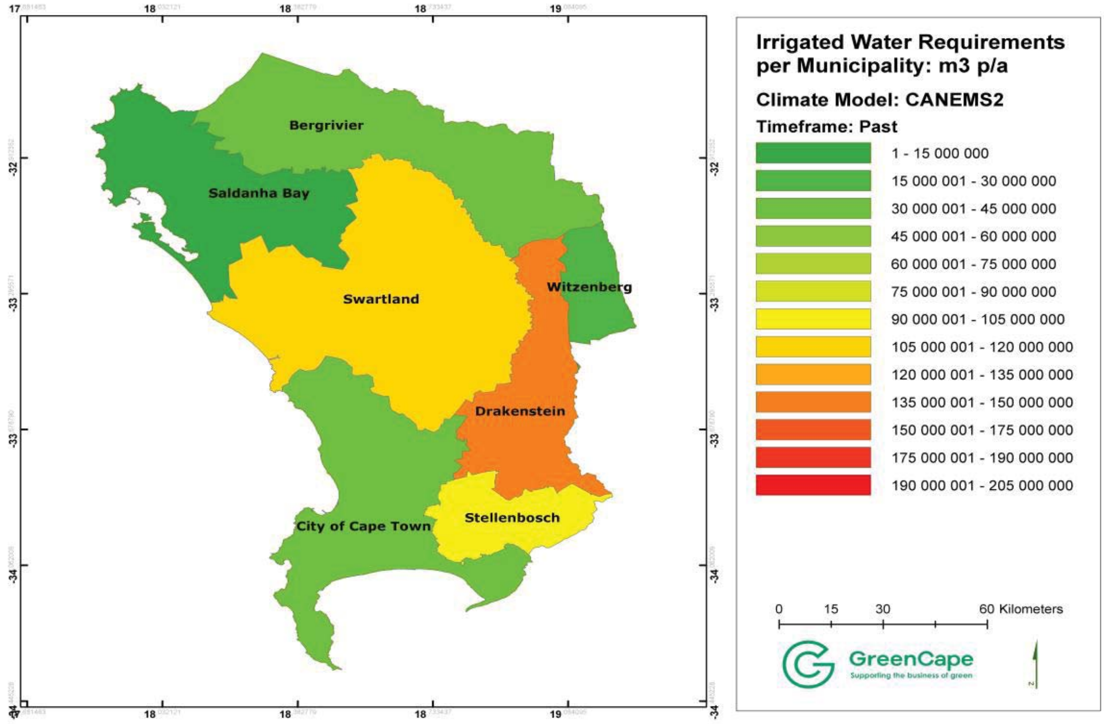


Figure 24: Irrigated water requirements per municipality per year

In terms of water intensity, grapes require an average amount of water per hectare in comparison to the other crops grown in the region, as seen below (Figure 25).

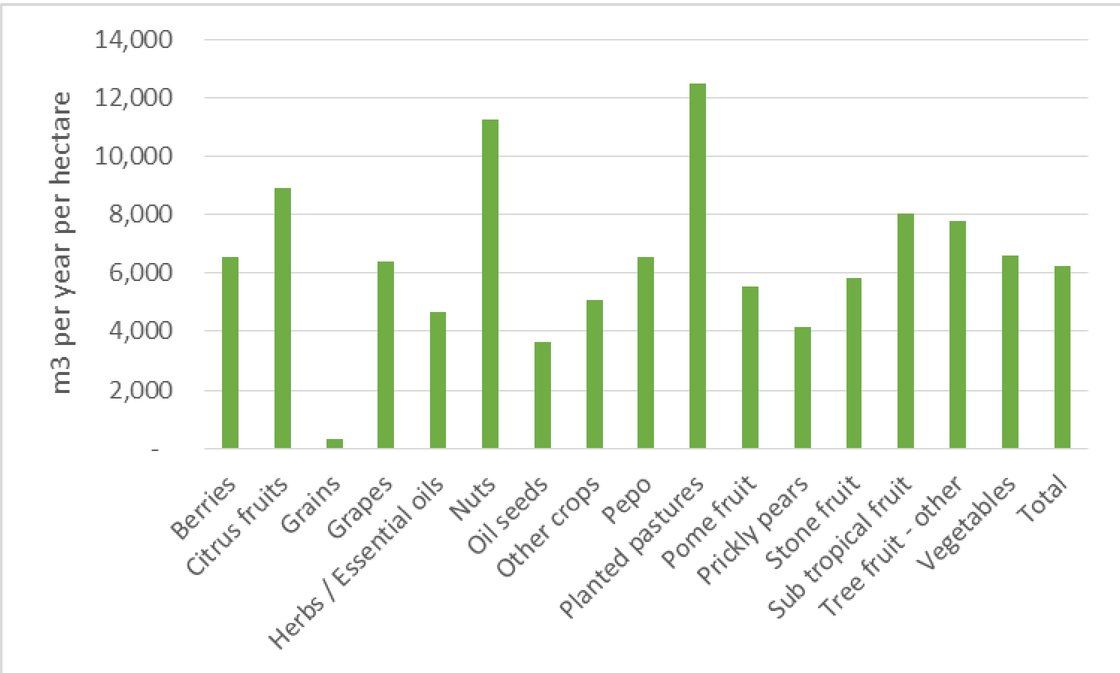


Figure 25: Average water requirement per hectare per year

However, the water intensity of grapes varies across the region, due to the local climatic conditions, as shown in the map below (Figure 26). With increased water scarcity, crop switching could occur, as farmers look to plant more water efficient crops in those regions where certain crops may produce marginal value in comparison to the water they consume. However, this assumption is largely dependent on farmers having the information readily available to understand the trade-offs between water intense crops and the revenue that these commodities could earn.

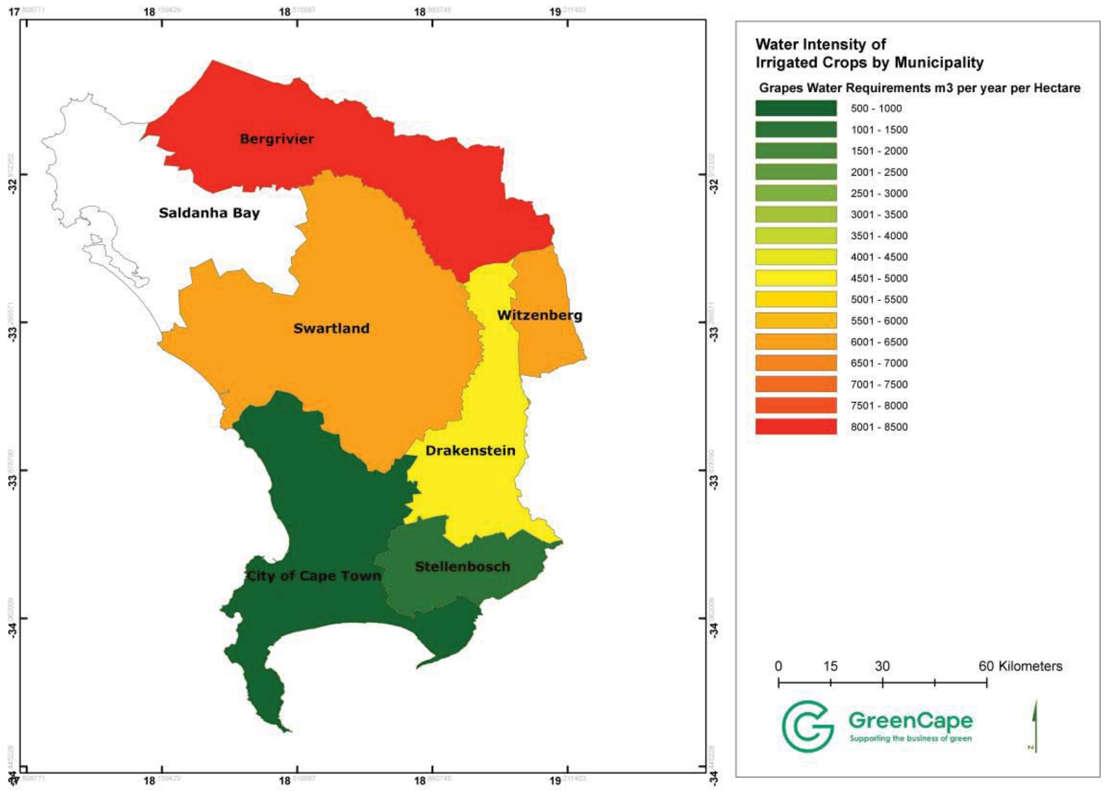


Figure 26: Grapes water intensity per hectare per municipality

6.2.1.4. Validation of bottom-up estimates

The validation of the irrigated agriculture water requirement estimates generated in this project was done on two levels with a number of different sources:

- At a macro scale where annual estimates for a region were compared with other models
- On a field by field basis where samples were taken and compared.

A margin of error in estimating the bottom-up calculations was expected. Crops were grouped into categories that don't take into account the variability of different cultivars on water consumption. Factors such as soil type were also not considered, but could have an impact at the start of a rainy season due to variability in the run-off. Furthermore, the expected irrigation requirements do not mirror actual farmer behaviour, for whom heuristics and previous experience may drive irrigation performance.

Crop coefficients are noted as the most significant contributing factor to inaccurate irrigation estimates (WRC, 2016). Therefore the crop coefficients utilised in this study should be carefully scrutinised and updated according to new information on region or cultivar-specific crop coefficients. DWS uses SAPWAT for generating estimates of irrigation requirements as part of their Validation and Verification process (DWAF, 2006) and SAPWAT was utilised to generate crop coefficients where it was discovered that the crop water requirements did not meet the validated results.

For a detailed description of the validation steps undertaken, refer to Appendix 6, with summary results displayed below:

Validation at a regional level:

- Water Authorisation Management System (WARMS) records for the Western Cape were spatially located and the agricultural registrations that fell within the Berg WMA were totalled
- Aurecon's Water Resource Simulation Model (WRSM) of the Upper Berg irrigation demands were compared to a clipped study area.

Table 20: Comparison of project estimations of irrigated water requirements at regional level to other available models

	Berg WMA Project Estimations	Berg WMA WARMS records	Upper Berg River Clipped Project Estimations	Aurecon WRSM estimations for the Upper Berg River
Total Irrigation Requirements m^3/a	468,556,760	438,932,728	201,135 325	239,000,000

For the Berg WMA, the project estimates are slightly higher than those recorded through WARMS. This is not unexpected due to the possibility of farmers under-registering their water usage, as well as the noted issues with the accuracy of the WARMS records. The Aurecon model estimates are slightly higher than the project estimates for the Upper Berg region. This may be due to factors utilised in the WRSM, such as evaporation from irrigation canals, that are not included in the project model. However, these comparisons indicate that the project estimates are largely in alignment with other regional models.

Field by field validation

- Sampled field irrigation estimates were calculated in SAPWAT4, matching the field location in the same quaternary catchments, with sensitivity analysis conducted for soil type
- Sampled project fields were matched to fields within Fruitlook, an online platform that captures satellite-based information on crop growth and water usage, to assist fruit and wine farmers with their irrigation scheduling

The field by field comparisons indicated which crop coefficients were providing inaccurate regional estimates, and were updated accordingly.

6.2.2. Future water requirements

6.2.2.1. Methodology

The estimation of future water requirements for irrigated agriculture were generated for the years 2025 and 2040. The basis of the existing water requirements for agriculture were based on crop type, irrigation type and climatic conditions. The crop and irrigation type were assumed to remain constant, but the climatic conditions updated for 2025 and 2040 on the basis of General Circulation Models (GCMs) sourced from UCT's Climate System and Analysis Group (CSAG). The climate models included mean monthly effective rainfall and temperature data from 01/01/1960 to 31/12/2099.

The following models were evaluated: the Beijing Climate Center Climate System Model (BCC-CSM1-1), the Beijing Normal University Earth System Model (BNU-ESM), the second generation Canadian Earth System Model (CanESM2), the Centre National de Recherches Météorologiques' GCM (CNRM-CM5), the Flexible Global Ocean-Atmosphere-Land System model, Spectral Version 2 (FGOALS-s2), the National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory's Earth Systems Models with General and Modular Ocean Models (GFDL-ESM2G, GFDL-ESM2M), the Model for Interdisciplinary Research on Climate and associate Earth System Models (MIROC5, MIROC-ESM, MIROC-ESM-CHEM), as well as the Japanese Meteorological Research Institute's Coupled Global Climate Model (MRI-CGCM3).

Without any degree of certainty as to which climate model best represented the future climatic conditions in the region, three models were selected from the possible 11. These models were selected on the basis of the sensitivity analysis outputs they provided:

- FGOALS: high temperature, low rainfall (i.e. worst case scenario)
- GFDL-ESM2G: low temperature, high rainfall (i.e. best case scenario)
- CANESM2: closest correlation for past temperature observations (i.e. closely correlated scenario to existing trends).

For each GCM, low and high emission scenarios were also considered. The 2025 and 2040 were averaged on a 10-year mean. Below are the temperature and effective rainfall comparisons between the climatic models used, including observed historical data (1979-2014).

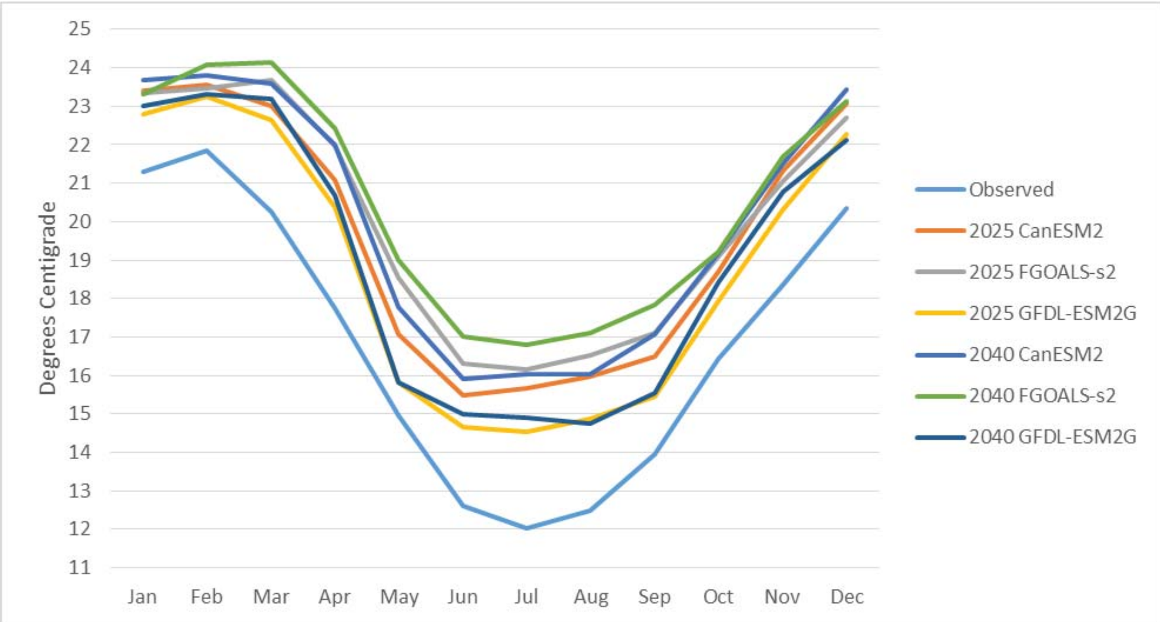


Figure 27: Mean monthly temperatures in the Berg WMA

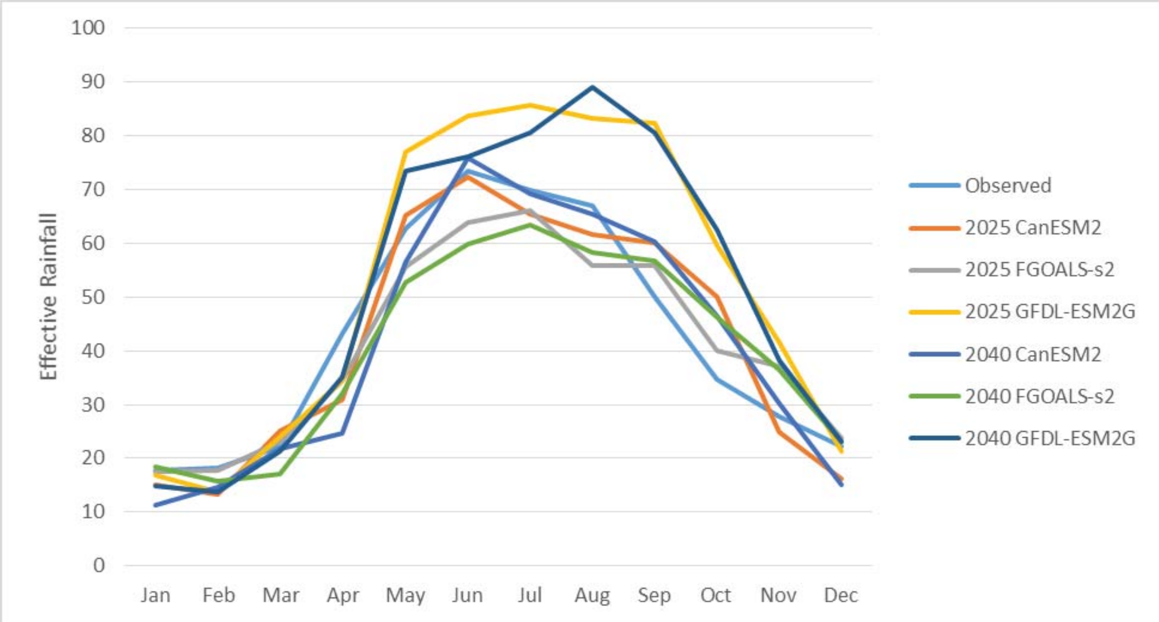


Figure 28: Mean monthly effective rainfall in the Berg WMA

As can be seen, all the climate models predict higher temperatures than the currently observed trends and this will increase the evapotranspiration rates of the crops. However, the rainfall predictions are much difficult to consistently analyse, but the trends do show a shift in rainfall patterns with later rain expected in autumn and spring according to current trends. Yet, it is not clear if the annual rainfall volumes will be similar to current volumes.

The GCMs had been down-scaled and were modelled on a quadrant basis at the scale of 45x55 km.

Figure 29: GCM climate quadrants for the Berg WMA

For each quadrant in the figure above, temperature and rainfall forecasts had been estimated and from that, the crop water requirements were calculated. Due to the number of measurements involved in calculating the Penman-Monteith reference crop potential evapotranspiration rate (*PE*), an analogous formula was used to estimate future crop water requirements, based on average temperatures and effective rainfall values. The Thornthwaite method (Thornthwaite, 1948) (*Equation* 4) was chosen due to its relative simplicity:

$$PE_m = 16N_m\left(\frac{10\bar{T}_m}{I}\right)^a \tag{4}$$

where *m* denotes the respective month, N_m is the adjustment factor representing hours of daylight, T_m is the monthly mean temperature, *I* is the heat index for the year:

$$I = \sum i_m = \sum\left(\frac{\overline{T_m}}{5}\right)^{1.5} \tag{5}$$

and: $a = 6.7 \times 10^{-7} \times I^3 - 7.7 \times 10^{-5} \times I^2 + 1.8 \times 10^{-2} \times I + 0.49$ (6)

A baseline comparison dataset was calculated to determine how the simpler Thornthwaite formula would compare with the Penman-Monteith method for calculating evapotranspiration. The baseline reference crop potential evapotranspiration rates were used to calculate a simple calibration factor in order to adjust PE values based on projected future climate conditions:

$$F_{cm} = \frac{E_{Tm}}{PE_m} \tag{7}$$

Figure 30 shows the distribution of the resulting calibration factors. New irrigation requirements were then calculated based on the adjusted PE values, using the crop factors and methodology described above.

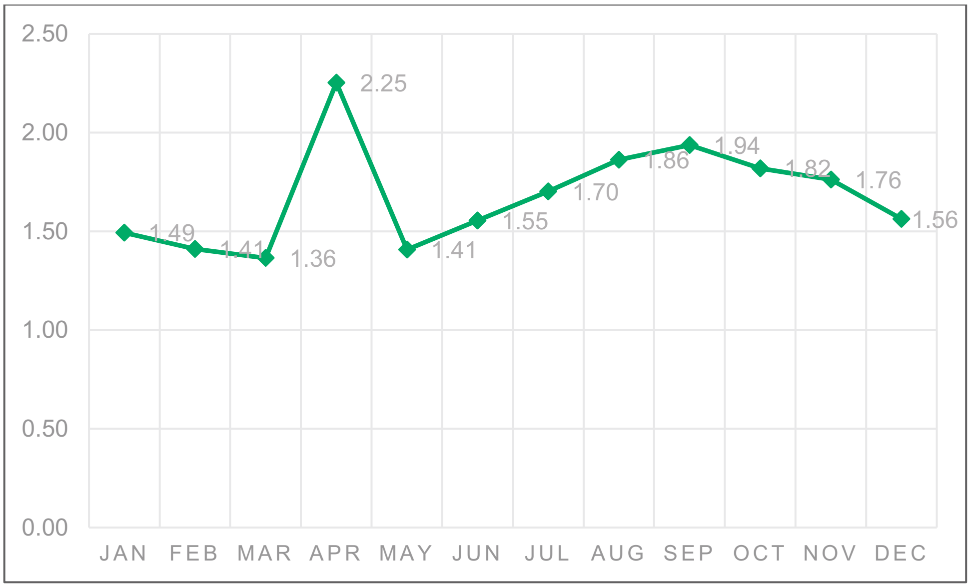


Figure 30: Distribution of average monthly ET_m /PE_m ratios

The monthly average ratios between the Penman-Monteith and Thornthwaite evapotranspiration figures show a distinctly seasonal trend, with an outlier in the April average ratio. September represents the month where the ET_m value is largest relative to the PE_m value, while March represents the month where the two estimates are closest. The calibration factors were not as expected: the significant rise in April, as well the quantum of the difference (around 150% higher on average). Numerous checks were conducted on the data and calculations, and no errors observed, however this should be investigated further if there is a concern. Important to note is the scale at which the two models are estimated: the Agrohydrological atlas provides climatic data at 30x30 m, while the down-scaled GCMs are at 45x55 km.

Figure 31 shows a comparison between the reference crop ET figures obtained from the South African Agrohydrological Atlas, calculated using the Penman-Monteith method, and PET values calculated using the Thornthwaite method. The ET values were calculated from temperature averages based on a 50-year dataset from 1950 to 1999, while the PET values were calculated based on temperature averages over a 35-year period from 1979 to 2013.

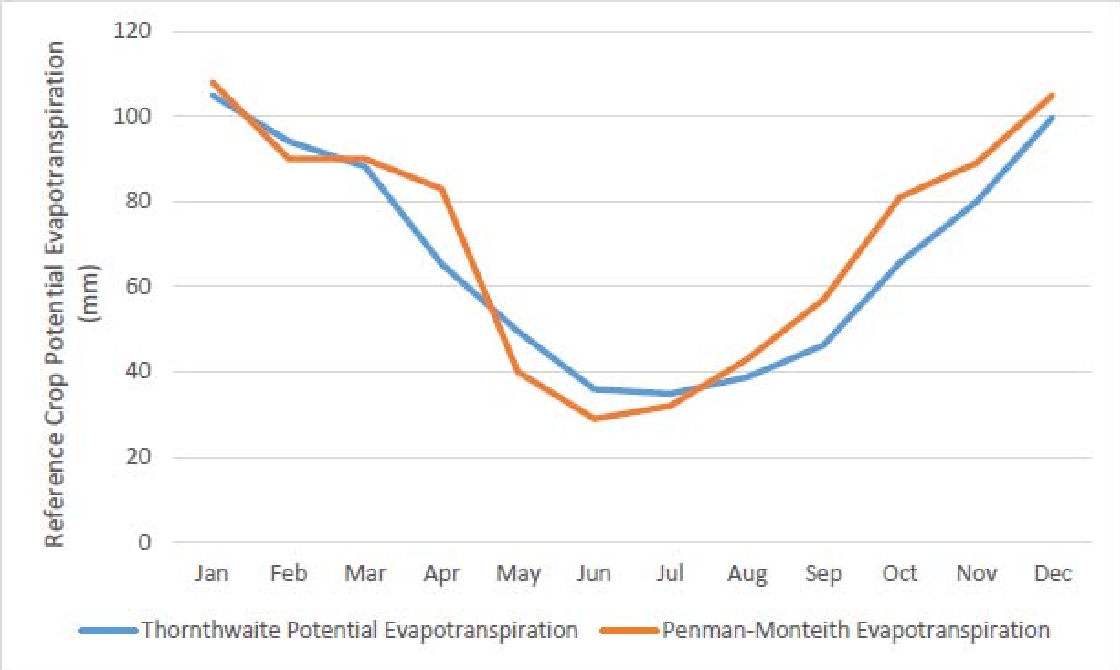


Figure 31: Comparison of historical monthly averages for potential reference crop evapotranspiration over the study area calculated using the Penman-Monteith method over a 50-year period (1950-1999) and the Thornthwaite method over a 35-year period (1979-2013).

While the different temporal spans of the two datasets were anticipated to result in different monthly averages, the different trends suggest an explanation for the distribution of the calibration factors for the month of April (Figure 30) but not the overall calibration quantum.

6.2.2.2. Results

The results for future irrigation requirements are summarised in Appendix 7, according to the total irrigated water requirements by municipality, by climatic model utilised. The results for the entire Berg WMA are summarised below according to the climatic model utilised, the emissions scenario assumed (either low or high) and the year 2025 or 2040. The x-axis on the graph below should be read as follows: the GCMs are named according to their organisation, i.e. GFDL, FGOALS and CANEMS2. The first number, 45 or 85, reflects the emissions scenario. 45 is the low emission scenario, and 85 the high emission scenario. The second number is the year with 25 reflecting the estimations for 2025 and 40 for 2040.

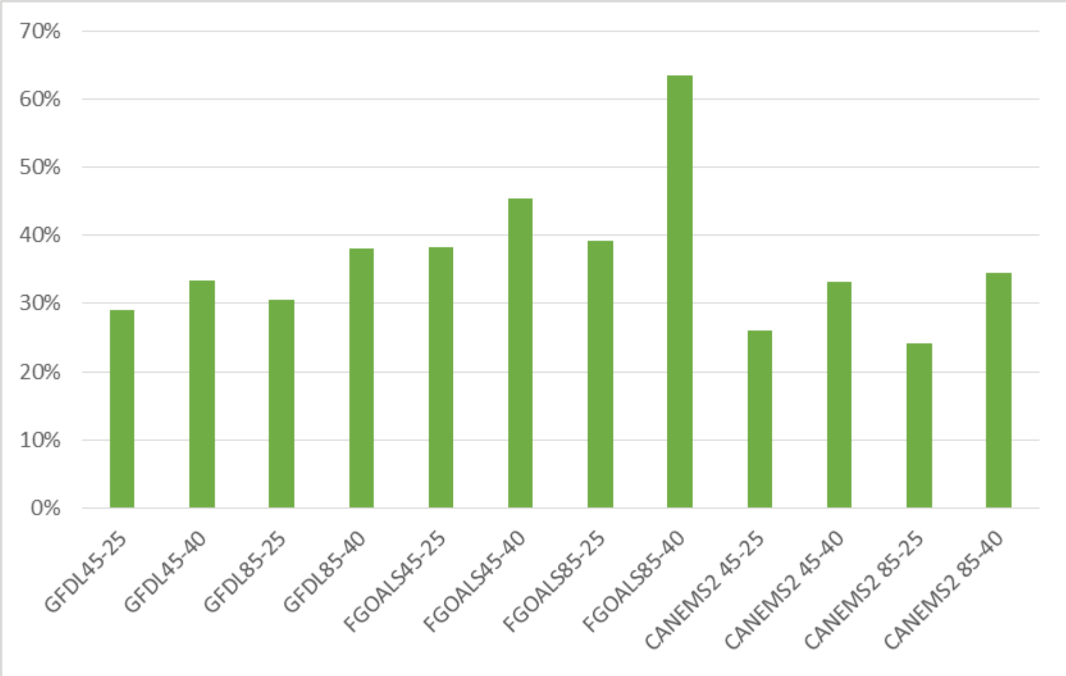


Figure 32: % increase in irrigated water requirements for Berg WMA in 2025 and 2040

The results reflect that regardless of the model utilised, increased irrigated water requirements are expected across the region. There is also consistently an increase between 2025 and 2040 expected, and the higher emissions scenarios result in higher requirements than the lower emissions scenarios. Interestingly CANEMS2 (the best-correlated model with past results) estimated the lowest increase in requirements in 2025, with very similar results to GFDL in 2040. FGOALS (worst case scenario), as expected, estimated the highest irrigated requirements for all years and emission scenarios. It was decided to utilise CANEMS2 45 as the “business as usual” climate model for use in estimating total water requirements for the region as this model was best correlated with existing records and produced the most conservative impacts on irrigated agriculture.

The results by municipality vary significantly, due to the local climate forecasts and the crops grown in that municipality. Using the results from CANEMS2 45, it appears that Saldanha Bay should expect the biggest increase in water requirements, with Witzenberg the lowest increase. However, important to note that Saldanha’s requirements under different GCMs differ significantly, with decreased water requirements expected for GFDL and FGOALS. This is largely due to grains being the dominant crop grown in that region. Grains have a short growing season and are impacted by the timing of rainfall, which fluctuates between models (see Figure 29 above).

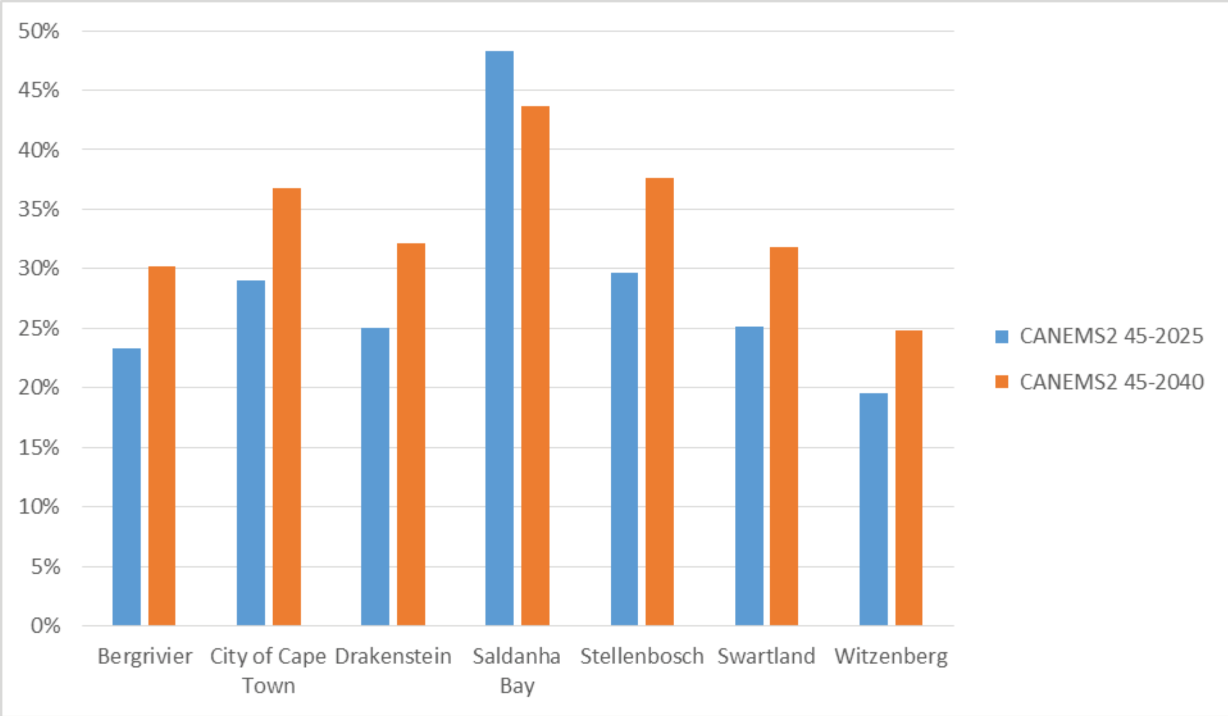


Figure 33: % increase in irrigated water requirements by municipality in 2025 and 2040 using CANEMS2 45 climate model

However percentage increases hide the total impact of changing climate on the total water irrigated requirements for a municipality. Utilising CANEMS2 45, the maps below illustrate how Drakenstein, Stellenbosch and Swartland continue to require the largest volume of irrigated water in the Berg WMA in 2025 and 2040.

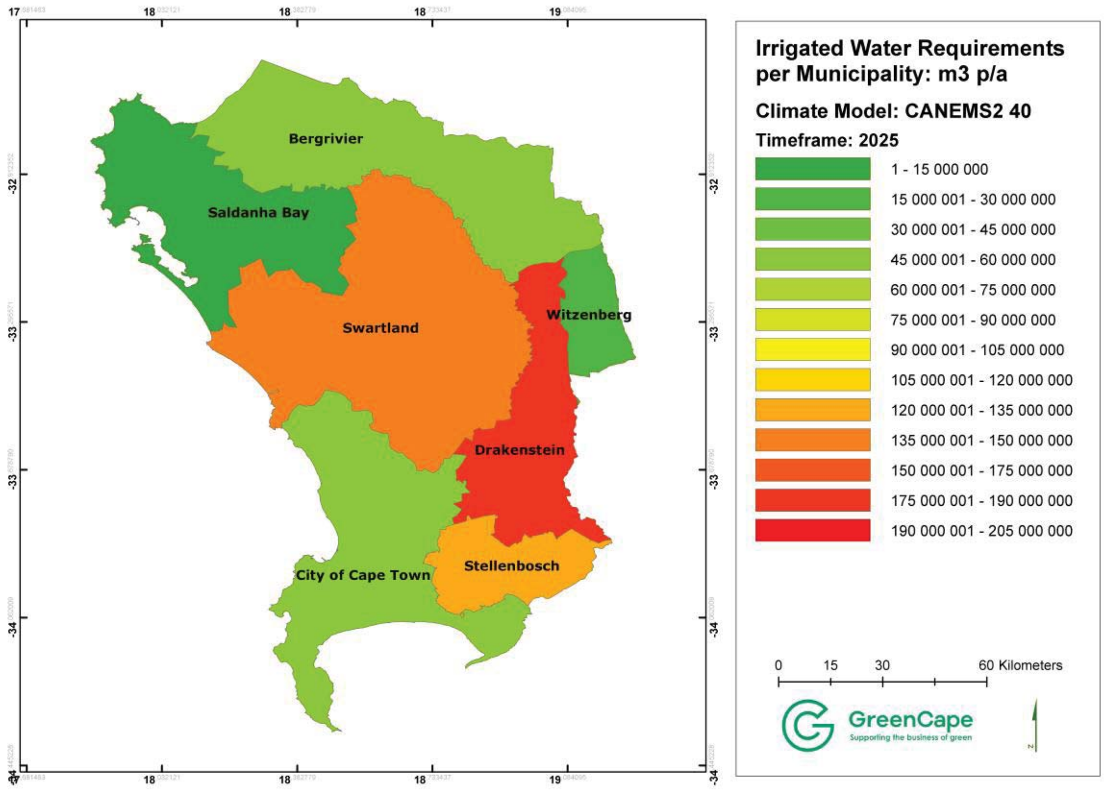


Figure 3420: 2025 estimated irrigated water requirements by municipality

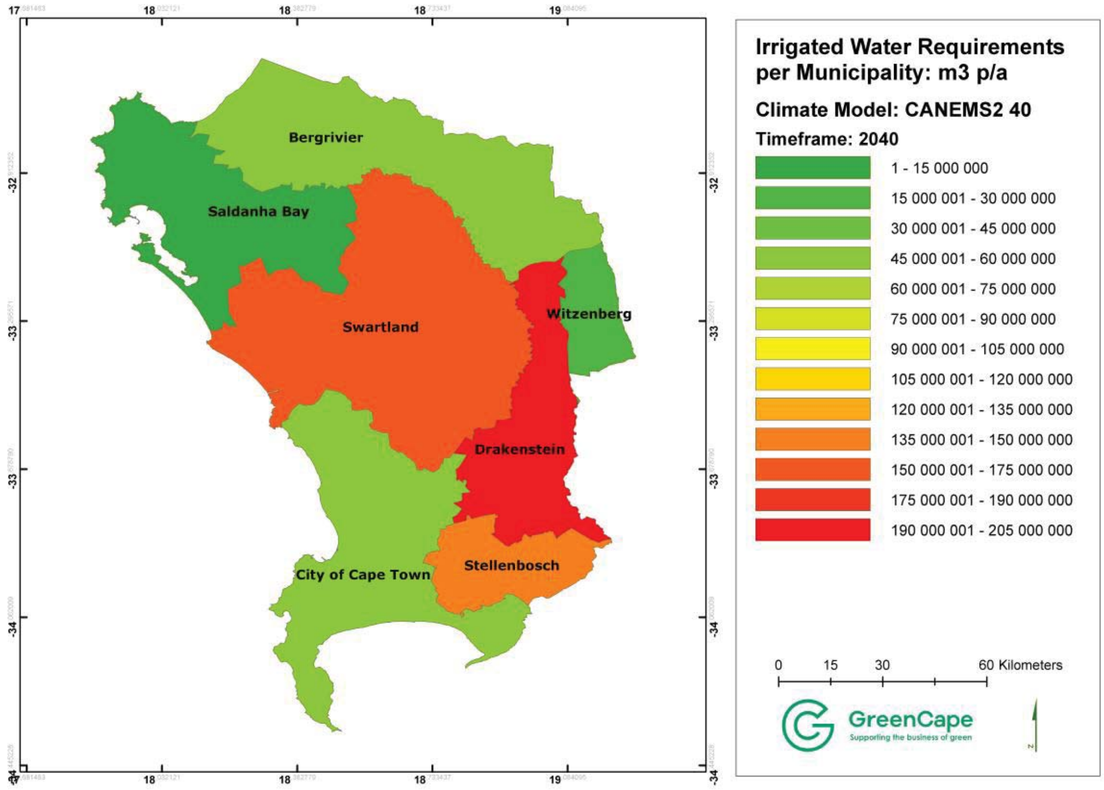


Figure 35: 2040 estimated irrigated water requirements by municipality

The forecasted changes in irrigated water requirements also differ by crop, this is due to the relative impact of changing crop evapotranspiration estimates as a result of increased temperatures, as well as changing rainfall patterns and their link to the growing season of the crop. The increases below are reflective of the total region's requirements and therefore the change expected by crop is also linked to where that crop is predominantly grown and their climatic changes.

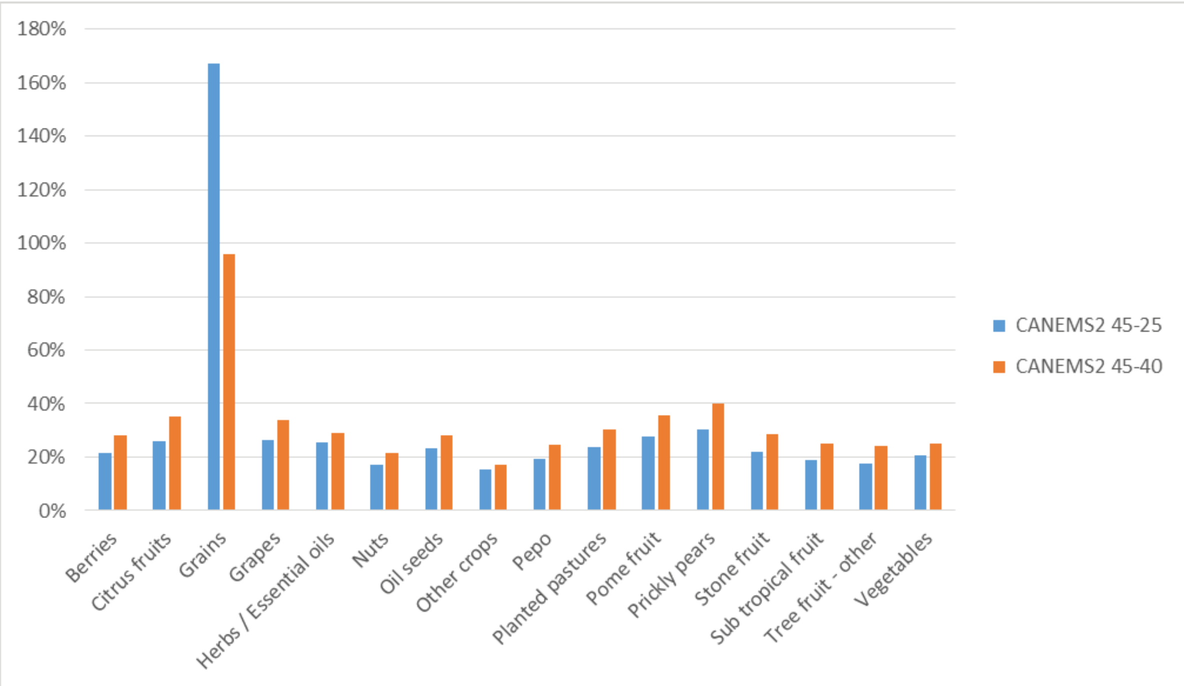


Figure 36: % increase in irrigated water requirements by crop in 2025 and 2040 for the Berg WMA

Grains are an outlier in this climate model (notably this is also the only crop that decreases its water requirements between 2025 and 2040), and represent a small proportion of the water requirements in the region (0.2%), and are therefore removed from the below analysis

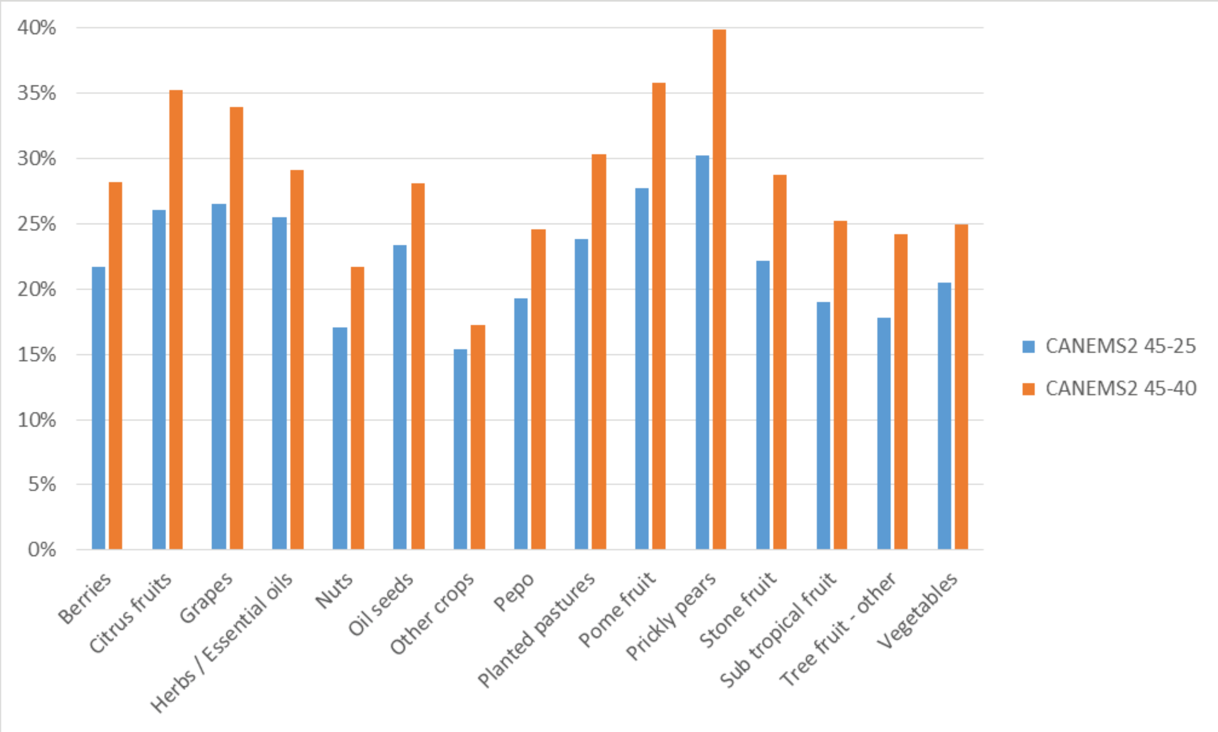


Figure 37: % increase in irrigated water requirements by crop in 2025 and 2040 for the Berg WMA (excluding grains)

These results highlight that, unfortunately, the most important crop in the region, grapes, is expected to increase their requirements substantially by 2040 (34% from current estimates). Stone fruit, the second most prevalent crop, is also expected to increase its irrigated requirements by 2040, although to a lesser degree (29%). Citrus fruits, which is the third largest crop in the region, and it also relatively water intense, is also expected to increase its requirements significantly (35%). This highlights how crop switching to more water efficient crops should be expected in this region, if no additional water allocation to agriculture is secured. At the same time, farmers should be encouraged to invest in water efficiency technology to ensure the longer-term viability of their farms.

6.3. Assessment of urban water requirements

The assessment of non-agricultural water requirements, termed urban water requirements[25], is particularly important for this WMA. Nationally, agriculture uses approximately 67% of the available water resources, whereas for the users who are connected[26] to the WCWSS, the proportion of water use by urban communities is much higher – approximately 65%. The urban population in this region is also growing rapidly, driven by better job prospects in urban centres as well as the relatively strong performance of the Cape Town and Western Cape economies in comparison to most other regions in the country (excluding Gauteng). Urban areas are drivers of economic growth in the region, therefore securing water supply for these areas is going to be crucial for their future development prospects.

[25] Urban water requirements refer to all users supplied by a municipal system, including farms that are connected to the municipal network for potable water use. This category also includes industrial users outside of urban areas that are abstracting raw water.

[26] The irrigated agricultural water requirements estimated in the section above included farms connected to the WCWSS as well as other farms that are irrigating using other sources of water.

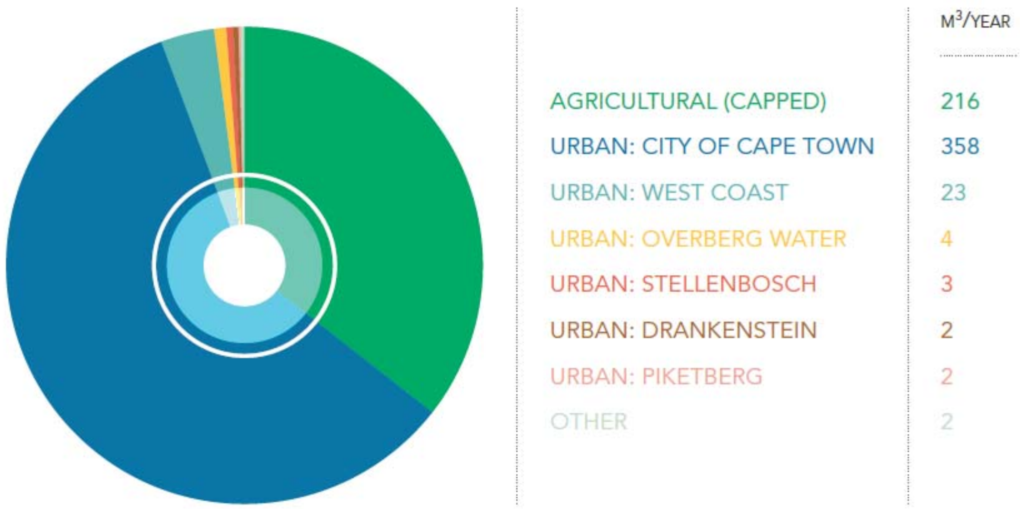


Figure 38: WCWSS allocations by user type (GreenCape, 2017)

6.3.1. Current urban water requirements

6.3.1.1. Methodology

The calculation of urban water requirements is comparatively simpler than irrigated agricultural requirements, as this usage is measured and reported on by municipalities to DWS. For industrial users outside of municipal areas, where records of actual usage were not available, WARMS registration data was utilised. 2011 was the year utilised as the baseline, effectively two years prior to the fly-over data that formed the basis for the irrigated agricultural requirements. 2011 was the last national census, and records from the municipalities on water usage were the most comprehensive in 2011/12.

Town data

Worley Parsons assists municipalities in the region with the annual water services audit reports that are delivered to DWS as part of their compliance requirements. This is public data, but it is not easily available, however it was secured through the assistance of Worley Parsons. Each town within the WMA was geo-located and included if it fell within the WMA boundaries. For each town, the consumption records for 2011 were recorded. These records included categories of water use, for examples, residential, commercial and municipal. However the application of these categories was not consistent between towns and therefore discarded. Total system input volume was recorded, as well as the population figures for the town from the 2011 Census. From this, per capita consumption for each town in 2011 was calculated by dividing total annual water usage by the population in the town.

Table 21: 2011 Town water usage and population figures

Municipality	Town	2011 usage m^3/a	2011 population	2011 per capita usage m^3/a
Bergrivier	Porterville, De Lust,	495,947	7,107	69.8
Bergrivier	Velddrif	1,005,660	11,027	91.2
Bergrivier	Dwarskersbos	83,274	668	124.7
Bergrivier	Aurora	41,072	576	71.3
Bergrivier	Piketberg, Wittewater	821,477	12,075	68.0
Cape Town	Cape Town	326,271,703	3,684,468	88.6
Drakenstein	Saron	594,291	7,814	76.1
Drakenstein	Gouda	159,918	2,985	53.6
Drakenstein	Paarl, Wellington, Simondium, Water-Vliet, Val De Vie	16,820,331	197,567	85.1
Saldanha Bay	Hopefield	358,670	6,212	57.7
Saldanha Bay	St Helena	1,698,930	11,457	148.3
Saldanha Bay	Langebaan	1,368,254	8,295	164.9
Saldanha Bay	Vredenburg, Jacobsbaai, Paternoster, Louwville	4,948,844	40,805	121.3
Saldanha Bay	Saldanha	5,659,283	27,915	202.7
Stellenbosch	Stellenbosch, Elsenburg, Raithby, Lynedoch	10,273,397	82,966	123.8
Stellenbosch	Pniel, Kylemore, Groot-Drakenstein, Dwarsrivier	666,729	6,893	96.7
Stellenbosch	Franschhoek, La Motte, Groendal	1,472,275	18,707	78.7
Stellenbosch	Klapmuts	376,656	7,574	49.7
Swartland	Riebeek West	214,216	4,633	46.2
Swartland	Riebeek Kasteel	263,467	5,431	48.5
Swartland	Yzerfontein	320,386	1,132	283.0
Swartland	Darling	699,043	10,477	66.7
Swartland	Moorreesburg, Klipfontein	762,024	12,818	59.4
Swartland	Koringberg	59,952	1,214	49.4
Swartland	Malmesbury, Chatsworth, Abbotsdale, Kalbaskraal	3,146,105	45,502	69.1
Witzenberg	Tulbagh	833,100	9,457	88.1

Rural data

Outside of the towns in the region there are a few industrial water abstraction points. These were recorded using the WARMS dataset, which includes each abstraction point's coordinates, the water source, the registered annual abstraction volume, as well as administrative details pertaining to the registration and nature of the abstraction record. For municipalities that only partly fall into the Berg WMA boundaries, the rural population was estimated using the following method: Total municipal population less the Town's population (both within and outside the Berg WMA) multiplied by the proportion of the municipal area that falls within the Berg WMA. In a similar manner to the Towns calculations above, the per capita consumption was calculated using the industrial water usage divided by the rural population. For some municipalities it was assumed there was no rural population: City of Cape Town – all residents within the metro boundaries and therefore likely to be included in Census for urban populations. However, WARMS industrial abstraction points were included in the urban calculations. Witzenberg only has the town of Tulbagh supplied by the WCWSS and although Wolseley falls on the boundary of the Berg WMA, it was not included. Witzenberg has such a small proportion of its total municipal area within the WMA, and only a single WARMS industrial point was recorded near the town, so Witzenberg only consists of the town of Tulbagh.

6.3.1.2. Results

Refer to the full results in Appendix 8. The City of Cape is responsible for 85% of the total urban water usage in the Berg WMA, which is very close to the contribution that the City makes to the total region's GVA (84%). The dominance of the City in this region implies that any regional change in water usage from urban populations is going to be driven by the City.

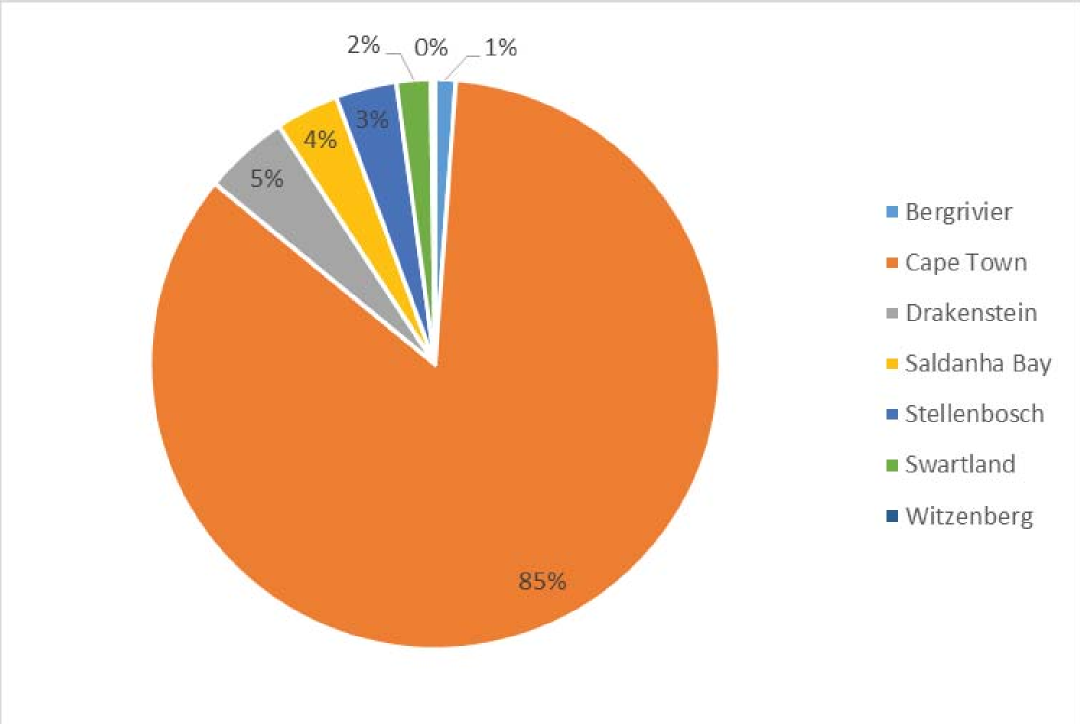


Figure 39: Urban water usage by municipalities in the Berg WMA

This importance of the City of Cape Town's water usage in the region is well illustrated in the below map (noting the step change in the legend to accommodate just how much more the City uses in comparison to the other municipalities).

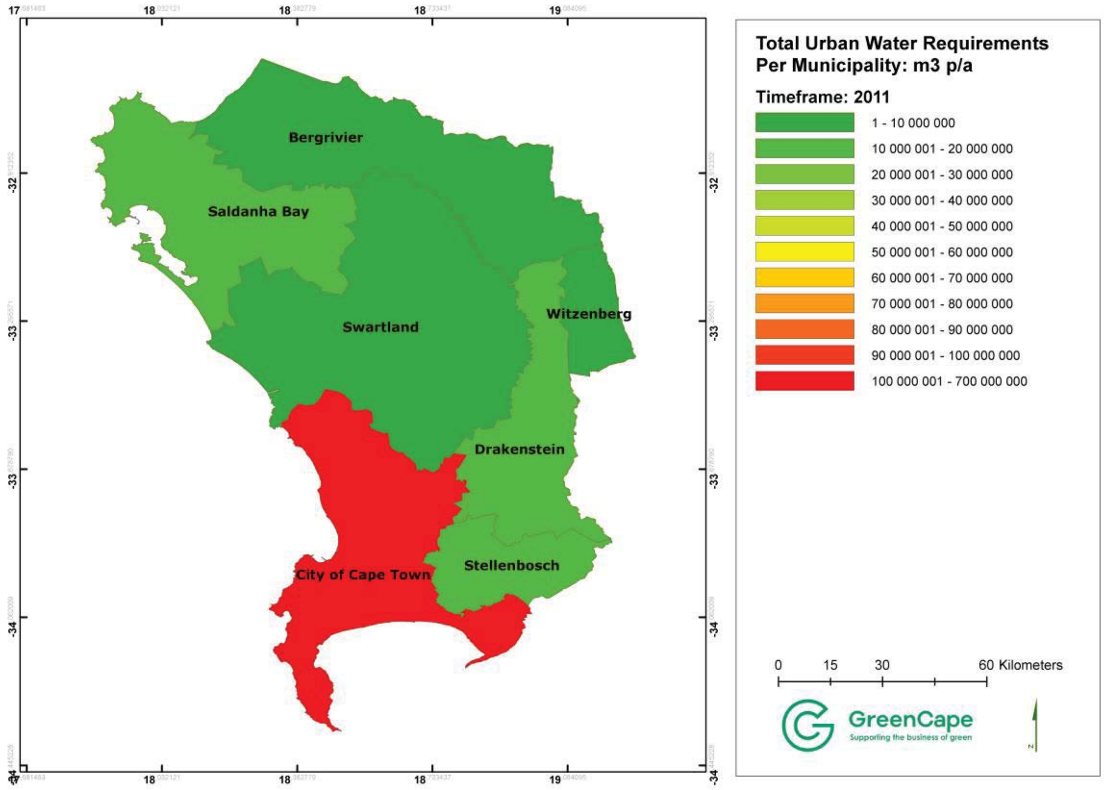


Figure 40: Total urban water requirements per municipality in 2011

The per capita consumption by town is displayed in the graph below. Yzerfontein in Swartland is a clear outlier, but not unusual for a holiday town that experiences high holiday-goer influx during peak season, but that has a small permanent population. Saldanha Bay Municipality has a number of high consumption towns, this is due to the industrial water consumption in the town from steel manufacturing and the fisheries. The average per capita consumption for the region is approximately 90 m^3/capita/a or 247 litres/capita/day – this is 16% higher than the national average of 208 litres/capita/day (Cole et al., 2017).

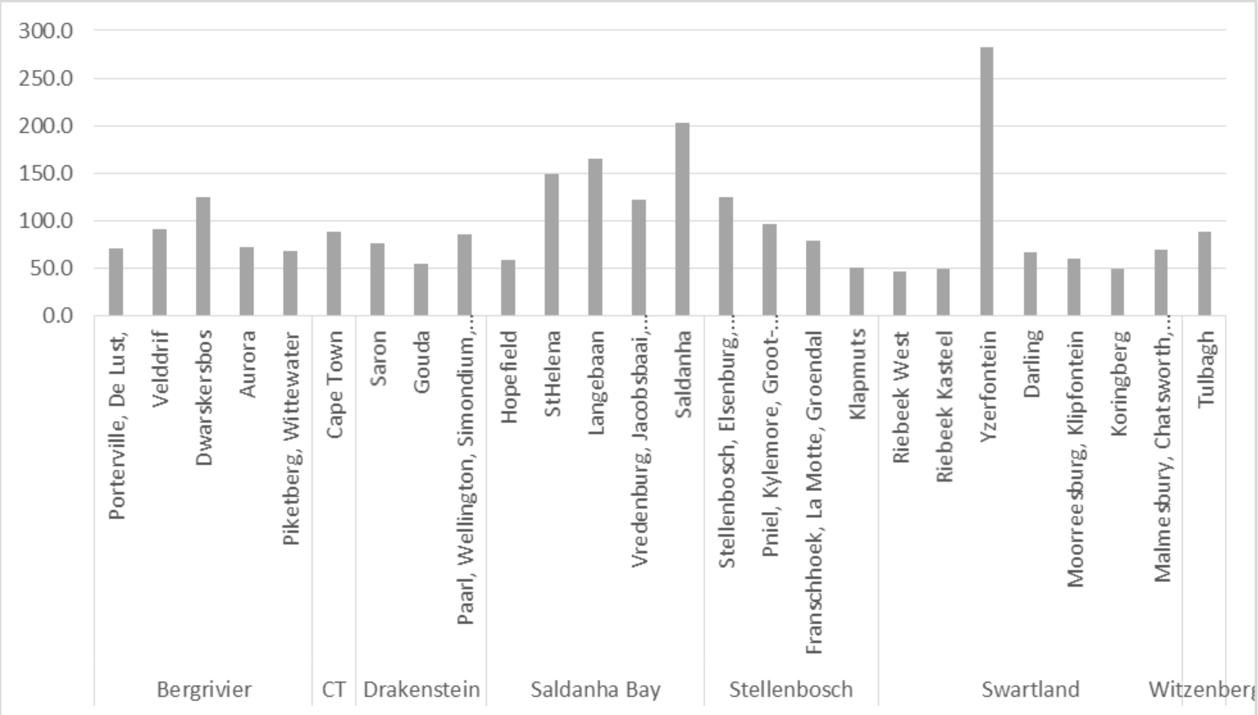


Figure 41: 2011 Per capita urban consumption per town (m^3/capita/a)

6.3.2. Future urban requirements

6.3.2.1. Methodology

The estimation of future urban water requirements in 2025 and 2040 was simply based on an extrapolation of population growth rates, with an assumption that per capita usage would remain constant. For each town listed in the Berg WMA, historical population growth rates (2001-2011) were extracted from the town's second reconciliation strategy (DWS, 2015). In addition, the low, medium and high growth rates were also captured to provide for sensitivity analysis, should growth rates change in these towns. For the rural populations, the overall municipal growth rates were applied.

The historical growth rates (2001-2011) were based as the "business as usual" baseline to estimate future total requirements. However, in mid-2017, the 2016 Community Survey results were released by Statistics SA (Stats SA, 2017). This provided a significant update to the previous population growth rates seen between the last two censuses. The Community Survey data was not available at the town level, but it had been split into urban (All settlements) and rural (Non-Urban) by municipality. In order to provide the most up to date population figures for 2025 and 2040, the 2016 data was then used, which required some manipulation of the previous urban water requirements calculations. The town water usage for 2011 per municipality was totalled and divided by the town population to generate an urban per capita usage. The rural estimates were generated in a similar manner.

The difference between the 2011 and 2016 population growth rates is quite marked, with every municipality seeing a decrease in population growth in 2016 (see Table 22 below). This is important to incorporate into the modelling of future requirements, as population growth rates compounded over a long period of time can grow quite dramatically, and impact on the results (see the following section) of future urban water requirement estimates significantly. Some of the municipal estimates may be not as accurate, as the 2016 data is not available at a town level, but this was counter-balanced with the larger concern for more recent population growth figures. The City of Cape Town's -46% change in the population growth rates between 2011 and 2016 was also a large driver to consider these updated figures, with 85% of the regional population.

Table 22: Comparison between 2011 and 2016 population growth rates by municipality (Stats SA, 2016)

Municipality		2001-2011 % growth rates	2011-2016 % growth rates	% change between 2016 and 2011 growth rates
Bergrivier	Urban	3.10	1.90	-39%
	Rural	2.50	1.50	-40%
Cape Town	Urban	2.60	1.40	-46%
Drakenstein	Urban	3.20	2.60	-19%
	Rural	-0.30	-0.30	0%
Saldanha Bay	Urban	3.70	2.40	-35%
	Rural	-0.40	-0.30	-25%
Stellenbosch	Urban	3.20	2.40	-25%
	Rural	1.50	1.30	-13%
Swartland	Urban	4.70	3.30	-30%
	Rural	4.60	3.30	-28%
Witzenberg	Urban	2.80	-0.80	-129%

6.3.2.2. Results

The results by municipality for the estimated urban water requirements in 2025 and 2040 are included in Appendix 9 and summarised below:

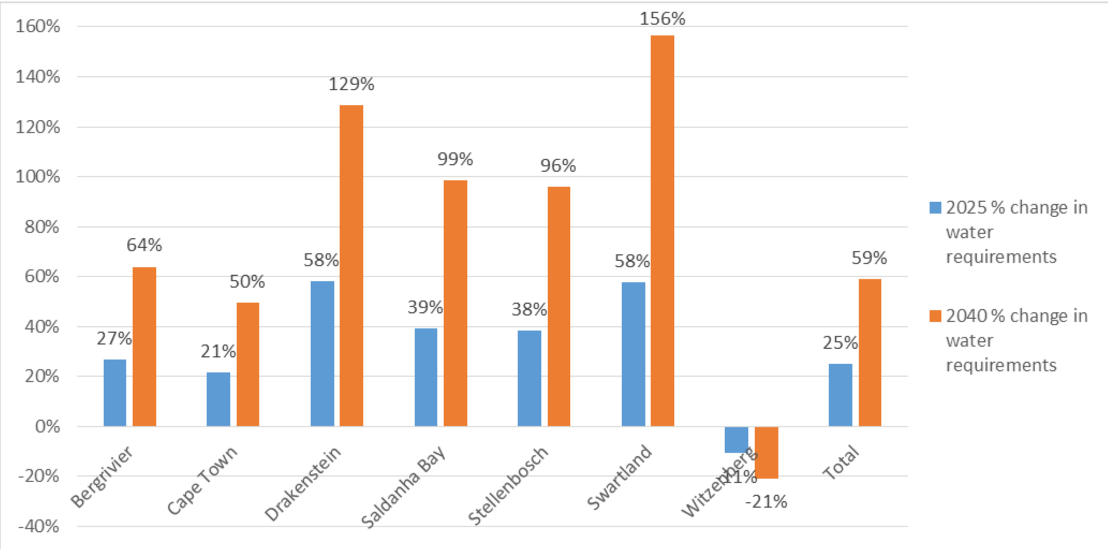


Figure 42: % change in urban water requirements in 2025 and 2040 per municipality according to historical population growth rates

The water requirements for the City of Cape Town grow at the slowest rate (excluding Witzenberg), yet still accounts for 80% of the regional usage by 2040, down from 85% in 2011. The updated 2016 population growth figures highlight Swartland as a rapidly growing municipality, closely followed by

Drakenstein and Saldanha Bay. In the absence of significant new supply options, reducing per capita consumption through Water Conservation and Demand measures is going to become increasingly important for these municipalities. The City of Cape Town has managed to de-couple its population growth from their water consumption trends for the past decade or so (see below).

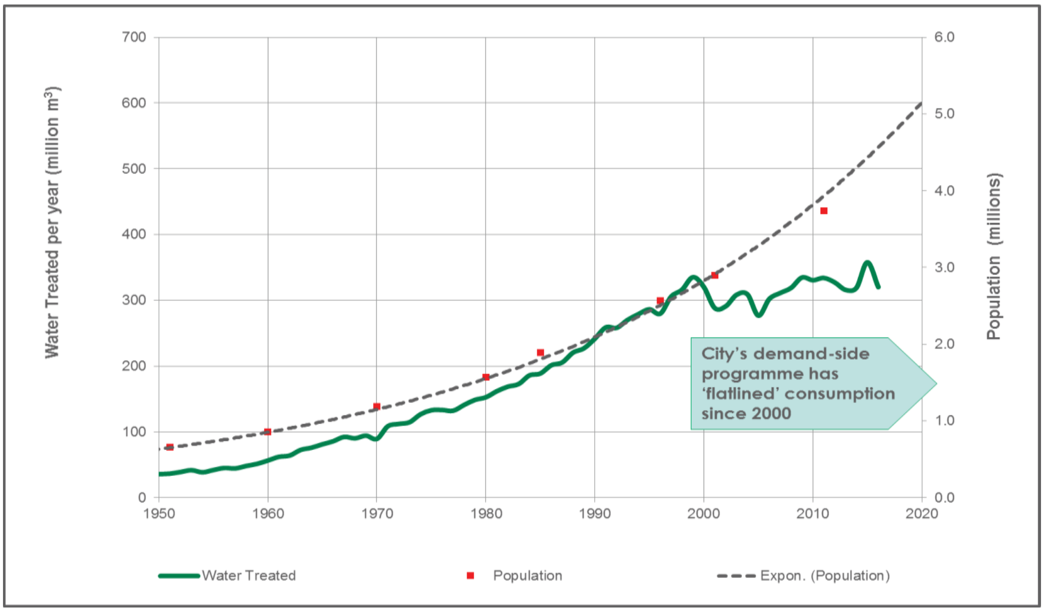


Figure 43: Water treated per year and population in the City of Cape Town

The summary growth rates for the region (see Figure 44 below) provide further impetus for using the updated 2016 population growth figures, as these produce more conservative estimates than even the low growth scenarios outlined in the All Town Reconciliation Strategies for the towns in the region.

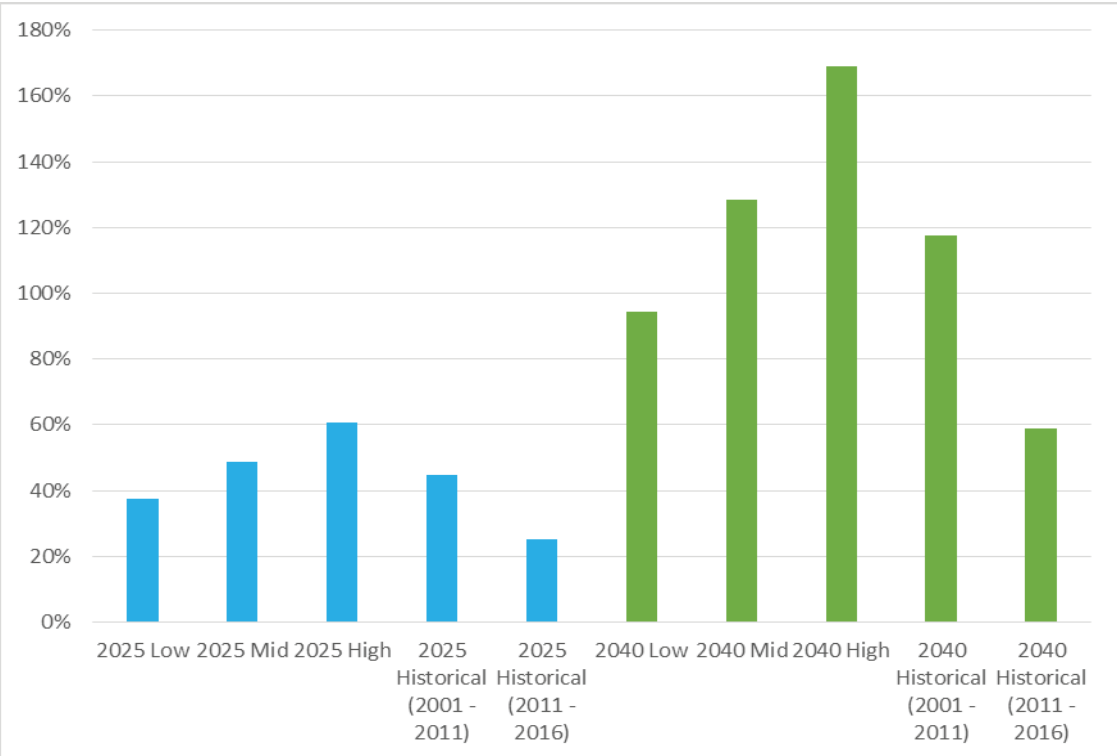


Figure 44: Urban water requirement growth rates for the Berg WMA under different population growth scenarios

The updated maps of the region for 2025 and 2040 below, continue to highlight how Cape Town is by far the largest user of urban water in the region, with the other municipalities starting to emerge as higher users by 2040.

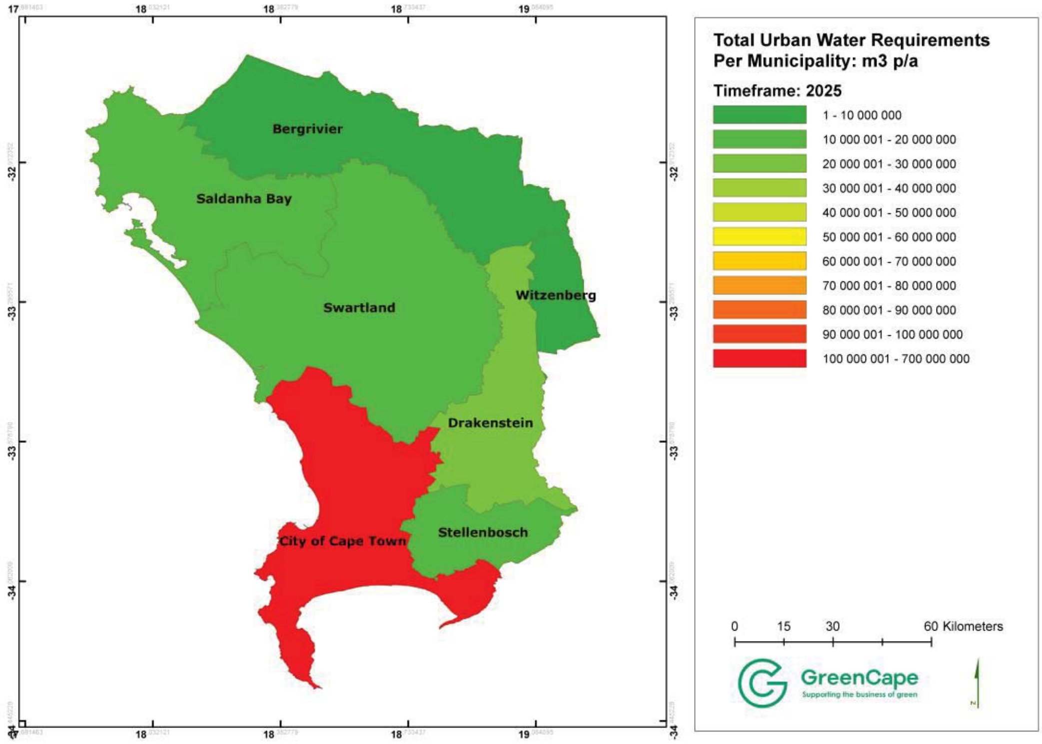


Figure 45: Urban water requirements per municipality in 2025

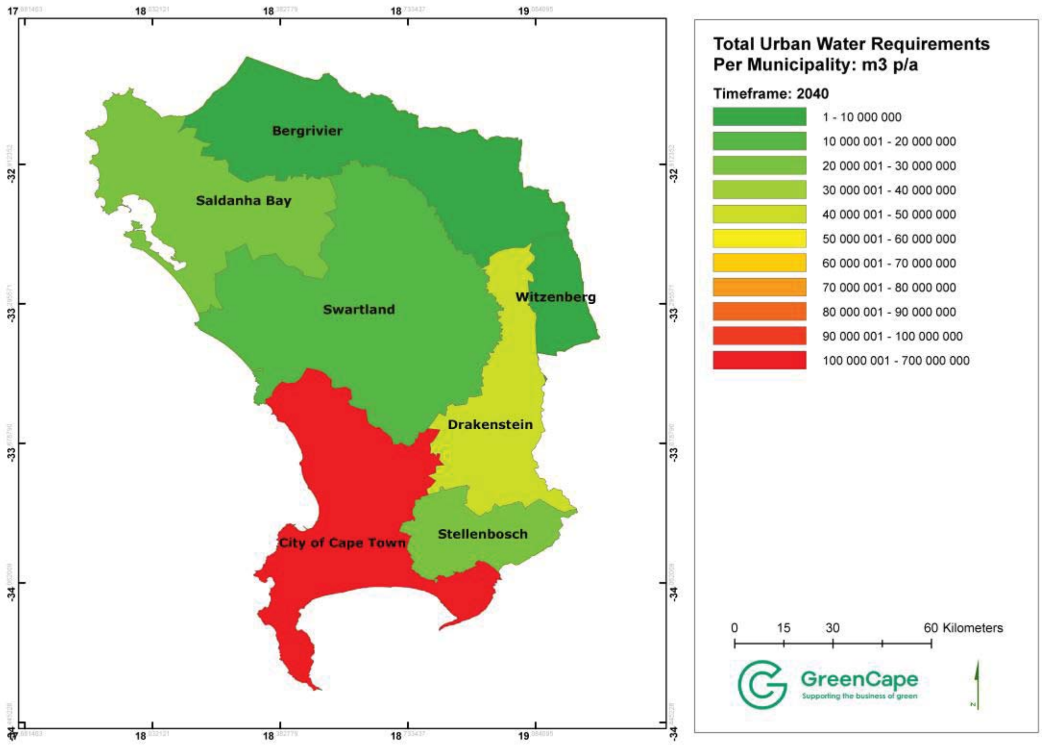


Figure 46: Urban water requirements per municipality in 2040

6.4. Total water requirements

6.4.1. Current total water requirements

The total water requirements were calculated by adding the urban (or non-agricultural requirements) to the irrigated water requirements (Table 23). Noting that these requirements were calculated at slightly different times (2011 and 2013), but with the assumption that the crops grown in the region in 2013 would be similar to the 2011.

Table 23: Total annual water requirements for the Berg WMA

Municipality	2011 urban water requirements m³/a	2013 irrigated agriculture water requirements m³/a	Total current water requirements m³/a
Bergrivier	4,598,070	40,489,366	45,087,436
Cape Town	332,352,881	39,587,871	371,940,752
Drakenstein	18,933,029	146,462,393	165,395,422
Saldanha Bay	14,077,231	451,297	14,528,528
Stellenbosch	13,560,881	101,060,066	114,620,947
Swartland	7,686,201	117,502,212	125,188,413
Witzenberg	877,746	23,003,556	23,881,302
Total	**392,086,039**	**468,556,760**	**860,642,799**

The pie chart below (Figure 47) is a significant update to the breakdown between urban and agricultural water usage seen on the WCWSS, with urban usage falling below the majority (WCWSS urban allocations are 65%). This illustrates that once all water usage is taken into account, not just for those farms that are supplied by the WCWSS, how agriculture is still a large water user in this region. And a reminder, that this study has only included irrigated agriculture, dry-land agriculture has not been calculated.

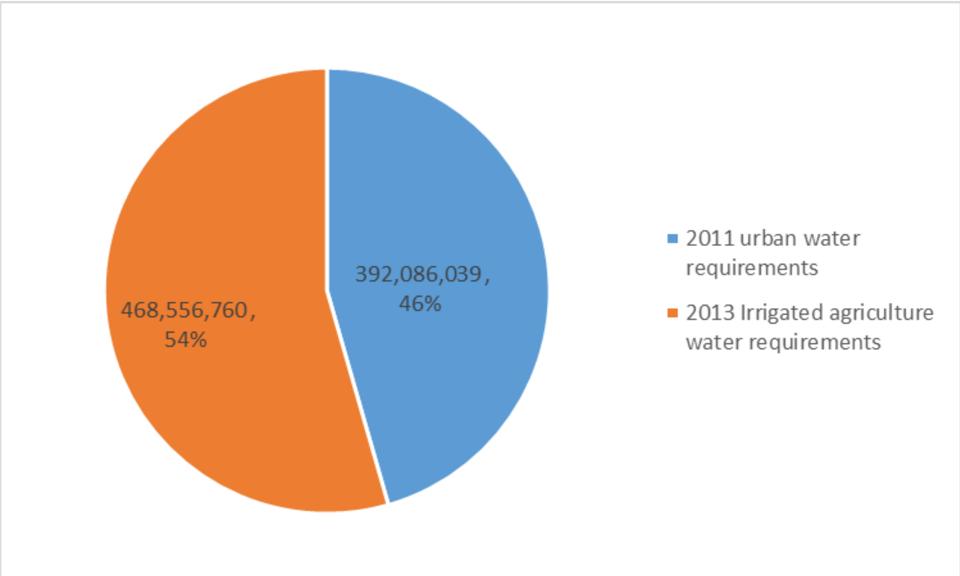


Figure 47: Total water requirements for the Berg WMA in m³/a

However, as noted in chapter 5, the water intensity of a local economy varies by municipality, and this is reflected in the split between agricultural and urban usage in the graph below. The City of Cape Town continues to consume the most amount of water, but the gap is not as dramatic as previously, with the more rural municipalities requiring substantial volumes of water for irrigation (refer to Figure 48 below).

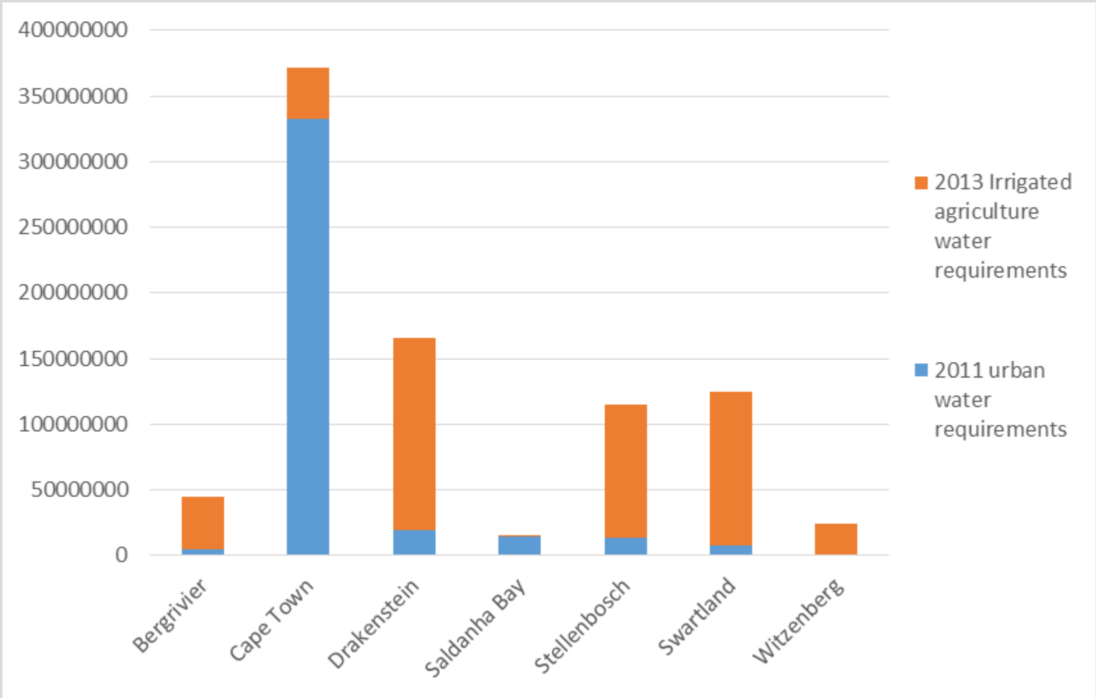


Figure 48: Total water requirements by municipality in m^3/a

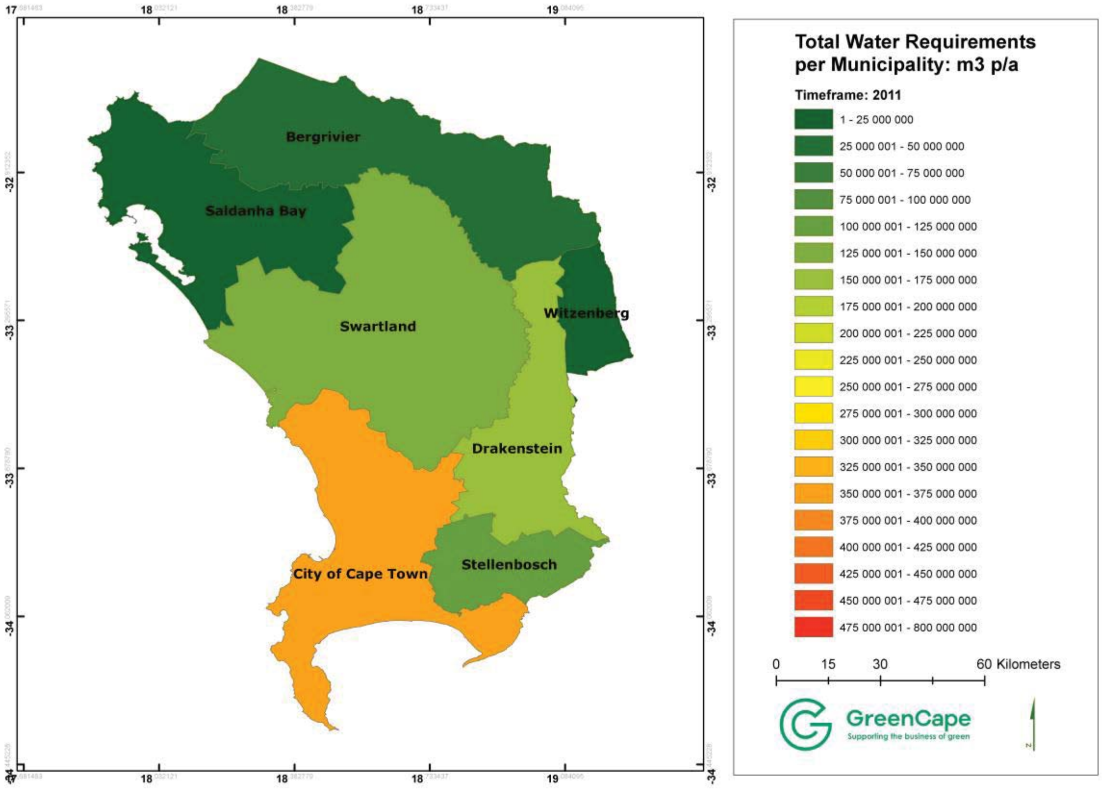


Figure 49: Total annual water requirements by municipality

6.4.2. Future total water requirements

In a similar manner to the current total water requirement estimates, the urban and agricultural totals for 2025 and 2040 were summed in order to estimate future water demands from the region (refer to

Appendix 10 for the results). This reveals that the driver of increased water demands in the region is going to be from urban growth, not agriculture, despite the concerning climatic predictions for the region and the high proportion of water being used by agriculture.

The City of Cape Town continues to demand most of the water in the region, with the local municipalities of Swartland, Drakenstein and Stellenbosch demanding increasingly more water from the region.

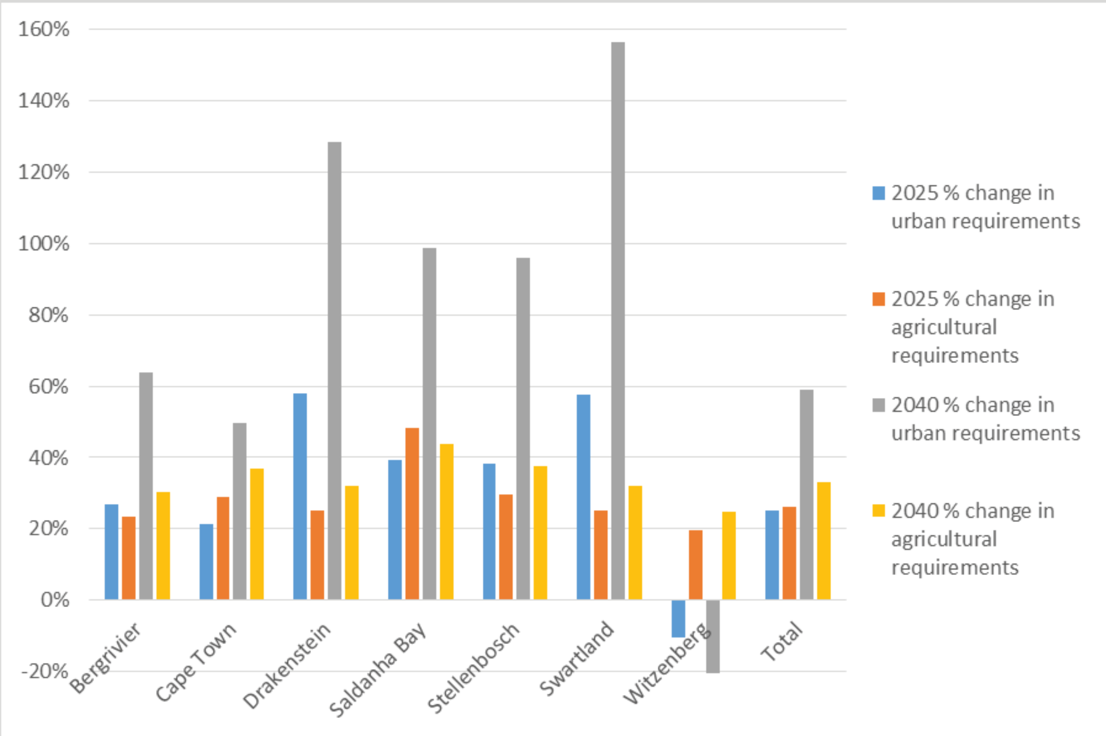


Figure 50: Comparison between urban and agricultural water requirements growth rates in 2025 and 2040 by municipality

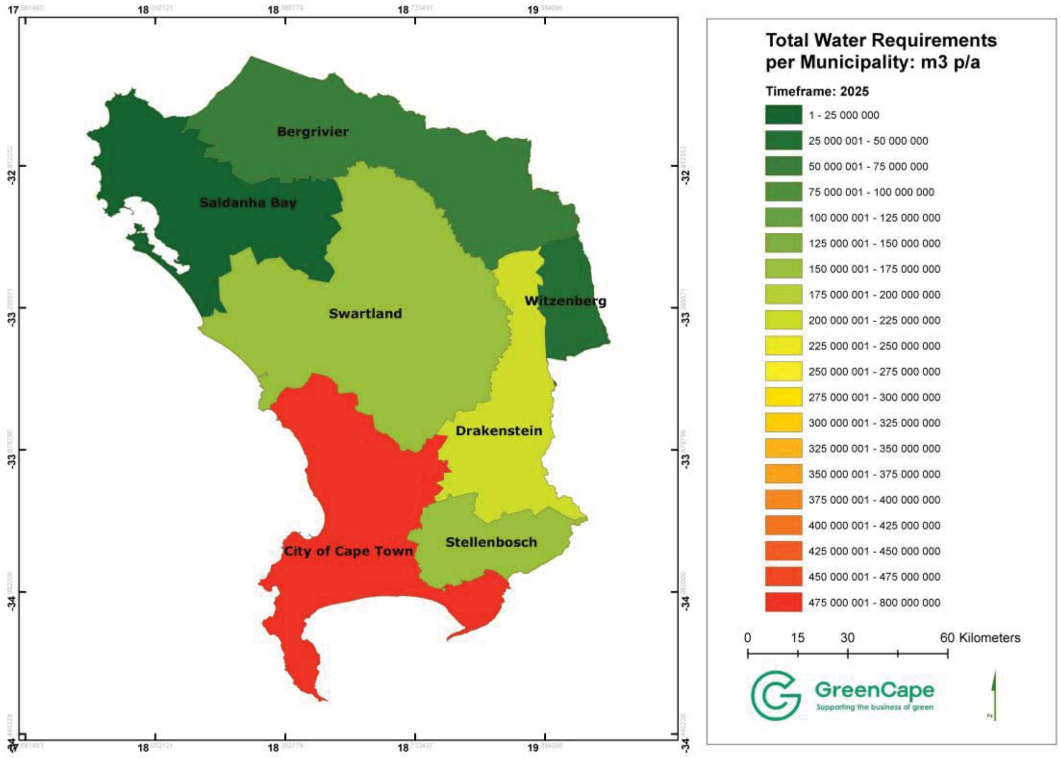


Figure 51: 2025 total annual water requirements by municipality

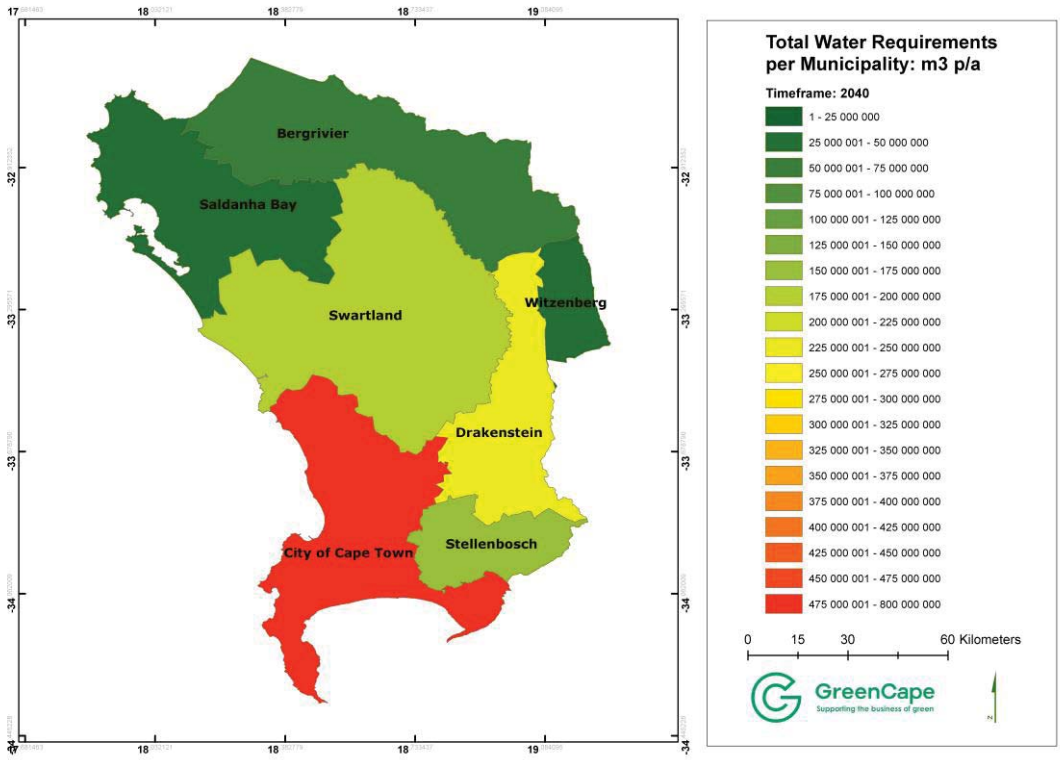


Figure 52: 2040 total annual water requirements by municipality

6.5. Comparative assessment of future water requirements to current economy

The estimation of future water requirements completes the volumetric demand side of the equation, however, to complete the picture, this forecast demand should be compared to supply. And then where there is an apparent “supply deficit”, i.e. where supply is unlikely to meet demand, this deficit should be valued in terms of the economic value that this water would enable through employment and value-add to the economy. This valuation will provide insight into where the largest opportunity costs may lie in the regional economy if water supply is not adequate to meet growth demands. With limited capacity and financial resources, this calculation will aid regional planners in their prioritisation processes. Thereafter, as the constraints of water availability are likely to be highly localised, a comparison is made between the opportunity cost of the supply deficit and the current size of the local economy.

6.5.1. Methodology

The methodology to estimate the “supply deficit” was split into agricultural and urban supply. The allocation of water to agriculture is capped, nationally and well as within this region (DWS, 2015a). The latest WCWSS reconciliation strategy notes that the total capped allocation to agriculture is 170 million m^3/a, with the data from 2014/15 indicating that 152 million m^3/a was released for agricultural use, but that this was an estimate with a degree of uncertainty as to the actual usage. There was provision made for agriculture to increase their allocation to 216 million m^3/a, but this is unlikely to happen due to the WCWSS already being over-allocated. It is under-going a Validation and Verification process (refer to Box 1) that will assist in evaluating how much water is actually being used by agriculture, and furthermore how much of this is lawful. The recent requirements for agricultural metering will also aid in better establishing actual water usage. However, regardless of existing usage, allocations are unlikely to increase, especially when considering the drought in the region, as well as the number of outstanding water use license applications from Water Services Authorities in the WMA. Therefore any increase in agricultural demand will result in a supply deficit. This increase in demand may be met with increased irrigation efficiencies, or by the switching of crops towards less water intense crops.

The estimation of the supply deficit for urban requirements in the region was based on existing allocations from the WCWSS (DWS, 2015a), industrial WARMS registrations and local supply sources. The supply augmentation options provided in the WCWSS reconciliation strategy were not included in the calculation as: a) the purpose of this study is not to provide an alternative reconciliation strategy, b) with the exception of Voëlvlei’s schemes, all the proposed schemes are intended for the City of Cape Town. The additional allocation available from Voëlvlei, once completed, has not been determined and this study could provide data on where the most economic benefits could be found through this allocation and c) there is still a high degree of uncertainty as to when/if these schemes will come online.

In some instances, it was difficult to determine the allocation to a certain town or municipality as it is not contractually set (such as Drakenstein, which receives variable allocations through the City of Cape Town) or where records were not available for minor towns on the system (2011 demand was utilised in areas that are already using more than allocated). Below are the results of the allocation by municipality (Table 24):

Table 24: Existing water allocations to urban or industrial users

Municipality	Existing allocations (m^3/a)	Description
Bergrivier	4,895,370	Allocation by town + WCWSS 2011 demand (Velddrif & Dwarskersbos) + industrial WARMS
Cape Town	398,700,000	WCWSS allocation and CT dams
Drakenstein	32,435,904	WCWSS + industrial WARMS
Saldanha Bay	11,376,250	WCWSS + Langebaan Rd + Industrial WARMS
Stellenbosch	15,896,904	WCWSS includes estimated 4 mill purchased from CCT (not fixed) + Industrial WARMS
Swartland	7,242,984	WCWSS allocation for Swartland from Voëlvlei + 2011 demand (Mooreesburg + Koringberg) + Industrial WARMS
Witzenberg	2,245,500	WCWSS allocations for Tulbagh
Total	**472,792,912**	

The existing allocations were then deducted from the predicted demand in 2025 and 2040. The "business as usual" scenario was utilised for the demand projections with CANEMS2 45 (best correlated, low-emissions climate model) and historical population figures (from the 2016 community survey), with negative figures representing a potential supply deficit.

Thereafter, the supply deficits were valued according to the per million m^3/a employment and GVA estimates per municipality for urban use (Table 13). Agricultural average value per million m^3/a was similarly estimated, with the irrigated water usage linked to the expected crop requirements per municipality in 2025 and 2040. The valuation of the supply deficit, or the opportunity cost of insufficient water supply, does not represent the actual cost to the economy of water constraints. This is impossible to model under the current data constraints and theoretically complex for allocations so far into the future (there are so many potential shifts in behaviour, technology and the structure of the economy by 2025 and 2040) and not accurate when based on average value. However, these opportunity cost estimates were generated to be compared to the total size of the current economy (2015). The purpose of this exercise was to highlight where a local economy is likely to feel the most constrained to grow its current economy due to water scarcity. This is a relative measure of the economic impact of water availability to a local economy in order to assist regional planners in prioritising support.

6.5.2. Results

The results indicate that, barring any additional allocations or augmentations schemes, the supply deficit is most keenly going to be felt in the agricultural sector in 2025, with the supply deficit for urban users only 13% of the total deficit. However this picture changes dramatically by 2040 with an almost even split between the supply deficit of the urban and agricultural requirements.

Table 25: Urban and agricultural supply deficit in 2025 and 2040 m^3/a

Municipality	2025 Urban deficit [27] compared to existing allocation m^3/a	2025 Change in irrigated agriculture water requirements m^3/a	2040 Urban deficit compared to existing allocation m^3/a	2040 Change in irrigated agriculture water requirements m^3/a
Bergrivier	938,982	9,447,272	2,640,940	12,236,017
Cape Town	5,066,997	11,506,373	98,693,543	14,564,853
Drakenstein	(2,531,425)	36,656,770	10,843,741	47,092,268
Saldanha Bay	8,225,733	217,849	16,581,091	196,891
Stellenbosch	2,862,026	29,925,972	10,679,324	38,024,375
Swartland	4,866,238	29,564,747	12,464,041	37,444,102
Witzenberg	(1,461,110)	4,498,203	(1,550,144)	5,711,880
Total	**17,967,442**	**121,817,185**	**150,352,536**	**155,270,386**

However, it is important to note how the Saldanha Bay and Swartland municipalities, which are small users on the WCWSS, have relatively large urban deficits in comparison to their existing allocations (Table 24). This is because they are already using more than their allocation, and they are both rapidly growing areas. Cape Town is expected to have the largest urban deficit in 2040, and it therefore stands to reason that most of the schemes planned for the region would supply the metro. However, given the combined total of all the other urban area deficits in 2040, the WMA will require more schemes built for the other municipalities in order to meet demand.

The increase in irrigation requirements is substantial with no clear avenue for additional supply for these users. Competition between urban and agricultural users is to be expected, particularly from riparian farmers who can abstract from the Berg River when releases are made upstream, possibly destined for downstream dams that supply urban populations. This kind of conflict is being experienced in the current drought. These results should motivate for further support for farmers to increase water efficiency and consider the switching to less water intensive and higher value crops.

Appendix 11 summarises the results on the opportunity costs from water constraints in 2025 and 2040, in terms of the value that could be generated from water availability in 2015 Rands and employment. Some of the key insights from this analysis are outlined below.

Irrigated agriculture water requirements increase most substantially in 2025 in comparison to urban requirements, but are still valued lower due to the much higher value created by urban economies. This can be clearly seen in the 2025 graph below:

[27] Positive numbers represent a deficit between expected demand and current allocation (supply), with negative numbers representing a surplus

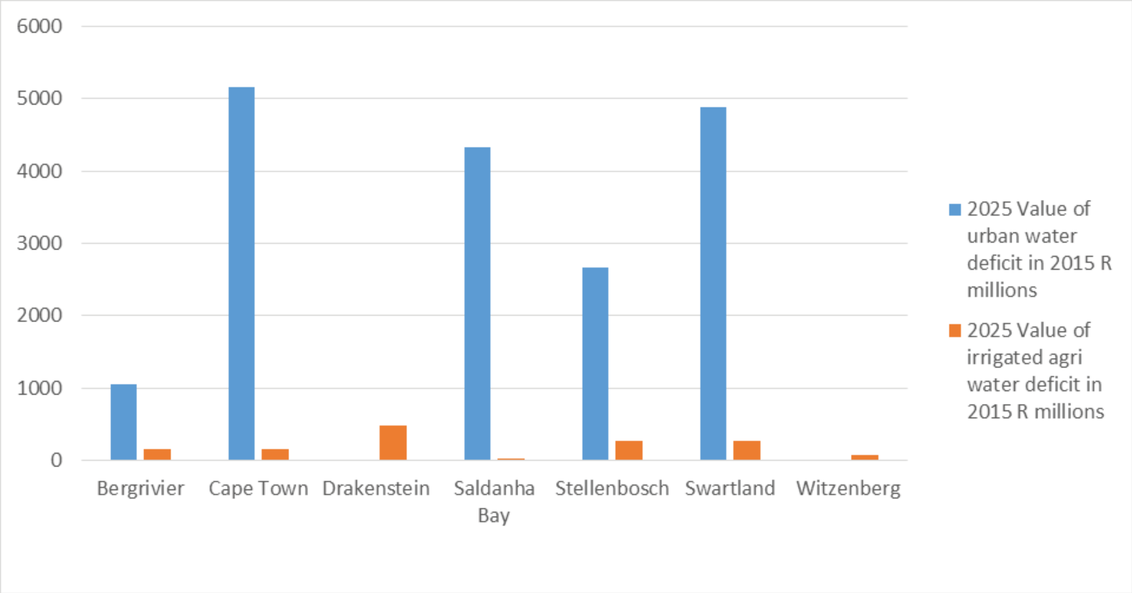


Figure 53: 2025 Value of water supply deficit in 2015 R millions

Even when employment is considered (agriculture is an important employer in rural economies), the comparison still largely values urban water usage, but this varies by municipality.

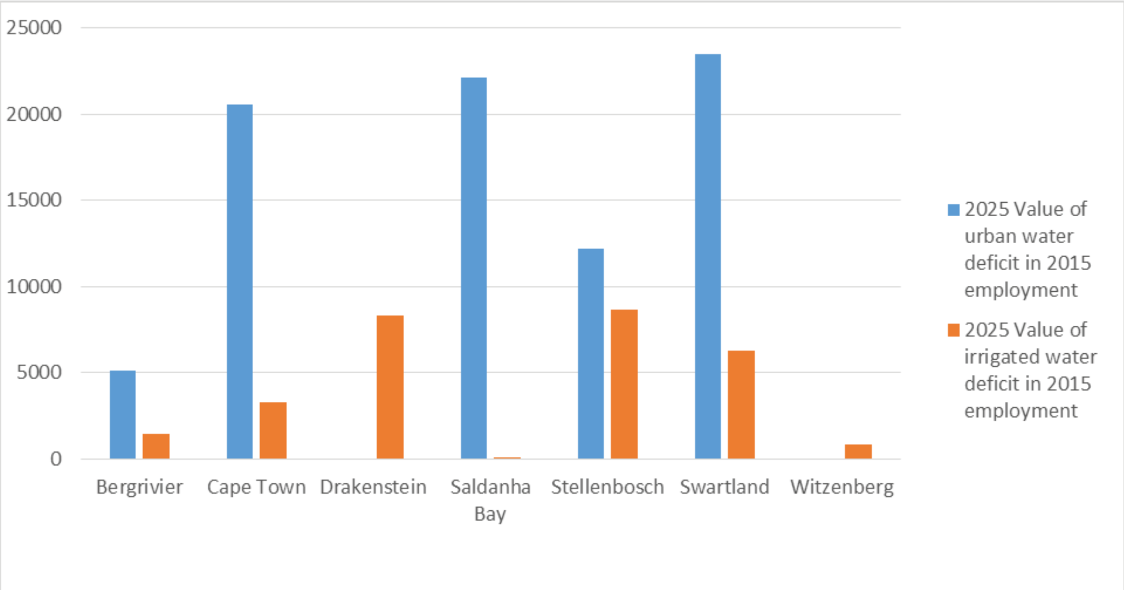


Figure 54: 2025 Value of water supply deficit in employment

When reviewing the results for 2040, Cape Town's urban requirements outsize the rest of the municipalities substantially in both rand value and employment impacts.

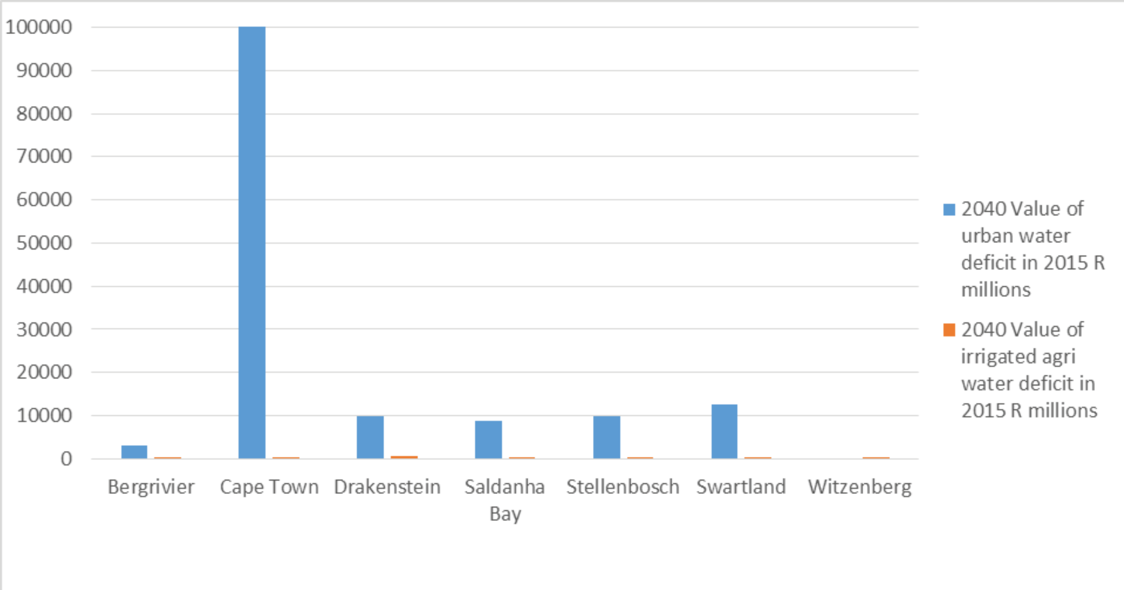


Figure 55: 2040 Value of water supply deficit in 2015 R millions

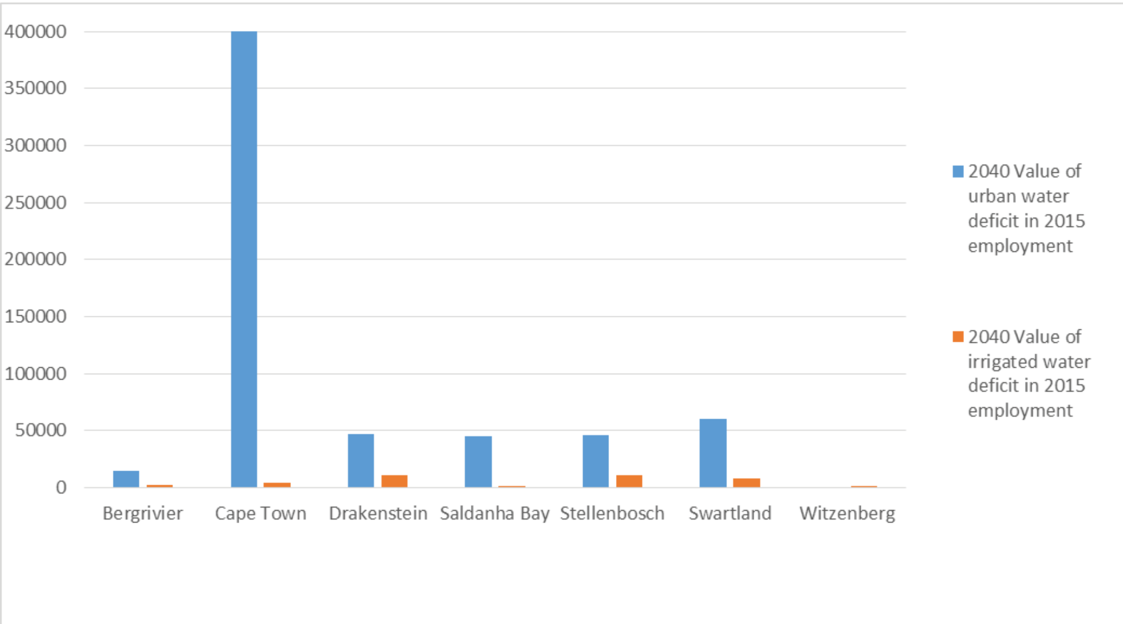


Figure 56: 2040 Value of water supply deficit in employment

The summary of the total costs per municipality in 2025 and 2040 is included below. As seen in the graphs above, by 2040, Cape Town's water requirement deficit and the opportunity cost of not having this water available is incredibly important for the region overall. However, in 2025, similar opportunity costs are seen (either in R terms or employment) to the City of Cape Town in Saldanha Bay, Swartland and Stellenbosch. This is because the City currently has allocation available that it can still grow into, while Saldanha Bay and Swartland are already using more than allocated.

Table 26: Water supply deficit opportunity costs in 2025 and 2040

Municipality	2025 total value of water requirements deficit in 2015 R millions	2025 total value of water requirements deficit in 2015 employment	2040 total value of water requirements deficit in 2015 R millions	2040 total value of water requirements deficit in 2015 employment
Bergrivier	1,200	6,540	3,143	16,229
Cape Town	5,307	23,817	100,614	403,877
Drakenstein	473	8,325	10,496	57,218
Saldanha Bay	4,326	22,152	8,715	44,640
Stellenbosch	2,931	20,884	10,303	56,602
Swartland	5,158	29,771	12,847	68,091
Witzenberg	69	857	89	1,088
Total	**19,467**	**112,347**	**146,206**	**647,746**

The results from the analysis above, justifies the focus for WCWSS supply augmentation on the City of Cape Town, as the largest driver of the economy in the region. In order to understand the impact that these opportunity costs may have on the local economy, and therefore their ability to withstand or absorb them, is shown below through the comparison of the costs in 2025 and 2040 to the current size of the local economy.

Table 27: Comparison of the opportunity cost from a water supply deficit to the current size of the local economy in 2025 and 2040

Municipality	Comparison of 2025 GVA deficit to 2015 total economy	Comparison of 2025 employment deficit to 2015 total employment	Comparison of 2040 GVA deficit to 2015 total economy	Comparison of 2040 employment deficit to 2015 total employment
Bergrivier	33%	30%	86%	74%
Cape Town	2%	2%	29%	29%
Drakenstein	3%	9%	58%	62%
Saldanha Bay	57%	56%	114%	113%
Stellenbosch	22%	32%	77%	87%
Swartland	76%	83%	190%	190%
Witzenberg	1%	2%	1%	2%
Total	**5%**	**7%**	**36%**	**38%**

In this comparison, it appears that the City of Cape Town is relatively better off in contrast to some of the other local economies in the region. With particular concern are the West Coast municipalities of Bergrivier, Saldanha Bay and Swartland. The lack of water availability in these areas may be a significant constraint to their economic development and ability to generate jobs, perhaps best illustrated by the below maps of the region:

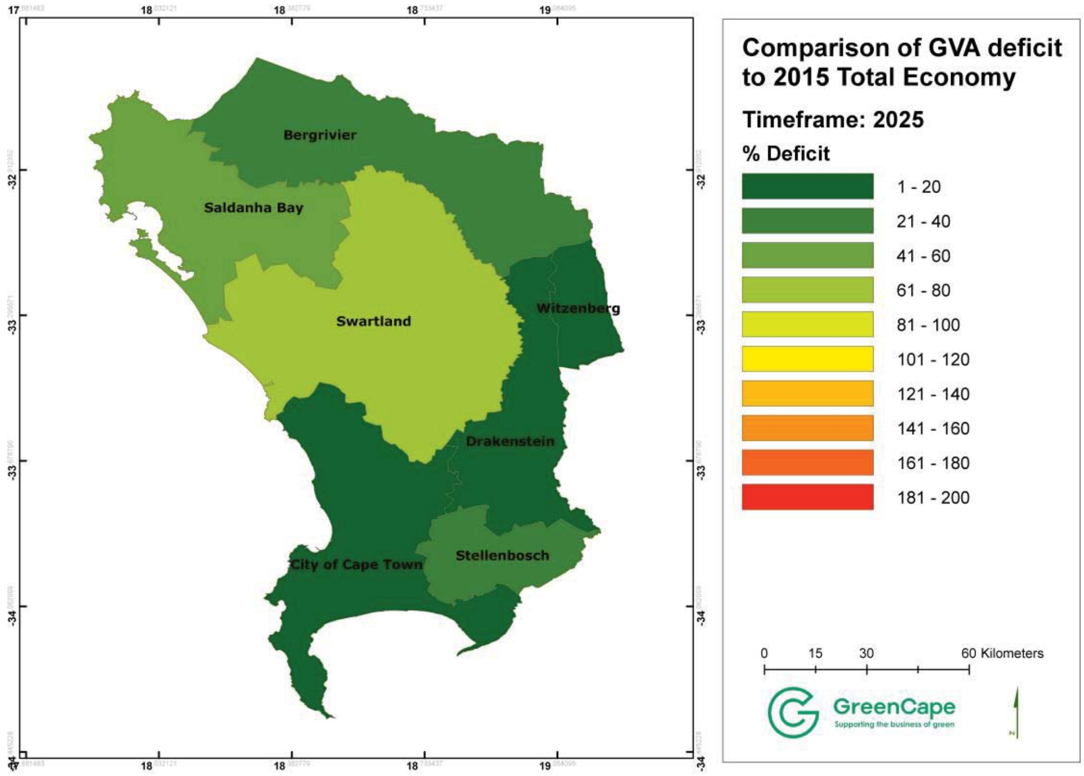


Figure 5721: 2025 comparison of GVA deficit to 2015 total economy

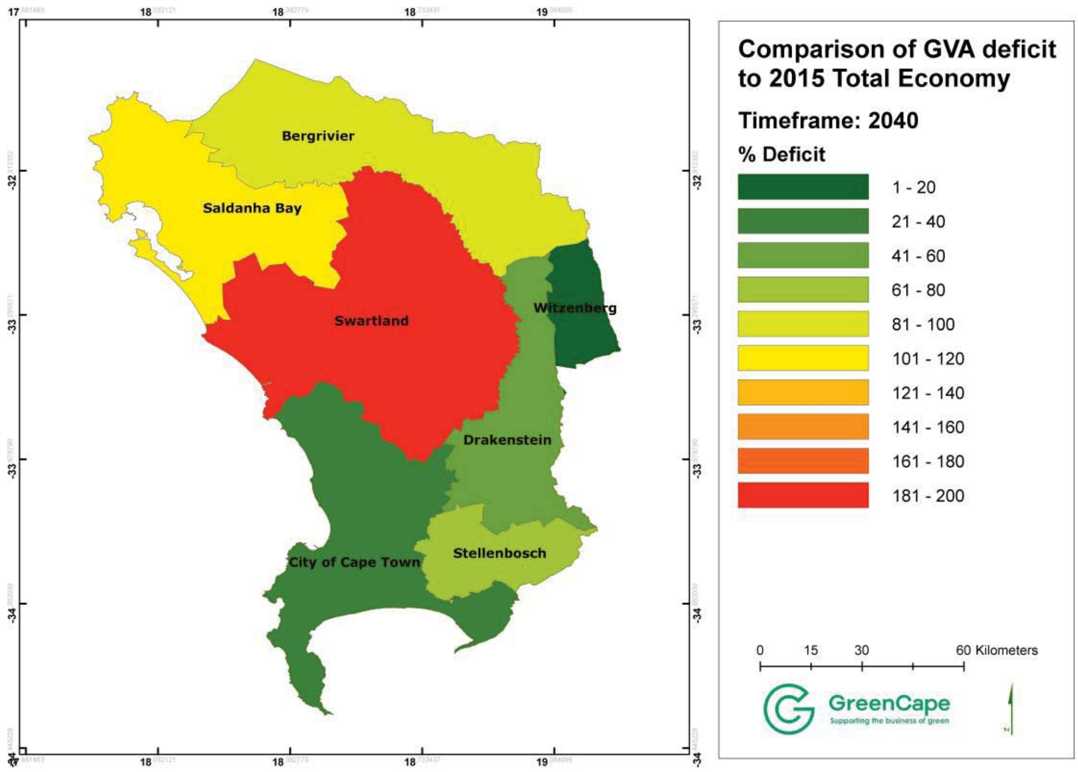


Figure 58: 2040 comparison of GVA deficit to 2015 total economy

7. Local water and development allocation prioritisation

7.1. Introduction

As discussed in the previous chapters, the Berg WMA's readily available water is fully allocated (termed water-constrained), and there may be a significant time lag until new resources come online and water availability can increase. It is proposed that allocation in these constrained situations should be towards those water users or developments that maximise socio-economic benefits for the water used. Strategically allocating water is relevant at both a regional and local level.

Saldanha Bay Local Municipality (SBLM), as a downstream user in the Berg WMA, has recognised the need to foster a decision-making environment which can effectively manage the municipality's water service delivery requirements through a systematic and explicit treatment of trade-offs. The provision of water is challenging in SBLM as the area has experienced significant population growth in recent times, with supply levels remaining constant. Adding to these challenges, the expansion of industrial activity in the area could soon result in a situation where demand for potable water exceeds supply (the municipality is already abstracting more from the WCWSS than their licence allows). The effective allocation of available water towards the municipality's development priorities is thus of paramount importance.

Interviews with local decision-makers in economic development planning and water resources planning revealed that proposed industrial projects are currently assessed individually and awarded water allocations essentially on a first-come-first-served basis. However, there was also an acknowledgement that this approach is not ideal and that tools and information required to be more strategic would be welcomed. Out of these discussions came the idea of developing a tool that could assist in the prioritisation of requests for water allocation from industry on the basis of the development gains to be realised.

Furthermore, GreenCape had gathered data on major proposed developments in the area during the scoping phase of the project (GreenCape, 2015) and their associated water requirements. Subsequent to the scoping study, DED&T commissioned the West Coast Industrial Plan (WCIP): a study to detail all major proposed developments in the area, evaluating all of their major resource requirements (land, energy, roads, skills requirements, etc.) (DED&T, 2016). This study formed a required data baseline for the local prioritisation tool. Maintaining an updated repository of information on proposed developments, and the water requirement thereof, is an on-going process that, since the scoping phase, DED&T has recognised as necessary and will need to continue with.

7.2. Multi-Criteria Decision Analysis (MCDA) and municipal decision-making

In discussions with the SBLM officials, it was apparent that water required from a new development was the most important criteria that they wished to evaluate in comparison to the other benefits and costs that a development may bring to the area, but that water demand alone would not be the only basis for a decision. It was also recognised that decision-making would likely require the input of multiple individuals with varying and possibly even competing goals. Cost-Benefit Analysis (CBA) was considered, but given that the approach requires variables to be monetised, it was found to be unsuitable. After some discussion, a Multi-Criteria Decision Analysis (MCDA) approach was identified as most appropriate for providing general guidance in the development of the tool. MCDA allows decision-makers to evaluate alternative options based on a diverse range of criteria, regardless of the units used to measure them. The criteria can be assigned varying levels of importance or weight, allowing for differing levels of prioritisation. The result is a set of weighted scores which can be used to evaluate alternatives. The approach also lends itself particularly well to group decision-making environments (Geneletti, 2007). Furthermore, the availability of the recently published WCIP was fortuitous, given that the study details all the key proposed developments in the Saldanha Bay area and includes an evaluation of their major resource requirements (water, land, energy, transport, etc.) and some of their likely socio-economic benefits (operational jobs, construction jobs, capital investment) for the area.

Having gained an understanding of the approach which would be used as well as a potential data sources, a series of meetings were held with representatives from SBLM. There was an iterative process of identifying ideal criteria to be used in evaluating industrial projects, and scrutinising how practical they were primarily based on data availability and/or the ease with which they could be estimated by managers. This process resulted in a list of five criteria, three of which could be informed directly from the WCIP dataset and two of which would require considered input from various municipal managers with adequate knowledge of the proposals being considered.

A succession of workshops and internal project meetings were also held to improve the integrity and robustness of the model. Input was thus received from professionals in the private sector, provincial government representatives and academics all of which informed iterations. The development of the model was strongly guided by the desire to produce a user-friendly product to aid decisions and highlighting trade-offs between alternatives in an environment of competing interests. Ultimately the tool's utility lies in its ability to enrich the user's decision-making process.

7.3. Overview of the tool

This section provides step-by-step guidance on how to use the tool. There are five sections, outlining the various Microsoft Excel sheets which comprise the tool. A schematic overview is provided Figure 59, which shows how the processes of alternative selection, criteria selection, criteria scoring and criteria weighting come together to generate results which can inform decision-making.

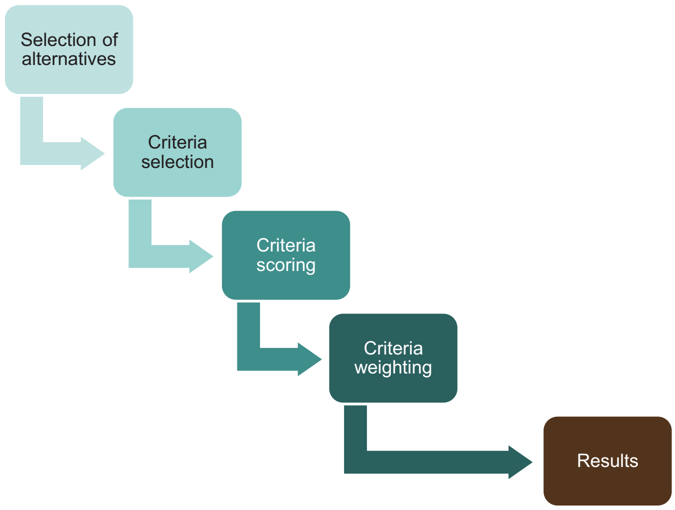


Figure 5922: Schematic showing the different processes making up the tool

The following sub-sections contain a closer look at each of the above processes using an instructional style.

7.3.1. Selection of alternatives

The first process has one step – list the alternatives that you wish to consider in the box. A maximum of 30 alternatives can be entered and compared using the tool.

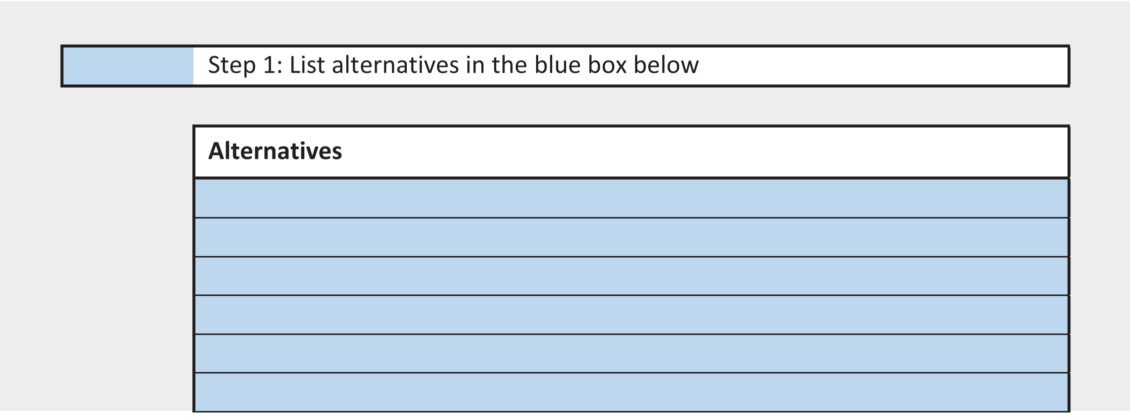


Figure 60: Selection of alternatives

7.3.2. Criteria selection and metrics

This process will establish which criteria the alternatives are to be measured by, how they are to be measured, and briefly consider the users' preferences towards the criteria. This entails five steps.

7.3.2.1. Step 1

Enter the range of criteria which are to be considered. Begin with the most important criterion. This will be the reference criterion, and will be used later when determining the relative importance of all the other criteria. Beyond this first criterion, the ordering of the other criteria is unimportant.

Criteria (singular – **criterion**) are the attributes selected to be used in evaluating an alternative. For example, one might evaluate a car based on its price, its rate of fuel consumption, or perhaps by engine performance.

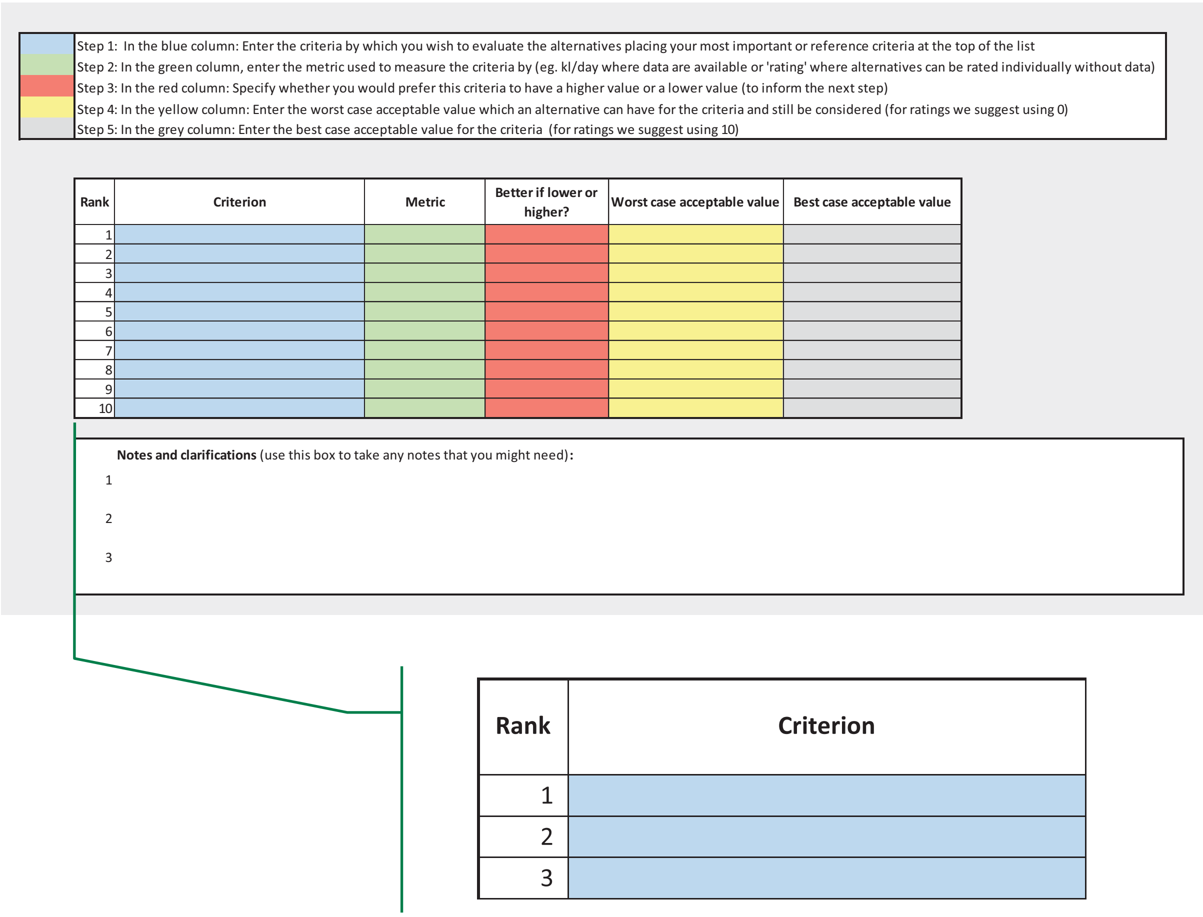


Figure 61: Criteria definition

7.3.2.2. Step 2

Enter the metrics by which the various criteria will be measured. Where data are available, these will simply be the units in which the data are represented. Where criteria are to be rated by the user, the metric could simply be ‘rating’.

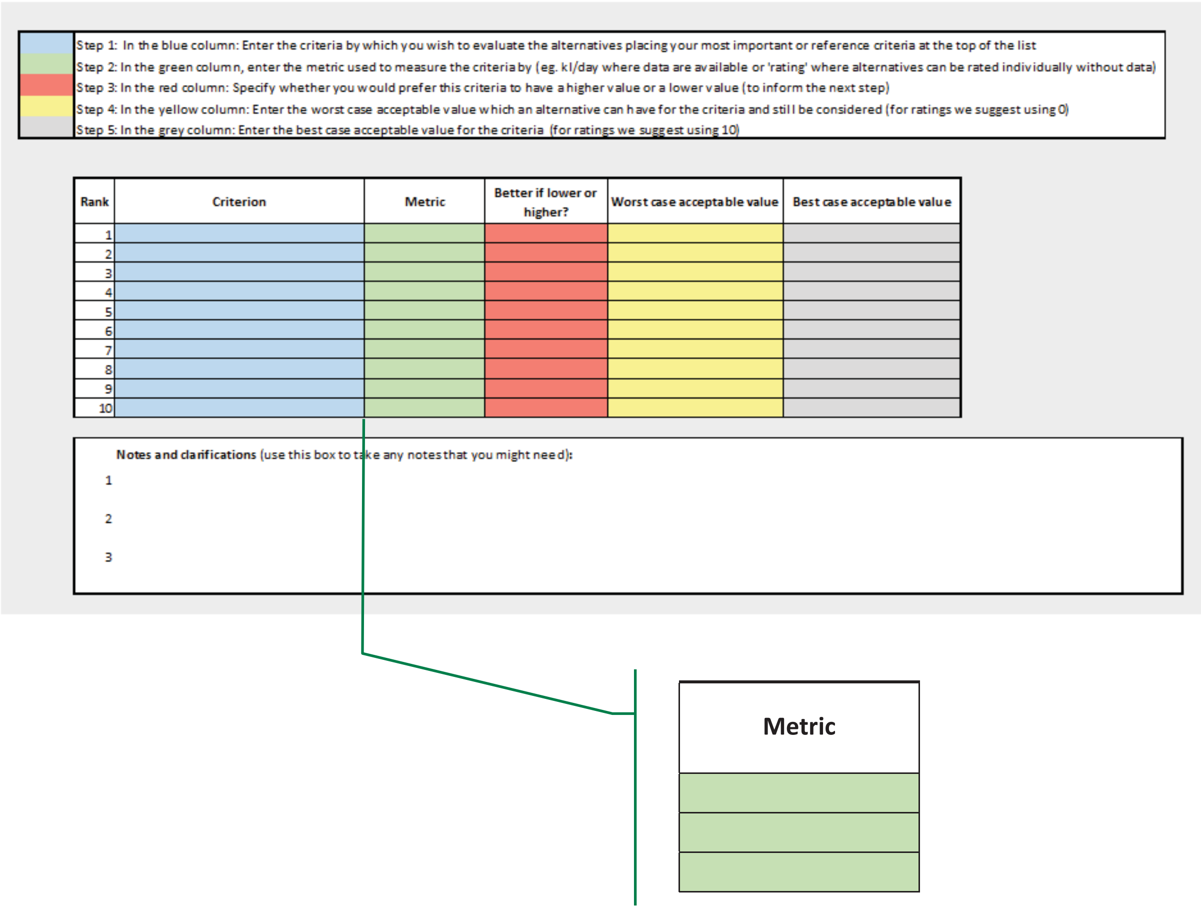


Figure 62: Criteria Metrics

7.3.2.3. Step 3

Next, decide whether it would be preferable for the value of each criterion to be lower or higher. In the red column, enter either ‘lower’ or ‘higher’. For example, one might favour a project with a low potable water use, but when it comes to a criterion such as operational jobs, a higher figure would probably be preferred.

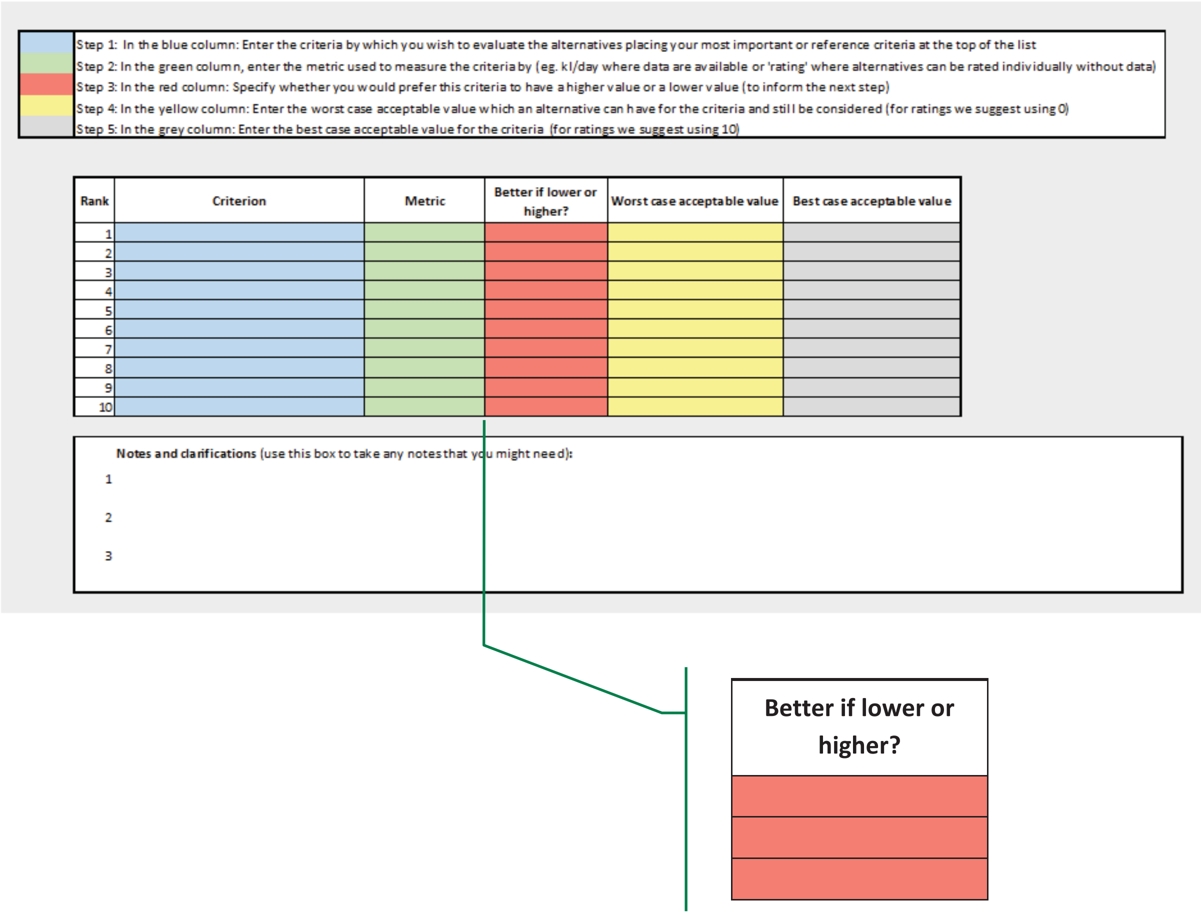


Figure 63: Criteria positive or negative relationship

7.3.2.4. Step 4

During this step, decide what the worst case acceptable value would be for each criterion. Where the preference is for the criterion to be higher, this value would be relatively low and usually set to “0”. Where criteria are preferred to be lower, this value can be set at the cut-off point beyond which alternatives would not be considered at all.

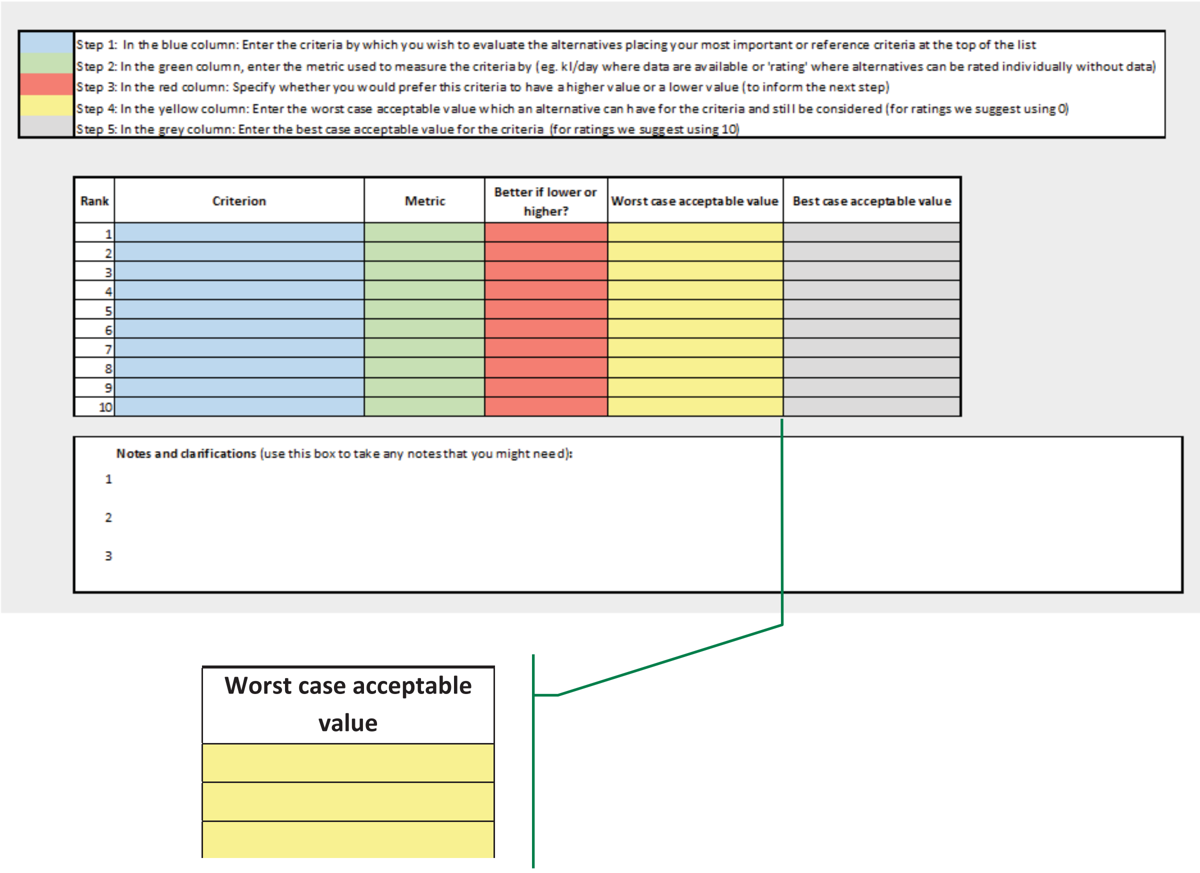


Figure 64: Criteria worst case acceptable value

7.3.2.5. Step 5

Decide on the best-case acceptable value for each criterion. This figure should be arrived at by carefully considering what the best-case value is that one could expect for each criterion. Where the goal is to have as low a value as possible this could simply be “0”, but where the goal is to have a large amount (ie. where it is better for the criterion to be higher), care must be taken to ensure that none of the alternatives end up with a higher number than what is decided on for this value. At the same time, the number should not be unreasonably high, and it should at least be conceivable that an alternative could have a value this high for each particular criterion. If the criterion is a rating-based and better when higher, the most straightforward approach would be to set this value to “100”.

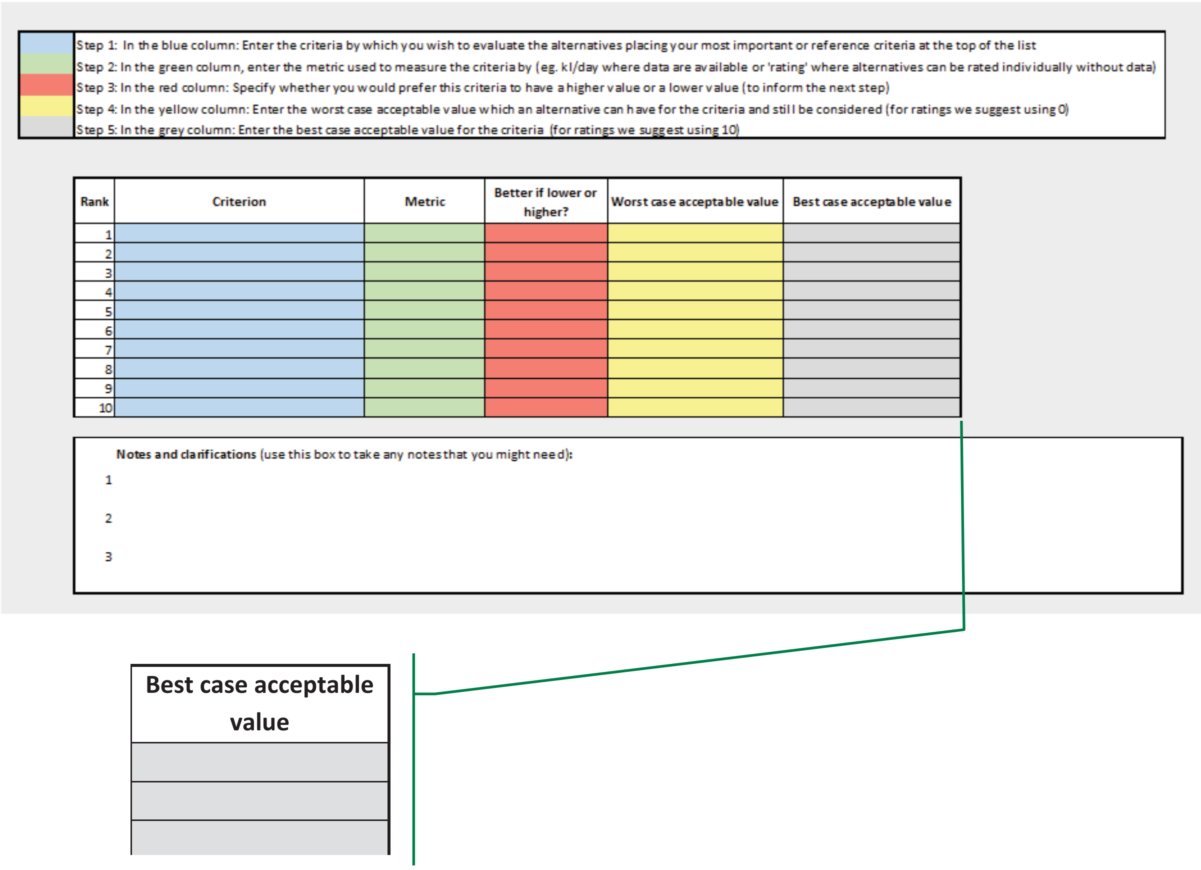


Figure 65: Criteria best case acceptable value

7.3.3. Criteria scoring

The criteria scoring process must be completed for each of the criteria selected in Section 7.3.2.1. For each criterion, there are 4 steps guiding the user through the formulation of a value function and the subsequent scoring of each alternative.

The goal of formulating a **value function** is to be able to express (in mathematical and graphical formats) the value which the user attaches to a criterion and how this value changes according to the range of quantities in which it could potentially be experienced.

7.3.3.1. Step 1

This step only applies if there are no data on the criterion being considered, and each project will thus need to be rated based on the knowledge held by the user. Where data do exist, proceed directly to Step 2. Where projects will need to be rated, use the blue box to develop a legend outlining information for rating alternatives, indicating what different ratings would mean in terms of project characteristics.

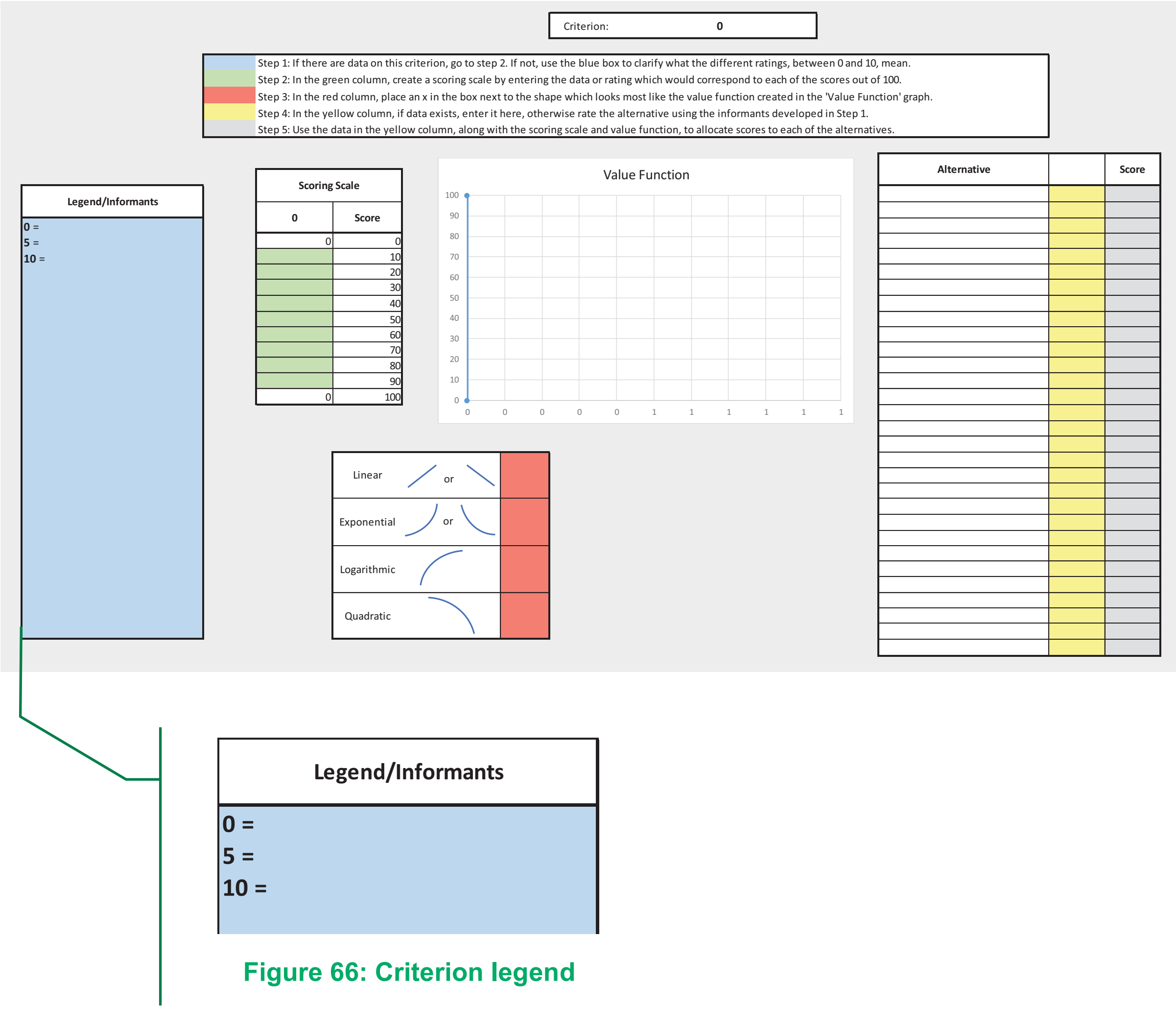


Figure 66: Criterion legend

7.3.3.2. Step 2

Consider the range of values which fall in between the worst case acceptable value and the best case acceptable value, and how these are to be distributed. In the green table, shown below, the worst-case acceptable value is automatically allocated a score of 0, and the best-case value is automatically scored at 100. Decide which values would be allocated a score of 10, 20, 30… up to 90. Instead of performing this exercise in a linear way, enter the values which you feel the most confident about first, such as the mid-way score of 50. Alternatively, perform the thought exercise of considering what a particular value would score for a number of different values and check the consistency of these scores with the overall value function.

As values are allocated to the various scores, the value function will materialise automatically in the graph next to the table (i.e. the tool has been programmed to generate value functions). You can then use this function as a guide to recalibrate how the different values relate to the scores. It is helpful to experiment with different numbers at this stage, revisiting and changing values until the graph shows a value function which you believe accurately reflects your preferences.

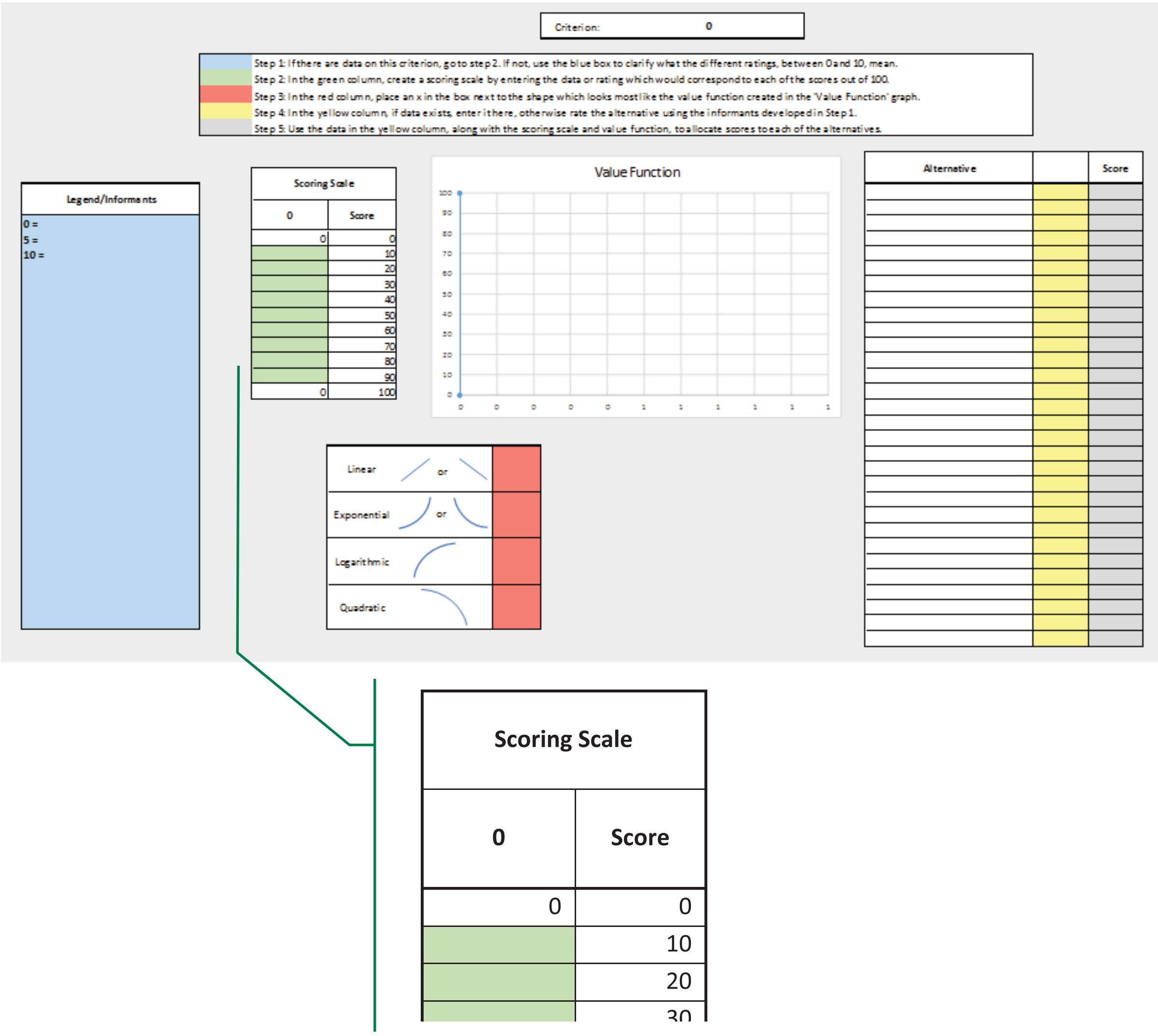


Figure 67: Criterion scoring scale

7.3.3.3. Step 3

Once values have been allocated to the different scores, the value function will have taken on a definite shape. Compare this shape to the pre-defined shapes in the table below and check the box next to the shape which most resembles the value function arrived at.

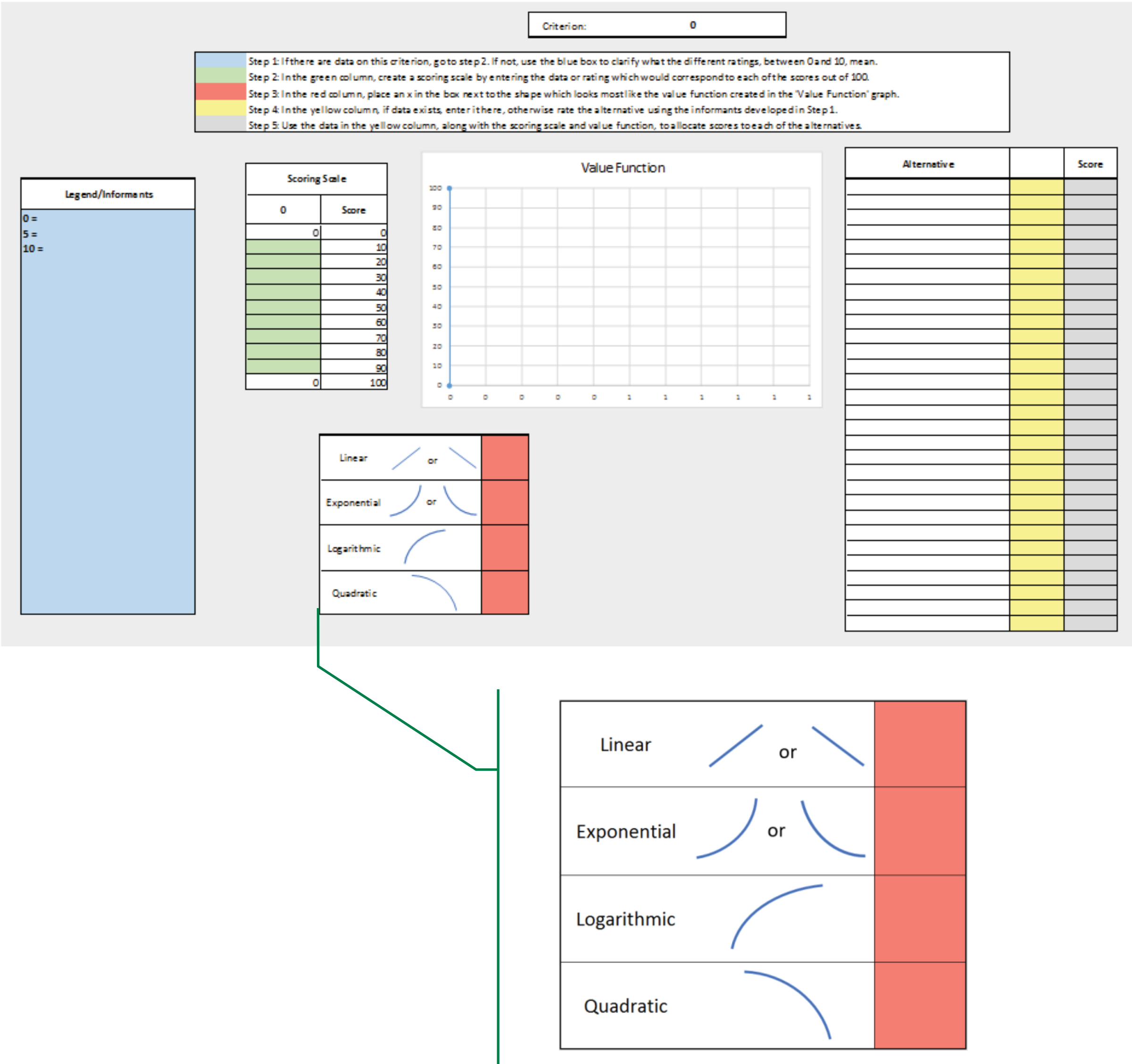


Figure 68: Value function shapes

7.3.3.4. Step 4

Once the value function has been established and the shape identified, the next step is to consider the alternatives being evaluated. In the final box on this sheet, enter data on the individual alternatives in the yellow column. For some criteria, data will already exist. For example, for operational jobs one will need to enter the number of operational jobs which each alternative is likely to create. For other criteria, a judgement may be required. For example, if the criterion is measured as a score from 0 to 100, manually rate each project on a scale between 0 and 100.

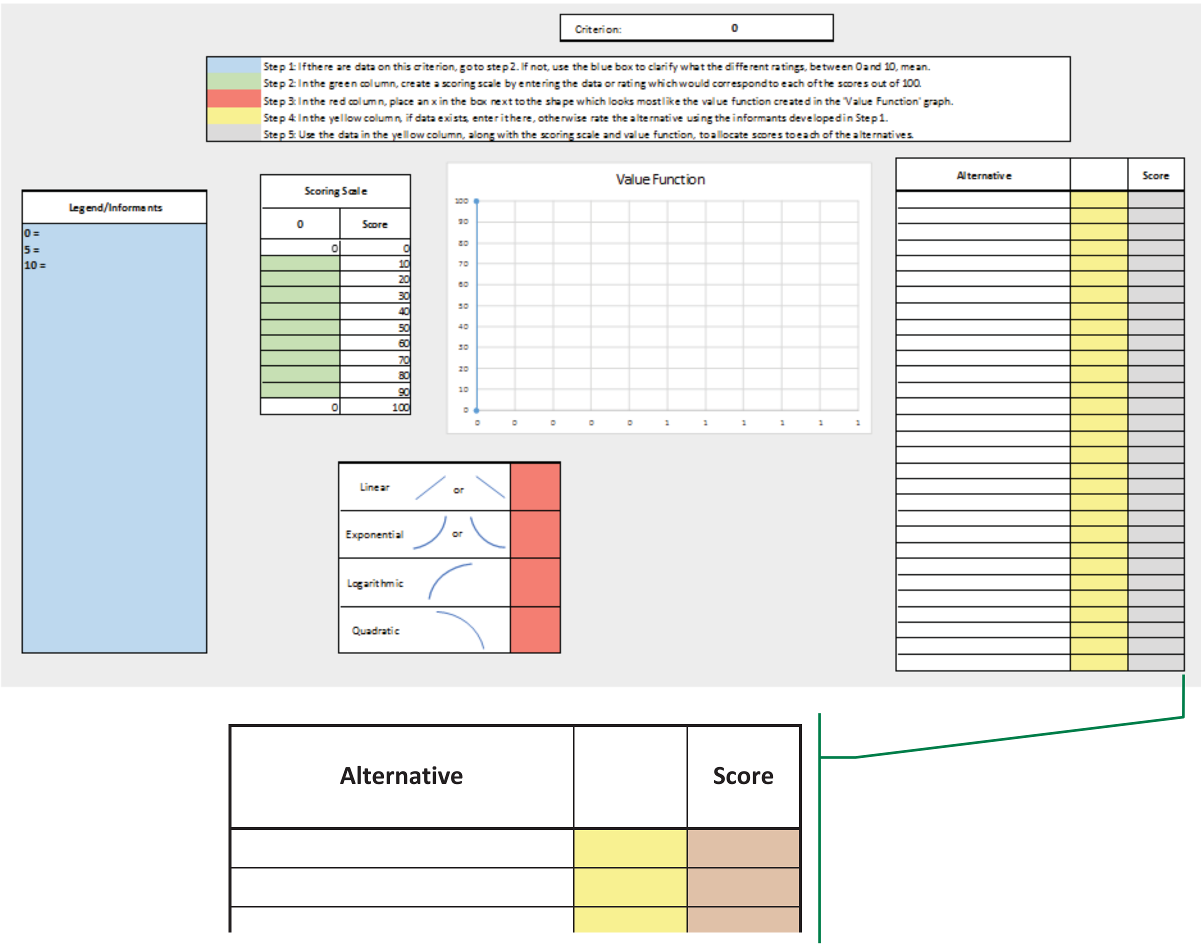


Figure 69: Alternative scoring

7.3.3.5. Step 5

Using the data entered in the yellow column, along with the Scoring Scale and Value Function as guiding tools, enter a score for each alternative in the grey column.

The procedure outlined in Steps 1 to 5 of this section will need to be completed several times, depending on the number of criteria selected on the 'Criteria' page. For example, if alternatives are being evaluated based on 3 criteria, then the sheets titled 'Crit 1', 'Crit 2' and 'Crit 3' all need to be filled out.

7.3.4. Criteria weighting

The final sheet to consider is the 'Weighting' sheet. The purpose of this sheet is to determine the relative importance of the different criteria. Note that there are two ways this can be done:

1. Answer the trade-off questions in the blue boxes (this is the more theoretically correct manner to calculate weights)
2. Enter weights manually in the red boxes (can also work well particularly when trade-offs are understood)

The instructions below will proceed on the basis that the user wishes to try the first approach and, failing a satisfactory result, move to the second approach.

7.3.4.1. Step 1

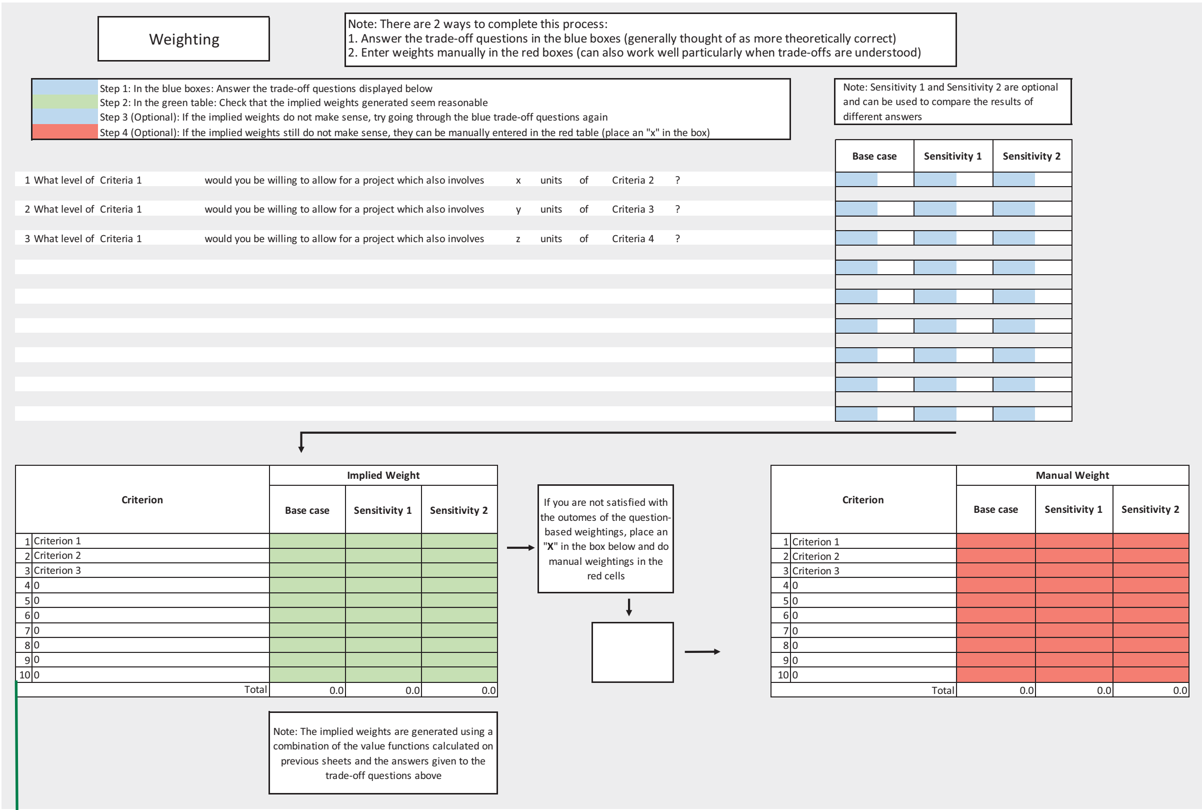
On the left-most part of the sheet, the user will find questions determined using the answers given in previous parts of the exercise. The number of questions will be one less than the number of criteria specified. For example, if three criteria were entered previously, there will be two questions. The questions use the first criterion entered as a reference criterion, and are set up in a way as to determine, for any given alternative, how much of the reference criterion one would be willing to trade-off against the full amount of each of the other criteria. On the right side is a box with blue-shaded cells. These cells are where the questions must be answered. Provision is made for two sensitivity tests. That is, one has the option to enter one answer in the 'selected/favoured' column, as well as two additional answers in the 'sensitivity 1' and 'sensitivity 2' columns.

Figure 7023: Weighting questions

7.3.4.2. Step 2

Once the blue cells have been populated, the tool will take the answers given, combined with the value functions determined previously, and calculate the inferred weighting for each criterion. This weighting should reflect the relative importance of each of the criteria. A higher weighting suggests that a criterion is more important. Altogether the weights should add up to 100.

Step 2 simply entails checking that the weightings generated are an accurate reflection of the importance which each of the criteria has for the decision at hand.



Criterion	Implied Weight		
	Base case	Sensitivity 1	Sensitivity 2
1 Criterion 1			
2 Criterion 2			
3 Criterion 3			

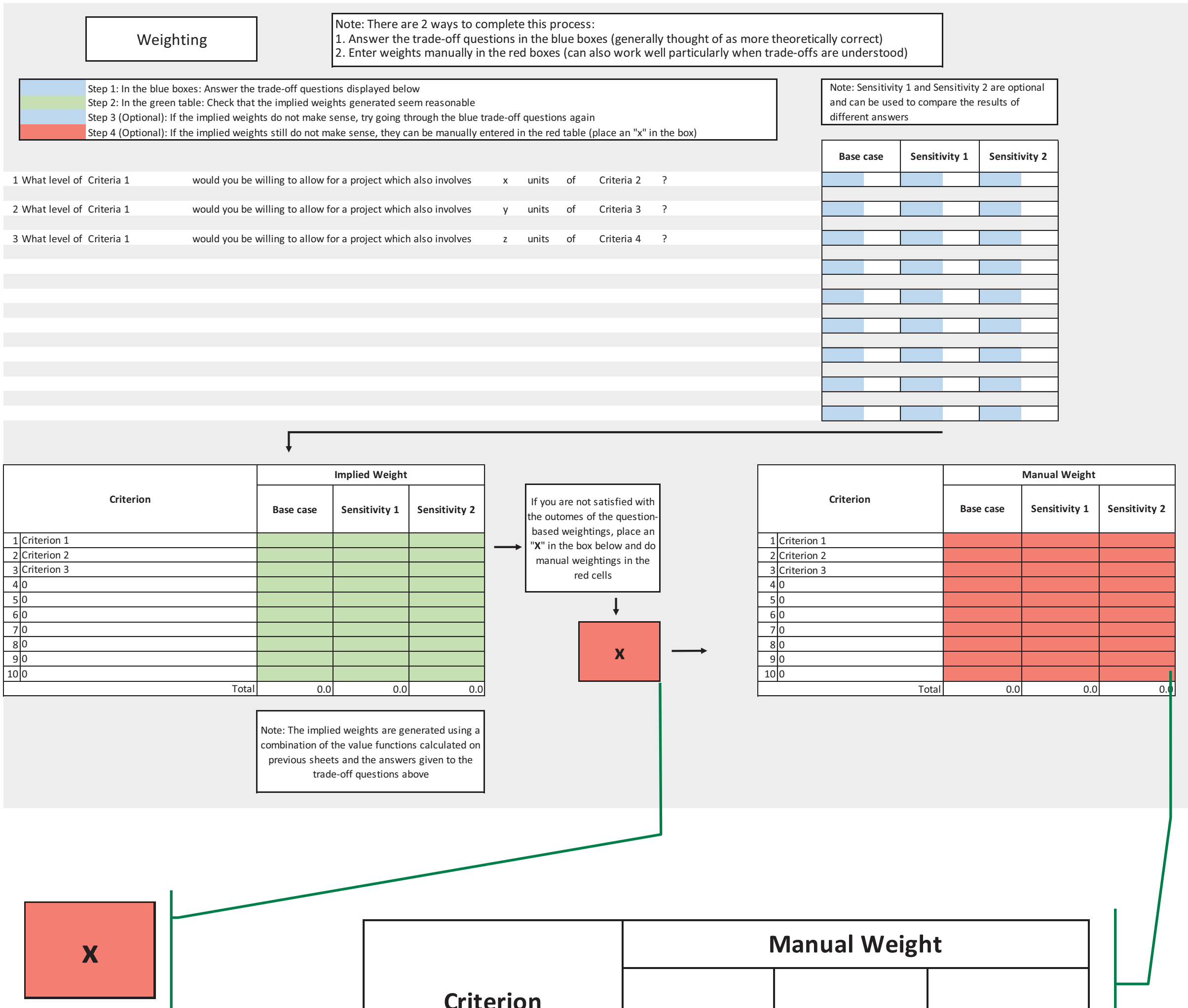
Figure 71: Implied weights

7.3.4.3. Step 3

If the weightings generated do not seem reasonable, it is recommended that the answers provided to the questions be reconsidered and adjusted if necessary. This process can be repeated until you are comfortable with the weightings generated.

7.3.4.4. Step 4

If, after reconsidering the answers provided, the implied weights generated still do not seem correct, the user may consider the manual weighting option. To select the manual weighting option, place an 'x' in the box between the two weighting tables and proceed to enter the manual weights in the red columns as shown below.



Criterion		Manual Weight		
		Base case	Sensitivity 1	Sensitivity 2
1	Criterion 1			
2	Criterion 2			
3	Criterion 3			

Figure 72: Manual weights

7.3.5. Generated results

The results sheet will automatically display the alternatives and their scores under the ‘base case’ weighting, the ‘sensitivity 1’ weighting and the ‘sensitivity 2’ weighting respectively. Here it is useful to consider how well each alternative performed under the three different weighting combinations. For example, one alternative might achieve a high score under the ‘base case’ weighting combination and a lower score under the ‘sensitivity 1’ weighting combination, based on the different emphases which each of the weighting combinations place on the various criteria. The layout is shown below.

Alternative	Weighted Score		
	Base case	Sensitivity 1	Sensitivity 2

Figure 73: Alternative results

At this point it is useful to consider the different trade-offs involved between criteria and whether the weighted score provides a fair representation of your overall preference for each of the alternatives.

7.4. Application of tool in Saldanha Bay

This section demonstrates the workings of the tool by showing an example – the ranking of a group of industrial projects proposed in the Saldanha Bay area. Alternatives were selected purely for illustrative purposes to reflect a broad selection of the types of developments currently proposed in the area. The findings are the result of three meetings held with the SBLM and reflect the opinions of the municipal officials present. During these meetings, various representatives provided input regarding the selection and prioritisation of criteria, construction of value functions, rating of alternatives and weighting of the various criteria.

7.4.1. Alternatives

A subset of projects was chosen from the West Coast Industrial Plan (WCIP). As the exercise was one to demonstrate the tool and familiarise the municipal officials with the tool, the projects were chosen purely because they illustrate typical projects in different sectors and as adequate data was available for them.

Step 1: List alternatives in the blue box below

Alternatives
IDZ
Afrisam - Phase 1
Elandsfontein 1
ArcelorMittal
Mineral beneficiation plant
TNPA Rig repair at Berth 205

Figure 74: WCIP alternatives

7.4.2. Criteria selection and metrics

The selection of criteria was guided by a consideration of municipal priorities, as well as by the recognition of constraints in data availability.

7.4.2.1. Step 1

Five criteria were identified by municipal representatives as important and feasible for inclusion in the analysis. The criterion deemed to be most important was potable water use, and it was thus chosen as the reference criterion. The other criteria selected by the SBLM representatives were non-potable water use, operational jobs, potential for local jobs and benefits, and environmental impacts, as shown below.

Step 1: In the blue column: Enter the criteria by which you wish to evaluate the alternatives placing your most important or reference criteria at the top of the list
Step 2: In the green column, enter the metric used to measure the criteria by (eg. kl/day where data are available or 'rating' where alternatives can be rated individually without data)
Step 3: In the red column: Specify whether you would prefer this criteria to have a higher value or a lower value (to inform the next step)
Step 4: In the yellow column: Enter the worst case acceptable value which an alternative can have for the criteria and still be considered (for ratings we suggest using 0)
Step 5: In the grey column: Enter the best case acceptable value for the criteria (for ratings we suggest using 10)

Rank	Criterion	Metric	Better if lower or higher?	Worst case acceptable value	Best case acceptable value
1	Potable water use	Kl/day	lower	5000	0
2	Non-potable water use	Kl/day	higher	0	1000
3	Operational job creation	jobs	higher	0	3000
4	Potential for local jobs and benefits	rating	higher	0	10
5	Environmental impacts	rating	higher	0	10
6	Criterion 6				
7	Criterion 7				
8	Criterion 8				
9	Criterion 9				
10	Criterion 10				

Notes and clarifications:

1 Potential for local jobs and benefits will also partially reflect indirect strain on municipal services (i.e. projects that employ more locals result in less in-migration and therfore less risk of additional strain on services).

2

3

Rank	Criterion
1	Potable water use
2	Non-potable water use
3	Operational job creation
4	Potential for local jobs and benefits
5	Environmental impacts

Figure 75: Selected criteria for SBLM evaluation

7.4.2.2. Step 2

The first two criteria, potable and non-potable water use, were measured in ‘kilolitres per day’. Operational jobs are measured as a discrete number – ‘jobs’. Both potential for local jobs and benefits and environmental impacts are criteria for which data did not exist. Alternatives were therefore evaluated on a scale from 0 to 10, using a ‘rating’.

Step 1: In the blue column: Enter the criteria by which you wish to evaluate the alternatives placing your most important or reference criteria at the top of the list
Step 2: In the green column, enter the metric used to measure the criteria by (eg. kl/day where data are available or 'rating' where alternatives can be rated individually without data)
Step 3: In the red column: Specify whether you would prefer this criteria to have a higher value or a lower value (to inform the next step)
Step 4: In the yellow column: Enter the worst case acceptable value which an alternative can have for the criteria and still be considered (for ratings we suggest using 0)
Step 5: In the grey column: Enter the best case acceptable value for the criteria (for ratings we suggest using 10)

Rank	Criterion	Metric	Better if lower or higher?	Worst case acceptable value	Best case acceptable value
1	Potable water use	Kl/day	lower	5000	0
2	Non-potable water use	Kl/day	higher	0	1000
3	Operational job creation	jobs	higher	0	3000
4	Potential for local jobs and benefits	rating	higher	0	10
5	Environmental impacts	rating	higher	0	10
6	Criterion 6				
7	Criterion 7				
8	Criterion 8				
9	Criterion 9				
10	Criterion 10				

Notes and clarifications:

1 Potential for local jobs and benefits will also partially reflect indirect strain on municipal services (i.e. projects that employ more locals result in less in-migration and therfore less risk of additional strain on services).
2
3

Metric
Kl/day
Kl/day
jobs
rating
rating

Figure 76: SBLM criteria metrics

7.4.2.3. Step 3

Potable water use was found to be a negative criterion. Thus, a project which used less potable water was preferred to a project which used more. It was therefore better for the value to be lower. For all other criteria, a higher value was found to be preferable.

Step 1: In the blue column: Enter the criteria by which you wish to evaluate the alternatives placing your most important or reference criteria at the top of the list
Step 2: In the green column, enter the metric used to measure the criteria by (eg. kl/day where data are available or 'rating' where alternatives can be rated individually without data)
Step 3: In the red column: Specify whether you would prefer this criteria to have a higher value or a lower value (to inform the next step)
Step 4: In the yellow column: Enter the worst case acceptable value which an alternative can have for the criteria and still be considered (for ratings we suggest using 0)
Step 5: In the grey column: Enter the best case acceptable value for the criteria (for ratings we suggest using 10)

Rank	Criterion	Metric	Better if lower or higher?	Worst case acceptable value	Best case acceptable value
1	Potable water use	Kl/day	lower	5000	0
2	Non-potable water use	Kl/day	higher	0	1000
3	Operational job creation	jobs	higher	0	3000
4	Potential for local jobs and benefits	rating	higher	0	10
5	Environmental impacts	rating	higher	0	10
6	Criterion 6				
7	Criterion 7				
8	Criterion 8				
9	Criterion 9				
10	Criterion 10				

Notes and clarifications:

1 Potential for local jobs and benefits will also partially reflect indirect strain on municipal services (i.e. projects that employ more locals result in less in-migration and therfore less risk of additional strain on services).

2

3

Better if lower or higher?
lower
higher
higher
higher
higher

Figure 7724: Definition of criteria as positive or negative relationship

7.4.2.4. Step 4 and Step 5

For potable water use, the worst case acceptable value was arrived at by considering projects which have in the past been denied water allocation rights because their demand was too high. This experience allowed the decision makers to confidently assert that the worst case acceptable value was 5 000 kl/day. Non-potable water use had a positive association, and thus the worst case acceptable value was deemed to be 0 kl/day. Operational job creation was also considered a positive criterion, and the worst case acceptable value was thus set at 0 jobs. The worst-case rating for potential for local jobs and benefits was set to 0, as was the worst-case rating for environmental impacts.

The best-case value for potable water use was found to be 0 kl/day. In the case of non-potable water use, municipal representatives considered 1 000 kl/day to be the best case acceptable value that they could hope for. The best case acceptable value for operational jobs was set to 3 000 jobs. For both potential for local jobs and benefits and environmental impacts, the best case acceptable rating was set at 10.

Step 1: In the blue column: Enter the criteria by which you wish to evaluate the alternatives placing your most important or reference criteria at the top of the list
Step 2: In the green column, enter the metric used to measure the criteria by (eg. kl/day where data are available or 'rating' where alternatives can be rated individually without data)
Step 3: In the red column: Specify whether you would prefer this criteria to have a higher value or a lower value (to inform the next step)
Step 4: In the yellow column: Enter the worst case acceptable value which an alternative can have for the criteria and still be considered (for ratings we suggest using 0)
Step 5: In the grey column: Enter the best case acceptable value for the criteria (for ratings we suggest using 10)

Rank	Criterion	Metric	Better if lower or higher?	Worst case acceptable value	Best case acceptable value
1	Potable water use	Kl/day	lower	5000	0
2	Non-potable water use	Kl/day	higher	0	1000
3	Operational job creation	jobs	higher	0	3000
4	Potential for local jobs and benefits	rating	higher	0	10
5	Environmental impacts	rating	higher	0	10
6	Criterion 6				
7	Criterion 7				
8	Criterion 8				
9	Criterion 9				
10	Criterion 10				

Notes and clarifications:

1 Potential for local jobs and benefits will also partially reflect indirect strain on municipal services (i.e. projects that employ more locals result in less in-migration and therfore less risk of additional strain on services).

2

3

Worst case acceptable value	Best case acceptable value
5000	0
0	1000
0	3000
0	10
0	10

Figure 78: Criteria best and worst case values

7.4.3. Criteria scoring

This following section will present results from the processes used to determine the project scores for each of the criteria through the construction of individual value functions.

7.4.3.1. Potable water use

Here the municipal representatives were required to determine the shape of the value curve for potable water use. Given that the worst case acceptable value (5 000 kl/day) and the best case acceptable value (0 kl/day) had already been entered, the municipal representatives proceeded to consider a relatively noteworthy value in between, asking themselves “if a project were to use 1 000 kl/day of potable water, what sort of score would they get?”. After some debate, it was decided that such a project would score 60 points. The value function on the right of the table now began to display a graph, which could be used to calibrate the answers as they went. The municipal representatives then asked themselves what a project would score if it used 4 000 kl/day of potable water. The answer was found to be 10 points. The value function had now begun to take shape and the municipal representatives could rely on it more to infer what their answers would be for projects scoring between 10 and 60, and between 60 and 100. Based on the graphical representation of the created value function, the municipal representatives could infer that the function looked most like an exponential one, and the appropriate box was selected.

Having entered project potable water use data in the yellow column, the municipal representatives went on to generate the scores shown below. It can be seen that *TNPA Rig repair at Berth 205* scored the maximum of 100 points, having a potable water use of 0 kl/day. *Afrisam – Phase 1*’s potable water use was also very close to 0, and so the project was given 99 points. The project which scored the lowest was the *IDZ*, using 1 453 kl/day and thus scoring 46 points.

Scoring Scale	
Kl/day	**Score**
5000	0
4000	10
2750	20
2250	30
1750	40
1350	50
1000	60
800	70
500	80
200	90
0	100

Figure 80: Potable water use scores

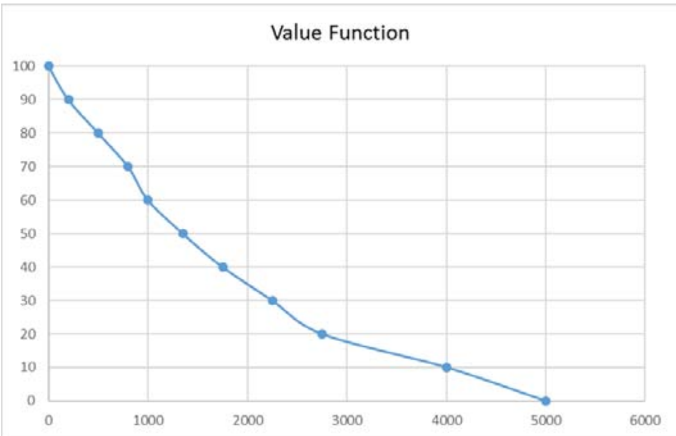


Figure 79: Potable water use value function graph

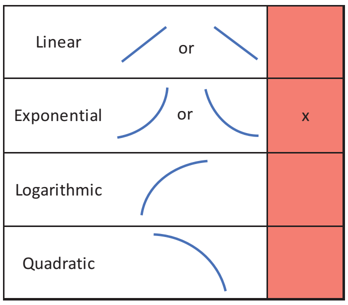


Figure 82: Potable water use shape

Alternative	Kl/day	Score
IDZ	1453	46
Afrisam - Phase 1	8	99
Elandsfontein 1	160	94
ArcelorMittal	411	82
Mineral beneficiation plant	1227	53
TNPA Rig repair at Berth 205	0	100

Figure 81: Potable water use project alternative values and scores

7.4.3.2. Non-potable water use

Establishing the value function for non-potable water use was relatively straightforward. The municipal representatives had already established that the best case acceptable use of non-potable water was 1 000 kl/day. Any project using more than or equal to this value would thus get 100 points. The municipal representatives felt that their preferences for non-potable water use were linear, and that projects using 100 kl/day should receive 10 points, 200 kl/day – 20 points, and so forth.

The linear function was thus selected with an ‘x’ and the non-potable water use data was entered for each project. The projects were then scored, as shown below. Most of the projects did not report any non-potable water use requirements and thus scored 0. According to the WCIP, *Elandsfontein 1* had a requirement of 3 040 kl/day. Because this is greater than the best case acceptable 1 000 kl/day, this project scored the full 100 points.

Scoring Scale	
Kl/day	**Score**
0	0
100	10
200	20
300	30
400	40
500	50
600	60
700	70
800	80
900	90
1000	100

Figure 84: Non-potable water use scores

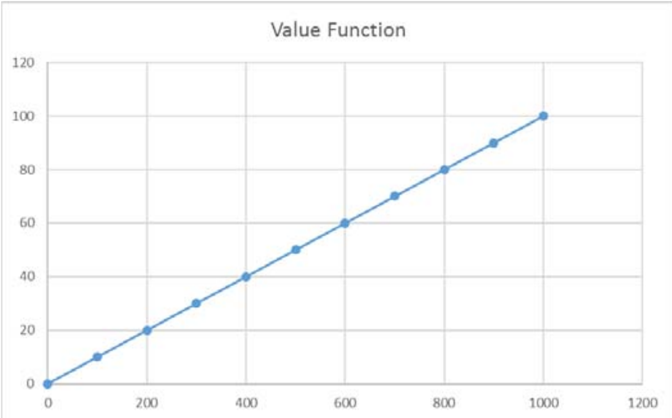


Figure 83: Non-potable water use value function graph

Linear or		x
Exponential or		
Logarithmic		
Quadratic		

Figure 86: Non-potable water use shape

Alternative	Kl/day	Score
IDZ	0	0
Afrisam - Phase 1	100	10
Elandsfontein 1	3040	100
ArcelorMittal	0	0
Mineral beneficiation plant	0	0
TNPA Rig repair at Berth 205	0	0

Figure 85: Non-potable water use project alternative values and scores

7.4.3.3. Operational job creation

In establishing the value function for operational job creation, municipal representatives began by considering how many jobs a project would have to generate to score 50 points. The answer was thought to be 300 jobs. Given that the best-case number of jobs was thought to be 3 000, the value function immediately showed a somewhat logarithmic shape. Projects generating anywhere between 0 and 10% of the best-case number of jobs would score between 0 and 50% of the maximum score.

Therefore, 300 can be thought of as a threshold figure in this case, and the graphical representation of the value function shown below shows that the function is almost linear on either side of 300.

Overall, the function was thought to be logarithmic and, having entered the data on each of the projects the municipal representatives went on to generate scores. *ArcelorMittal* scored the lowest (8) as it would generate the fewest jobs (45). *TNPA Rig repair at Berth 205* would generate the highest number of jobs (2 800) and thus scored 97 points.

Scoring Scale	
jobs	**Score**
0	0
50	10
100	20
150	30
200	40
300	50
800	60
1300	70
1800	80
2500	90
3000	100

Figure 88: Operational jobs scores

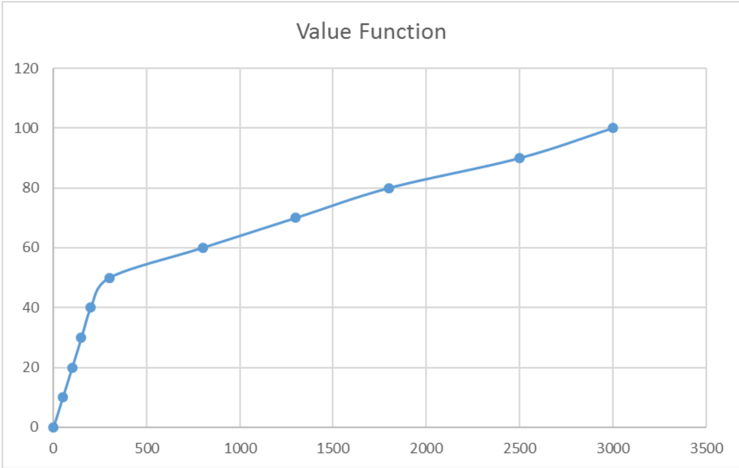


Figure 87: Operational jobs value function graph

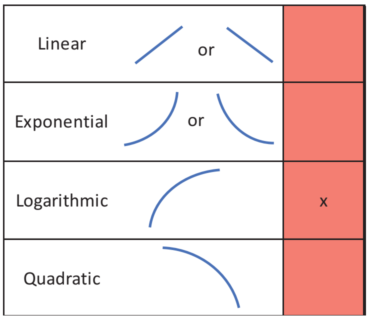


Figure 90: Operational jobs shape

Alternative	jobs	Score
IDZ	2602	92
Afrisam - Phase 1	113	22
Elandsfontein 1	284	48
ArcelorMittal	45	8
Mineral beneficiation plant	181	37
TNPA Rig repair at Berth 205	2800	97

Figure 89: Operational jobs alternatives values and scores

7.4.3.4. Potential for local jobs and benefits

The potential for local jobs and benefits criterion did not have any data and was thus chosen to be a rating-based criterion. The following guidance was developed to inform the project ratings:

Legends/Informants
0 = not compatible with socio-economic development goals with very limited benefit for local economy (all employees are from elsewhere, all expenditure is directed elsewhere) 5 = moderately compatible with socio-economic development goals with moderate impact on local economy (50/50 split between employees that are local and from elsewhere, expenditure partially sourced locally, partially from elsewhere) 10 = highly compatible with socio-economic development goals with maximal impact on local economy (75/25 or higher split between employees that are local and from elsewhere, high level of local expenditure)

To keep things simple, the value function was made linear, with the ratings varying proportionately with score (1 = 10, 2 = 20, 3 = 30, etc.). The rating box was updated accordingly and an ‘x’ placed next to the linear curve.

The municipal representatives were then asked to rate the projects. *Afrisam – Phase 1* and *Elandsfontein* were both predicted to be ‘highly compatible with socio-economic development goals’ in the local area and were thus rated 10 each, translating into scores of 100 each. The *TNPA Rig repair at Berth 205* was thought to be the least compatible with local development goals, receiving a rating of 5 (score of 50).

Scoring Scale	
rating	Score
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80
9	90
10	100

Figure 92: Potential for local jobs scores

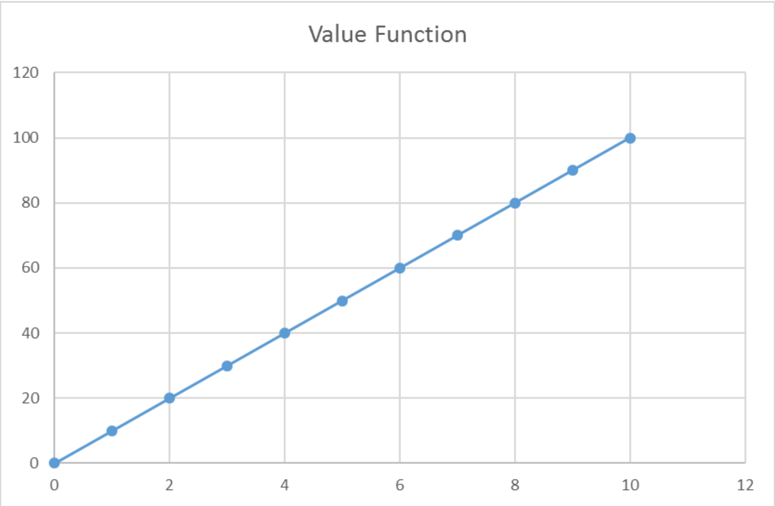


Figure 91: Potential for local jobs value function graph

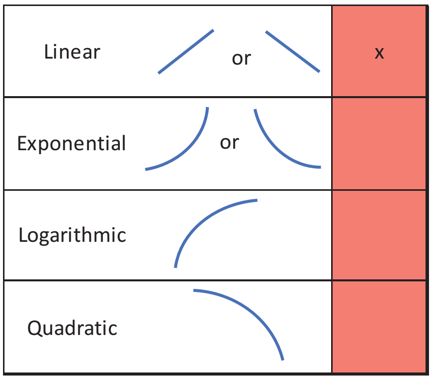


Figure 94: Potential for local jobs shape

Alternative	rating	Score
IDZ	7	70
Afrisam - Phase 1	10	100
Elandsfontein 1	10	100
ArcelorMittal	6	60
Mineral beneficiation plant	6	60
TNPA Rig repair at Berth 205	5	50

Figure 93: Potential for local jobs alternatives values and scores

7.4.3.5. Environmental Impacts

It was decided that a rating would also work best to capture the complex array of factors used to measure a project’s environmental impacts. The following guideline was developed to inform the rating process:

Legend/Informants
0 = very high impacts on any of the key environmental factors (biodiversity loss, air pollution or water pollution) regardless of mitigation measures 1 to 3 = high impacts on any of the key environmental factors, 1 = where mitigation measures have been included but are at risk of not being sufficiently implemented (technical, regulatory or cost constraints) and 3 = where mitigation measures are highly likely to be sufficiently implemented 4 to 6 = medium impacts on any of the key environmental factors, 4 = where mitigation measures have been included but are at risk of not being sufficiently implemented and 6 = where mitigation measures are highly likely to be sufficiently implemented 7 to 9 = low impacts on any of the key environmental factors, 7 = where mitigation measures have been included but are at risk of not being sufficiently implemented and 9 = where mitigation measures are highly likely to be sufficiently implemented 10 = no environmental impacts expected

The value function for environmental impacts was also made linear. The rating box was updated accordingly and the relevant curve was selected with an ‘x’.

All of the alternative projects being considered were found to have either medium or high impacts on the environment. *Afrisam – Phase 1* and the *Mineral beneficiation plant* were found to have the highest impacts on the environment and thus scored 30 points each. The rest of the projects scored either 50 or 60, as seen below.

Scoring Scale	
rating	Score
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80
9	90
10	100

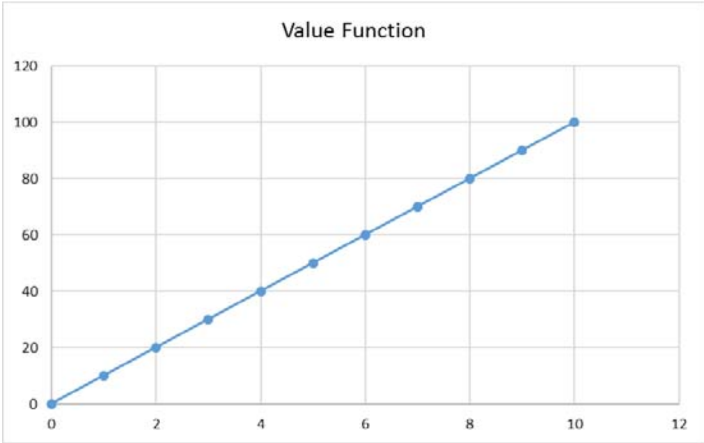
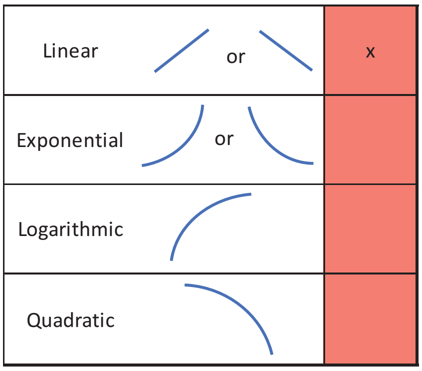


Figure 95: Environmental impact value function graph

Figure 96: Environmental impact scores



Alternative	rating	Score
IDZ	6	60
Afrisam - Phase 1	3	30
Elandsfontein 1	5	50
ArcelorMittal	6	60
Mineral beneficiation plant	3	30
TNPA Rig repair at Berth 205	6	60

Figure 97: Environmental impact values and scores

Figure 98: Environmental impact shape

7.4.4. Criteria Weighting

The final sheet to consider was the ‘Weighting’ sheet. The purpose of this sheet was to determine the relative importance of the different criteria. The municipal managers opted to go for the first of the two approaches, using the questions to generated implied weights.

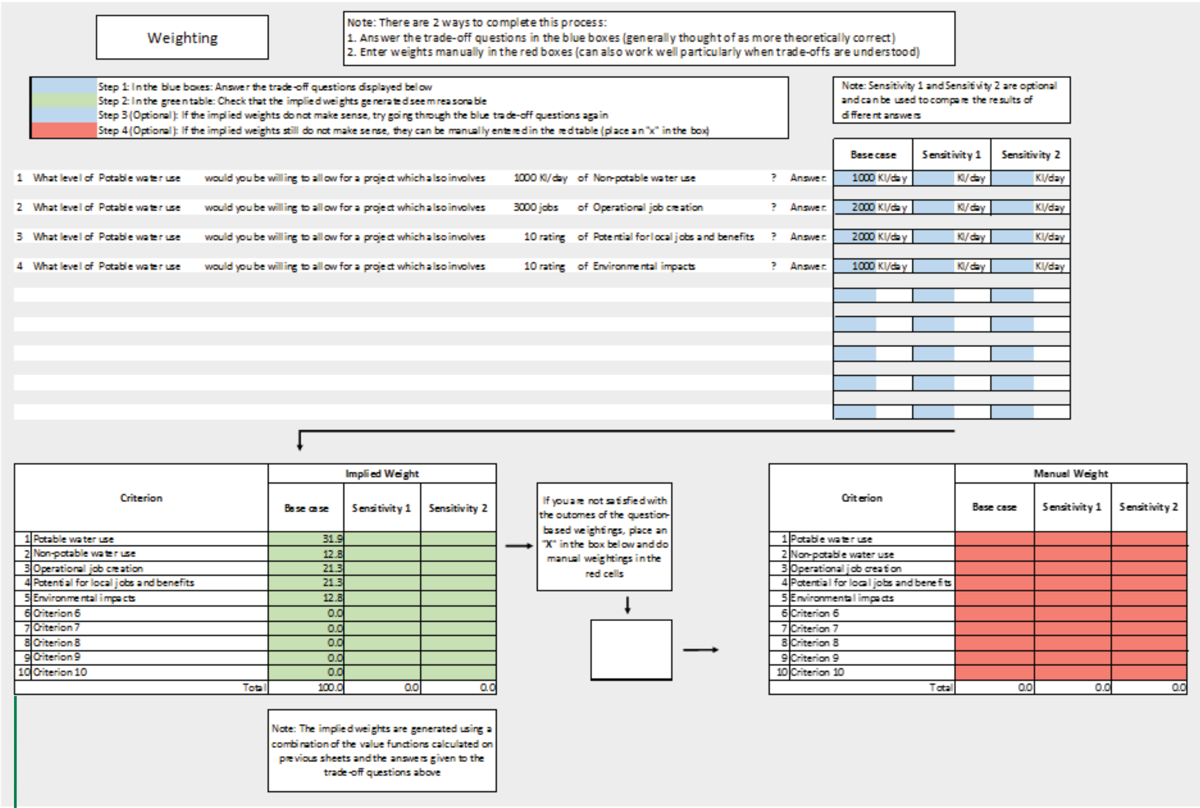
7.4.4.1. Step 1

The municipal stakeholders proceeded to answer the questions generated by the tool, considering the trade-offs implied in each. The questions were answered as shown below. It was decided that one set of answers would be sufficient, and so only the base-case questions were answered.

Figure 99: Weighting question responses

7.4.4.2. Step 2

Once the questions had been answered, the tool generated the inferred weighting for each criterion. The final task was to verify that the weightings generated were an accurate reflection of the importance which each of the criteria have for the decision at hand. The weightings generated were found to be satisfactory to the municipal representatives. They are shown below.



Criterion		Implied Weight
		Base case
1	Potable water use	31.9
2	Non-potable water use	12.8
3	Operational job creation	21.3
4	Potential for local jobs and benefits	21.3
5	Environmental impacts	12.8

Figure 100: Criteria weights for base case

7.4.5. Generated Results

The automatically generated results are outlined below. The best performing project was *Elandsfontein 1* (81) given the high scores achieved for most of the criteria, particularly for potable and non-potable water use. The *TNPA Rig repair and Berth 205* scored fairly high as well (71), as did *Afrisam – Phase 1* (63). The lowest scoring projects overall were the *Mineral beneficiation plant* (41) and *ArcelorMittal* (48). The *Industrial Development Zone (IDZ)* scored a relatively average 57 points.

Some of the municipal representatives were at first surprised that *Elandsfontein* ended up being the highest scoring project. Upon reflection, however, they realised that it made sense given the chosen criteria, scores and weights. The project should use a very small amount of potable water and a significant quantity of non-potable water, both positives. It should also employ significant numbers of unskilled workers and its potential to benefit the local economy was thus deemed to be relatively high. The environmental criterion was the only one where the project did not do well, but this criterion was not given a prominent weighting in this particular decision-making setting. This illustrates that from the context of the municipal officials evaluating these projects, that there is an appetite to trade off environmental impacts in favour of improved socioeconomic outcomes when limited water resources are required.

Another interesting result was the *IDZ* achieving an average weighted score relative to the other alternatives, despite the project being a strategic priority for both provincial and national government. However, again, this score was clearly explained through its relatively high potable water use, the lack of requirements for non-potable water, and although there are expected to be a high number of jobs generated, these were not seen to be highly compatible with the existing skill-sets of the local population. Therefore many of these jobs will likely result in in-migration to the area, increasing pressure on existing municipal services.

Alternative	Weighted Score
	Base case
IDZ	57
Afrisam - Phase 1	63
Elandsfontein 1	81
ArcelorMittal	48
Mineral beneficiation plant	41
TNPA Rig repair at Berth 205	71

Figure 101: SBLM project alternative scoring results

It is important to note that these results are purely illustrative. The projects considered are only a subset of the 31 projects included in the WCIP, and so the conclusions that can be drawn from this ranking are limited. Furthermore, the tool has been designed to be used within a broader decision-making process – one which preferably involves stakeholder engagement and which occurs within the context of exploring options for supply-side interventions, some of them involving public-private partnerships, which could meet the needs of a growing industrial sector in SBLM.

7.5. Conclusions and insights

Achieving sustainable development in the context of limited resources is an immense challenge facing municipalities. The implications are that trade-offs may need to be made. However the consideration of trade-offs should be done in a systematic and transparent manner. The use of MCDA to guide this decision-making process provides a vehicle for dialogue, cross-sectoral collaboration and exposes the preferences of the municipal officials that may not otherwise be apparent.

The MCDA process undertaken with the Saldanha Bay municipal officials was highly iterative and collaborative in nature, with discussions occurring between departmental officials at all stages of the process. It also evolved as the process went along, with criteria being added, amended and removed. This is the flexibility that MCDA allows. Then when the results from the WCIP sample set of projects were presented, they were not what was expected by the participants in the process. These counterintuitive results were examined carefully, but when reviewed, it became apparent why the results were generated – and they were in complete alignment with the preferences of the officials generating the results. That was the power of the process – it makes the preferences of the decision-makers explicit.

However, there are also limitations to using MCDA. Generating the value functions and the weightings can be quite complex if the criteria are not straight-forward. The weighting process in particular was quite tricky, hence the ability for a “manual override” function. This could likely be improved upon in later iterations of the tool. The use of Excel as the tool’s software platform was deliberate as it is an easily accessible, it does not require any additional software licences, nor is there a knowledge hurdle to using it. However there are limits to what Excel is able to perform and the value functions, when exponential or logarithmic, were not performing according to expectations. This meant that some values had to be manually generated. Utilising an MCDA software may have solved some of these issues, but the project team was unable to find an open-source or free MCDA software to use.

7.6. Way forward

The municipality has been provided with three Excel files:

1. A blank MCDA tool that could be used to generate results on any multi-factored decision. This tool could be utilised in other municipalities for any decision that they wish the model using MCDA. The tool has been developed with a key resource constraint around which other criteria are weighted, but this resource (or reference criterion) could also easily be cost.
2. The MCDA tool with the criteria and value functions specific to Saldanha Bay, but without any project alternatives included. This tool version therefore allows the municipality to quickly and easily evaluate project alternatives using the data available. The municipal officials can either use the tool to compare competing development applications, or they can start building a database of development applications, and for every new application that is received, they can compare to previous applications in order to benchmark its performance.
3. The MCDA tool with the WCIP projects included (as described in the section above) that can be referred to in order to provide a benchmark for new projects, or it could be added to as new project applications are submitted.

The municipality has also been provided with a detailed handover document to assist in the usage of the files. Should copies of the files be required, please email claire@greencape.co.za

In order to operationalise the use of the tool, support is being sought from the Saldanha Bay councillors and the newly appointed Municipal Manager. It is important that political support for this type of approach is secured, so that the officials involved in the decision-making process are able to effectively allocate water to new developments in a manner consistent with the development aspirations of the politicians.

8. Project insights and successes

8.1. Analytical insights

Currently the economic impact of water resource decisions, and the water resource implications of economic decisions, are not fully considered. Water is taken into account in economic planning (and vice versa), but generally as independent variables, rather than accommodating the co-dependence of water and economics. Optimally integrating water resources and economic development planning would see:

- i) available resources allocated for optimal benefit, including consideration of economic development and job creation;
- ii) the economic benefit and water intensity of different water uses informing development decisions;
- iii) the ability of future developments to fund water resources interventions taken into account in the feasibility of interventions; and
- iv) overall water resources challenges taken into account in regional development decisions.

What is needed to realise the type of integrated planning outlined above is largely provided for in legislation. However, there are significant shortcomings in the processes through which the legislation is implemented, resulting in them falling short of their intent and potential. Not all private developments are known during the development of a municipal Integrated Development Plan (IDP), and consequently considered during budgeting, which can lead to a situation where the local municipality (LM) is incapable of providing sufficient water resources for development. More fundamentally, in most cases the Water Services Development Plan (WSDP) is failing in its consideration of water resources (i.e. supply options) and only considers service requirements, essentially assuming an increase in the resource supplying that service is feasible. In the case of the Berg Water Management Area (WMA), the Berg-Olifants Catchment Management Agency (CMA) is not established, hence there is no Catchment Management Strategy (CMS) to support the IDP and WSDP process. Contributions to the IDPs, including provincial oversight, are also often rushed and serve to confirm a legislative requirement, but lack meaningful input from both government (at local, provincial and national level) and the private sector.

Water allocation, which is the mandate of the national Department of Water and Sanitation (DWS) in the absence of a CMA, functions as a licensing or authorisation process. If a water use licence application meets the necessary application requirements, and there is water available to allocate, the application is passed. The DWS has no scope (in its mandate) to, for example, wait for other potentially more economically beneficial uses of the same (limited) water resource and allocate water to this later application or benchmarks against which to compare relative merit of applications.

On a local scale (and where water resources are local), it is the responsibility of a LM to ensure that economic planning in the IDP is in line with water resources planning contained in the WSDP (given the role of a Water Service Authority (WSA)). The reality, however, is that LMs are generally not capacitated to plan accordingly. The WSAs are generally under-performing in terms of water resources planning, and over-relying on DWS to provide this role, which it provides only for regional schemes. Where adequate plans are made by WSAs, implementation slows due to hurdles such as financing. In the Berg WMA, as with many other areas, water resources are shared between many LMs, district municipalities (DMs) and a metropolitan municipality. Because of the regional nature of the scheme, DWS does coordinate planning for water resources interventions to reconcile future demand on the Western Cape Water Supply System (WCWSS). However, this coordination is also insufficient, i.e. not at the level required, given that competing applications have been submitted from various WSAs that are using the WCWSS. The DWS has been recommended to urgently resolve these competing applications, but not specifically the lack of coordination which leads to such competition (DWS, 2015a).

The various assessments of the governance structures, done as part of this study, suggest that provincial government is the most appropriate body to provide this strategic oversight and integration role. Provincial government has the potential to identify and recognise threats to development plans as a consequence of (water) resource constraints, and provide support to LMs – both in terms of appealing for funding from national government for local water resource development and by providing capacity and support in driving these processes (and in the necessary water resources assessments). In the case of the Berg WMA, this oversight role should not only focus on LMs requiring capacity support. The water resource needs and development within City of Cape Town (CoCT) also needs to be considered by provincial government, in terms of implications for the province. A more systemic/holistic view of the regional water needs and potential sources would identify the potential for economies of scale, which are currently not being adequately considered between WSAs within the Berg to prioritise the most appropriate water resources infrastructure, prior to the related water use licence applications (WULAs) being submitted to DWS for consideration.

In this study, an assessment of the value that water provides to the economy of the Berg WMA was conducted and, as with other similar studies, the results showed that water utilised for agricultural production produces less economic value than water used in urban sectors. This is reflected for both employment and GVA. Furthermore, this value is not equally distributed across the region, with the type of crops grown determining some of this difference, along with climatic conditions. Drakenstein, Swartland and Stellenbosch generate the greatest value from their agricultural water, while the City of Cape dominates in terms of value generated from urban water. A structural analysis of the water intensity of an economy was also conducted in order to understand how resilient the overall economy and those of different municipal economies are to water shocks and constraints. This also revealed that local economies in the region have highly varied water intensities. The combination of the value of water used and the intensity of this water use is important to consider. A reduction in water supply to a largely agricultural economy will not have the regional economic impacts that the same proportional reduction would have for a largely tertiary economy, like the City of Cape Town, however, the local impacts would be felt severely. (However, this does not consider the interdependence between rural and urban economies.) The local impact can be seen in the current drought where the agricultural sector has been hit hard by water restrictions and the lack of rainfall with job losses estimated to be as high as 50,000 in the Western Cape (Evans, 2017). When considering the impact that climate change may have on the water demands in the region, it was clear from the analysis that climate change will increase agricultural water requirements. Together with growing urban water demands, future water demand in the Berg WMA will exceed existing supply.

The findings from the project highlight that, without significant supply augmentation, the development ambitions of the region will be severely constrained. There are augmentation plans included in the WCWSS reconciliation strategy, however, with the exception of raising the wall of the Voëlvlei Dam, all the schemes are intended for the City of Cape Town. This makes sense when considering the impact that Cape Town has on the regional economy. But the water intensity of the other local municipalities in the Berg WMA cannot be ignored when considering how their local economies may deal with water scarcity. Furthermore, the current (2015-2017) drought has highlighted that complete reliance on surface water does not provide resilience in the midst of a changing climate – diversification of supply thus needs to be prioritised. In this context, the analysis shows that the West Coast municipalities of Swartland, Saldanha Bay and Bergrivier emerge as the municipalities where water is likely be to a significant constraint to future development, unless water supply augmentation options are urgently developed. Swartland and Saldanha Bay are rapidly growing areas, with significant development proposed for Saldanha Bay, with focus on the Industrial Development Zone (IDZ). However, these WSAs are already using more water than they have been allocated and have highly water intense economies. Without a significant structural shift in the resource base underlying their economy or an increase in their local water supply and/or active regional optimisation/coordination to obtain solutions that benefit the region as a whole, these economies will struggle to meet their development goals.

8.2. Project successes

Although the impact of the project has not been specifically assessed, there are several qualitative indications that the project findings, and the project process itself, have had positive impacts in forging greater integration between water resources development and economic development planning in the Berg WMA. The project outputs have been incorporated in a number of planning documents for the region, including the WCWSS reconciliation strategy, the Municipal Economic Review and Outlook (MERO) and the Greater Saldanha Regional Spatial Implementation Framework (GS RSIF). This implies that water resource planners and development planners are paying closer attention to the potential impact that water has on economic development and vice versa.

In recent engagements with stakeholders, there is an increasing acknowledgement that water and economic development cannot be planned in isolation. During early engagements, not all stakeholders saw the necessity for better integrated water and economic development planning. Some thought some aspects being suggested by the project team were irrelevant, being handled already, or too complex to meaningfully assess, and issues over mandate, turf and necessity muddied debate. However, the conversations occurring in the latter part of the project highlighted that the importance of integrated water and economics is now accepted. The project (along with other initiatives and the 2015-2017 drought) has had a significant contribution to this shift.

At a provincial government level, there is commitment from the Spatial Intelligence Unit of Department of Environmental Affairs and Development Planning of the Provincial Government of the Western Cape and the GIS unit at the Provincial Department of Agriculture (DoA) to utilise the regional tool GIS files in their departments once the final report has been published. This demonstrates that the research outputs have proven useful for their purposes, although they would ideally like the analysis to extend to their entire province and not just the Berg WMA (thereby also illustrating that they see value in this work).

The work conducted with Saldanha Bay Local Municipality (SBLM) on the development of the tool, was also accompanied by other conversations and engagements relating to the local municipality's water resource options. The project team has spent a substantial time in the Saldanha Bay area, working with civil society and business. This has allowed the project team to build relationships in the area and gain a clearer understanding of the local challenges. These relationships have been leveraged during the current drought, and the team has been able to assist the municipality and businesses in the areas in their drought response strategies.

Furthermore, this study funded two Masters students. They not only delivered their research dissertations, but also gained experience in applied research. Working with decision-makers on a Masters project is difficult (see discussion below), and required multiple iterations of their research proposals, methodology and analysis, but the students were able to deliver research that proved to be useful and influential.

8.3. Methodology and process insights

One of the key innovations of the project structure was to provide an avenue for research developed by academia to be guided and fully utilisable by government decision-makers. GreenCape acted as the coordinating and facilitating entity for this project, attempting to bridge the gap between the research requirements placed on the Masters students and the practical insights required by government.

This was a challenging process at times:

- The students needed to work with shifting research goals. They received feedback on their research proposals, approaches and analysis from a number of different stakeholders, and at times this was in conflict with their academic supervisor feedback. It was both confusing and frustrating for the students to not have a clear research agenda and pathway.
- The WRC requires that students contribute or are at least supported by the funding allocated. Furthermore, the research funds available are generally inadequate to support large teams or full-

time researchers (in addition to students). The initial proposal for this study therefore included time spent by students supported by their supervisors, with time spent by GreenCape in coordination. The proposal team structure, however, had too much reliance on the students to contribute to the project's core research objectives, and the supervisors were focussed on the individual dissertations rather than the overall project output. A full-time researcher (per focus area) should have been included in the proposal to deliver on the study, with supplementary research conducted by students.

- The GreenCape project team, and the stakeholders that the team worked with, needed research outputs that were useful and addressed their needs. However data constraints were a concern and therefore the models that could be feasibly utilised were not necessarily as academically robust as required for a Masters level degree (refer to the discussion in chapter 5 about the marginal value of water versus the average value). This created tension between developing tools that were useful versus academic outputs that meet university requirements for methodology, originality and rigour, but that may never be used.

The challenge of combining academic requirements in an applied research environment was overcome through splitting the reporting responsibilities of the students: they needed to deliver on their academic requirements, while at the same time deliver on the project requirements. It was not assumed that they would necessarily be the same outputs. GreenCape also played a stronger role in coordinating and filtering stakeholder feedback, only reporting on aspects that were relevant. GreenCape also took on a number of the research pieces in-house. So, although the WRC intends to support and capacitate students with the research funds, this is not always practical especially with a project of this nature that has direct and immediate relevance to and input from its ultimate beneficiaries.

Utilising multiple criteria decision analysis (MCDA) to develop the SBLM water allocation prioritisation tool allowed for greater flexibility and inclusion of different factors in comparison to a cost-benefit analysis (CBA) as originally envisioned. It also demanded a cross-sectoral engagement with a number of different municipal departments. The use of MCDA is also much more transparent than CBA and this makes preferences explicit, opening up for further dialogue. It also does not simply produce an "answer" or a figure, but rather requires engagement in the process. However, this approach also came with its own complications as it is theoretically more complex than a CBA, posing challenges for the project team, but the team was fortunately assisted by an international MCDA expert (on a voluntary basis). The development of the tool in Excel also required a number of workarounds that could have been avoided had an MCDA software had been utilised. However, programming the tool in Excel enabled the project team to gain in-depth understanding of the MCDA methodology, which had the benefit that the team could also engage the stakeholders in a manner that allowed the tool to be used correctly and not treated like a "black box" and thereby realise the wider benefits of MCDA, i.e. to enable understanding of preferences and their implications and to promote debate among stakeholders.

8.4. Concluding Remarks

Overall the project is considered a success on the basis of having developed tools that meet the needed of the intended beneficiaries, enabled capacity development for water sector challenges and allowed knowledge sharing at a national level (primarily through conference presentations and publications). Significantly, the project has had impact in terms of creating awareness of the need for integrating water resource planning and economic development planning – there is clear evidence of a change in awareness and mindset within key institutions and individuals involved in water resource planning and economic development planning in the Berg WMA, and agreement to adopt the tools in two provincial government departments. The work is considered replicable in other water constrained catchments, and with both the key institutions (ACDI and GreenCape) committed to further dissemination of the work and continued engagement with relevant stakeholders in the Berg WMA, the impact of this project is expected to be extended further in future.

9. Recommendations

9.1. Planning approaches

Based largely on the insights and way forward provided in section 4.5 and 4.6, the following actions are recommended to achieve better integrated water resources and development planning in the Berg WMA:

- The WSAs in the Berg WMA (primarily municipalities) require support for water resources planning, and in the absence of a regional water utility or water board (both of which should be explored as possible avenues to resolve this issue), this support is best provided at a provincial level by the WCG. However, tension remains with DWS regarding the WCG's involvement in water resources as this is not within their mandate. A facilitated discussion between the WSAs in the region, WCG and DWS over mandate and the potential for the formation of a separate entity (such as a water board) is recommended. This process should ideally result in an agreement over an implementation protocol, as per the Intergovernmental Relations Framework (RSA, 2005). Implementation protocols are frameworks between organs of state designed to meet the challenge of joint work. This framework is a tool or instrument for the practical application of co-operation and co-ordination between organs of state, stakeholders or other agencies. An implementation protocol should:
    - Set out clear outcomes of the joint work of the three spheres of government
    - Detail who is responsible for what task
    - Determine what resources are required for the task at hand and who will provide them
    - Set performance indicators
    - Put in place oversight mechanisms to ensure that outcomes are achieved.

  An implementation protocol for a Berg WMA regional water utility could be coordinated through the Western Cape Sustainable Water Management Plan (SWMP), and would ideally involve the pooling of resources from local government, provincial government and DWS for a feasibility study to assess the most appropriate water resource development options (see point below).
- Coordinated planning for future water resources interventions for those WSAs supplied by the WCWSS must be strengthened. Competing applications are evidence that coordination is lacking. There is currently a reliance on the WCWSS reconciliation strategy, but local municipalities (including the City of Cape Town) will need to develop their own local supplies due to a lack of viable surface water augmentation options. These local schemes should be evaluated in comparison to the potential for regional schemes that may allow for economies of scale. The most appropriate (cost effective and resource efficient when considering the whole) water resources infrastructure should be determined, prior to the related Water Use Licence Applications (WULAs) being submitted to DWS for consideration. Achieving this may require a feasibility study to be conducted (by the intergovernmental team noted above).
- In order for WSAs to perform better in terms of water resources planning, water resources planning must be strengthened in the Water Services Development Plan (WSDP) process, and as such, water resources planning strengthened in the Integrated Development Plan (IDP). Far greater emphasis needs to be placed on the availability of water resources in the WSDP and IDP when a LM is considering its development plans. This should be a requirement of provincial government when approving a local municipality's IDP, as should it be by DWS when approving the WSDP. It is recommended that provincial government, (through the SWMP and other mechanisms), oversee the water resources planned at LM level in WSDPs, coordinating these between neighbouring LMs / DMs.
- A gap (and a need) exists in the support to LMs in the preparation of project finance applications to DWS (and other funding mechanisms, including commercial financiers). The WCG should explore the options in terms of providing support to LMs for these applications and/or the establishment of a regional water fund to assist in the financing of water resource infrastructure.

- Provincial and national development plans need to be more cognisant of the local capabilities and water resource availability in the areas in which the development is planned, crucially as it relates to the availability of water to support their development ambitions. If sufficient water is not available, then a careful consideration should be made about the suitability of a particular industry for the area (linked to its water intensity) versus the cost/benefit of developing new water resources. To assist LMs to engage in debate on such national (and provincial) plans, it is recommended that WCG use the outputs of the regional tool to guide them in their regional planning and their assistance to the LMs, and hence in terms of appropriate development trajectories to promote in their IDPs.
- Financing of off-budget water resource development continues to be a major hurdle when the scheme is not being developed by DWS. Either Trans-Caledon Tunnel Authority (TCTA) should be permitted to finance smaller projects that are not necessarily linked to DWS (TCTA has been developing skills in desalination for the past few years and it may prove capable of raising financing for these projects) or a public-private fund should be created to assist local municipalities in their local water resource development plans. There is a need for private sector investment in the water sector, and a regional water utility could be a mechanism for this, while providing municipalities with access to affordable finance.

9.2. Use of tools developed

The tools developed here can assist in achieving some of the planning related recommendations made above. It is therefore recommended that:

- WCG utilises the outcomes of the regional hydro-economic GIS model to promote particular development trajectories at provincial scale, and to guide development choices at LM scale, and to guide development of IDPs
- LMs utilise the outcomes of the regional hydro-economic GIS model to understand the impact of particular development choices, and to guide development of IDPs
- SBLM utilise the developed MCDA tool to help inform discussions over permissions for access to water
- Other WMAs evaluate the potential to develop their own hydro-economic or MCDA tools using the methodology described in this study. The blank MCDA tool can be provided in an Excel format and used in a variety of situations to guide decision-making. The GIS hydro-economic tool utilised publically available data, and although tricky to collate this data, it is relatively straight-forward to re-run the model using the formulas described and a GIS software (such as ArcGIS).

9.3. Further development of tools

Based on feedback gathered from stakeholders during the various stages of this project, it is clear that there is demand for the tools developed, and that their outcomes will be implemented. Furthermore, there have been requests made for certain add-ons or amendments to the tools which are listed below.

- That the analysis be expanded to a wider area, specifically the Western Cape as a whole (i.e. beyond the Berg WMA);
- that additional layers be added to the GIS tool that incorporates environmental and other social criteria;
- that the current tool be updated when significant updates are made to the key input data, including:
  - Inclusion of the new fly-over data when available (expected in 2018). In this regard, it would be interesting to analyse changes in crop distribution and determine the difference in water requirements, to assess whether farmers are responding to water scarcity in the region.
  - Updates to water use data when validation and verification is completed expected in 2018.
  - Update the model with the latest rainfall and temperature records for the drought period (2015-2017) to see what the impact on the irrigation requirements may have been.

9.4. Remaining gaps and suggestions for future research

The development of a hydro-economic tool as per the definitions included in section 5.1, Box 4 requires additional data that are currently not available in South Africa. A hydro-economic tool is the best means of evaluating the socio-economic impacts of different water allocation scenarios. In order to achieve this ultimate aim (which this project partially achieved), the following would need to be considered:

- Urban water usage classifications should be consistent between municipalities, and ideally these classifications should be broken down into sectors as per the SIC codes reported in their GVA and employment statistics. Multi-year data-sets would be required to understand how changing water usage patterns result in different economic outcomes.
- In a similar manner, the agricultural census should be revived (the last census was in 2007) and regularly conducted. This is essential to understand the change in agricultural revenue as per the change in water availability (among others).
- Furthermore, all irrigated agricultural water use should be metered and made publically available. This will allow for an accurate calculation of the marginal value of irrigated agriculture and provide insight as to where the benefits from water can be best realised in the agricultural sector. This data could also aid policy-makers looking to understand irrigated water use in order to optimise it in constrained environments.

A key intervention that was not in the scope of the project, but kept on emerging in discussions, relates to the financing of bulk water infrastructure and the leveraging of private sector funds. This project highlights the urgency for a focused analysis on the potential for an innovative financing solutions for the development of water resource infrastructure, which looks beyond Public-Private-Partnerships (PPPs), such as a national water bond or bank. There was clear appetite expressed by a number of stakeholders for this type of financing arrangement, but it is unclear if analysis is currently being done on this topic.

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