South Africa's water sector investment requirements to 2050

Final report

August 2023

Executive Summary

Purpose and scope of study

A partnership between the Development Bank of Southern Africa (DBSA), National Treasury's (NT) SA-TIED[1] research projects, the National Planning Commission (NPC) and the Presidential Climate Commission (PCC), was formed to assess what level of investment is required between now and 2030 to achieve the Sustainable Development Goals (SDGs) related to access to adequate water and sanitation as well as the water sector objectives of the National Development Plan 2030 (NDP), and ensure these service levels are met up to 2050. This work will also feed into the broader SA-TIED workstream related to Water-Energy-Food (WEF) in the context of Climate Change (WEF CC) with a particular focus on the WEF nexus. The study does not yet deal with WEF nexus issues but forms part of the groundwork for future work to come on this topic.

The study has been completed as the latest Blue and Green Drop watch reports were released. These indicate a regression in the overall quality of service provision and infrastructure condition between 2013 and 2022, with 34% of the country's water supply systems (DWS, 2022a) and 54% of its wastewater systems (DWS, 2022b) in high or critical risk condition. The current trajectory is thus antithetical to achieving the SDGs, not towards achieving them, and urgent change is required.

This research paper builds on work undertaken previously by the project team, which quantified the costs of achieving SDGs 6.1 (adequate water) and 6.2 (adequate sanitation) by 2030 (DBSA and World Bank, 2022). This previous study did not cover the entire water sector as it omitted investments required in water resources infrastructure for *non-potable uses* (mainly agriculture, but also including energy generation and industry). This new study therefore extends the previous work to include all water resources and extends the timeframe of the analysis to 2050.

Methodology

The project methodology applied was adapted from the World Bank's Beyond the Gap methodology (see Rozenberg and Fay, 2019). The approach applied can be broken down into the following steps:

[1] Southern Africa: Towards Inclusive Economic Development, https://sa-tied.wider.unu.edu//

- **Identify objectives:** The SDG objectives were interpreted for South Africa through a review of national water sector policy and informed by engagements undertaken as part of the previous study with the Department of Water and Sanitation, Water Research Commission (WRC), and a broader Water Sector Working Group.
- **Identify exogenous factors:** Exogenous factors that might influence the magnitude of funding required were identified from the literature. Socio-economic trajectories were included in the previous study but were found to have only a small impact on investment need. These were therefore excluded from this study. Climate change impacts were included as an exogenous factor, as well as whether an energy transition takes place. The latter is influenced by the policy of the South African government but is largely exogenous to the water sector, which is the focus of this paper.
- **Identify policy choices:** Policy choices that might affect the magnitude of funding required were identified and used to specify scenarios. Policy choices were identified from the literature and based on the experience of the project team and inputs from a steering committee including SA-TIED, the PCC, NPC and DBSA. The policy choices considered are not an exhaustive list but are considered to include those most pertinent to the research questions. Policy choices considered in the analysis included:
    - Achievement of the SDG-standard as a service goal, compared to 'universal basic access';
    - Four water technology options, namely full conventional, low-cost, alternative technologies and aggressive Water Conservation and Demand Management (WCDM);
    - Delaying achievement of the service level goals, as well as WCDM targets and infrastructure renewal backlog to 2040 or 2050, instead of by 2030;
    - The extent of clearing of Invasive Alien Plants (IAPs);
    - The size of allocations of water to agriculture; and
    - The extent to which operational efficiencies are achieved in the integrated bulk water supply system.
- **Estimated investment requirements for achieving objectives:** A set of scenarios was developed that encompassed the range of outcomes possible based on the policy choices and exogenous factors identified. The cost of achieving the identified objectives under each scenario was modelled using two bespoke Microsoft Excel models. The first, a Water Services Model, calculated potable water demand requirements, capital and operating costs from 2023

to 2050. The second, a Water Resources Model, quantified the additional capital and operating expenditure that would be required to be spent on water resources infrastructure to meet all future water demand.

- **Estimate the funding gap:** The cost of achieving the objectives is compared to the magnitude of available funding in the water sector to determine the size of any funding gap. Available funding is considered both in terms of current actual funding flows, but also as an optimised funding mix assuming existing public and private funding sources.

Findings

A summary of the findings is provided below.

Investment need[2] to achieve water sector goals

- It will cost R256 billion on average per annum (real 2022 Rands) between 2023 and 2050 to achieve water sector objectives under the base scenario (achieving the SDGs without any other major policy or operational interventions). This translates into a R7.16 trillion investment requirement (real 2022 Rands) through to 2050.
- This level of investment is reduced to R214 billion on average per annum (real 2022 Rands) under a combination of a wet climate, an energy transition, universal basic servicing, aggressive WCDM, increased clearing of IAPs, reduced allocations to agriculture, and improved system efficiencies. This translates into a R6.0 trillion investment requirement through to 2050 (real 2022 Rands).
- The level of investment increases to R314 billion on average per annum (real 2022 Rands) under a combination of dry climate, no energy transition, achieving the SDGs with full conventional technologies, no management of IAPs, increased allocations to agriculture, and a decline in system efficiencies. This translates into a R8.79 trillion investment requirement through to 2050 (real 2022 Rands).
- The large range in potential investment requirements is driven largely by the sensitivity of the funding required for water resources (as opposed to water services) to exogenous factors and policy choices. The costs of water resource augmentation options such as re-use and desalination

[2] The term 'investment need' is used in this report to refer to investments to cover both operating and capital expenditures required.

are high, particularly their operating costs associated with energy use, and so scenarios that bring these options on earlier can drive up the investment requirements significantly.

- For the same reasons, investment requirements for water resources grow more rapidly over time than those for water services, and the share of funding needed that is due to water resources is higher in 2041 to 2050 than it is in 2023 to 2030.
- Expenditures required to support WCDM and capacity building are a small proportion of the total cost but support achievement of several water sector objectives and have high potential impact for relatively low levels of expenditure.
- Capital expenditure need is dominated by the renewal of existing infrastructure.

Additional investments required

The notion of a funding gap is used to refer to the difference between current levels of investment and what will be required to achieve the NDP goals and SDGs over time.

- The funding gap for the base scenario is R91 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is equal to 37% of the required level of investment.
- A funding gap remains under the lowest cost scenario but is reduced to R75 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is equal to 36% of the required level of investment.
- The funding gap under the highest cost scenario increases to R149 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 49% of the required level of investment.
- The funding gap grows over time because growth in available funding does not keep pace with growth in expenditure needs. Under the base scenario, the gap is 35% between 2023 and 2030 but 37% by 2041 to 2050.
- The funding gap can be reduced through improvement in the collection of water and sanitation tariffs, more extensive use of the Equitable Share for water services, and the increased use of development charges.
- This optimisation of funding closes the gap under the base scenario to R61 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 23% of the expenditure required.

Impact of exogenous factors on expenditure needs

- Climate impacts have a significant impact on future investment requirements. Investment requirements will be higher under a drier climate but lower under a wetter climate.

- The implementation of an energy transition reduces water use in the energy sector by 34% but has a very small impact on total water sector investment requirements, because water use by the energy sector is currently only 2% of total water use in the country.

Impact of policy choices on expenditure needs

- The individual services required by the NDP goals and SDGs are significantly more expensive to provide than the shared services allowed under the previous 'universal basic access' policy.
- Implementing aggressive WCDM has a large impact in terms of reducing expenditure need.
- A mix of low cost and alternative technologies, combined with aggressive WCDM, provides the lowest water services cost pathway to achieving the SDGs and NDP goals.
- Delaying achievement of the NDP goals and SDGs to 2040 has a very small impact on expenditure needs.
- Increased expenditure on active clearing of IAPs reduces overall investment requirements.
- Reduced water allocations to agriculture reduce investment requirements but come at some risk.
- A reduction in operational efficiencies in the integrated bulk water supply system increases the investment requirements significantly. The negative impact of efficiency losses is greater than the positive impact of efficiency gains.

Recommendations

Two broad issues that will affect the efficacy of the report's recommendations are noted: 1) the stagnant economy; and 2) overall leadership and governance of the local government sector. Shifts on these two issues are important but fall outside the scope of this study.

Recommendations emerging from the analysis presented in this paper are listed below. Most of these recommendations will have a larger impact in terms of reducing investment requirements if they are implemented sooner, and so an over-arching recommendation is to act on them with urgency.

The recommendations are organised into three broad groupings, related to improved management of water services; reduced water demand; and closing the financial gap. Recommendations are summarised here with more detail provided in the body of the report.

Improve the management of water services

Proceed with proposed reforms to introduce Water Operating Licences for WSPs: DWS has made proposals to introduce Water Operating Licences under the Water Services Act and use the regulation of these to strengthen the management and governance of water services (DWS, 2023). These proposals are supported by this study. Their implementation should be accelerated through Operation Vulindlela if necessary. The introduction of Water Operating Licences will only be effective if these can be adequately monitored and enforced. This recommendation is thus strongly linked with other recommendations that follow, related to capacity building at DWS and the establishment of an economic regulator for water services.

Implement a nationally coordinated capacity building and institutional strengthening strategy: Most of the interventions required to reduce the size of the water sector funding gap can only be implemented with increased institutional capacity. Specific recommendations are made in the report regarding building technical capacity in local government. Capacity building is not required only at local government level. DWS' capacity to monitor municipal performance and to intervene where necessary must also be strengthened. This includes creating the capacity for economic regulation.

Incentivise proper integrated asset management: Capital expenditure needs are dominated by renewal, and ongoing maintenance expenditures must be improved. Integrated infrastructure delivery systems should be developed, tailored to the different municipal categories. An annual awards system should be introduced, and learning networks established. The recommendations of the Blue Drop and Green Drop monitoring programmes should be implemented.

Reduce water demand

Prioritise WCDM: Standards for municipal water losses should be put in place and enforced. Water services by-laws should be reviewed. The position on Performance Based Contracts (PBCs) for Non-Revenue Water (NRW) reduction should be clarified. The introduction of DWS's proposed National NRW Programme should be accelerated.

Improve operational efficiencies in the bulk water supply system: Improved efficiencies in operating the bulk water supply system have significant benefits in terms of reducing water sector expenditure needs, particularly if implemented soon. Efficiency declines have even larger negative impacts. Operational decision-making systems have been piloted and should be rolled out at scale as soon as possible along with improved monitoring and enforcement mechanisms. Improved operational efficiency also requires improved institutional capacity.

Better manage water resource allocations: There are competing uses of water and clear allocations and agreements on the levels of assurance of supply are required to ensure adequate water for all requirements. Consideration should also be given to the benefits and opportunity costs associated with allocations to different water users as well as for international obligations and for environmental flows at risk due to climate change impacts. Catchment Management Agencies should be established in all nine provinces. DWS and its Catchment Management Agencies should review water allocations, with due consideration to climate impacts, and strengthen regulation of the abstraction of raw water.

Coordinate efforts on IAP clearing and investments in Ecological Infrastructure: Reduced IAP infestation can improve surface water availability. Similarly, investments in the protection and rehabilitation of wetlands and riparian areas can help improve water quality and reduce flood risk. DWS, in collaboration with other sector stakeholders, should identify priority areas for IAP clearing and develop catchment protection plans that include IAP management planning at a catchment level. In addition, institutional responsibilities and the funding model for IAP clearing should be clarified. Investment in ecological infrastructure from the private sector should be encouraged and better co-ordinated. The clearing of IAPs should also become a requirement in the costing of new water supply investments.

Close the financial gap

Establish an economic regulator for water services: The need for improved economic regulation of water services has been acknowledged for many years. The establishment and capacitation of the regulator is a key priority. Several of the other recommendations made under this study will not succeed if stronger regulation is not in place. Given that the establishment of the regulator has not progressed, a high-level assessment is needed to understand what the blockages are and put a plan in place to overcome these. The regulator must be adequately capacitated, and the performance framework must include criteria that balances long-term economic viability with social justice outcomes that take into account the plight of those who cannot afford market-related tariffs.

Make appropriate service level choices: A mix of low cost and alternative technologies provides the best value-for-money way of achieving the SDGs and NDP goals. It is the position of this study that some degree of shared sanitation services is necessary in urban informal settlements. 'Interim' or 'emergency' services with low capital but high operating costs should be avoided. Faecal sludge management should be improved. Alternative technology options, particularly for sanitation, should be used where they are available and appropriate and can be delivered at scale, and research and development in this field should continue to be supported.

Strengthen all links in the revenue value chain: All connections should be metered and 'deemed' consumption should be eliminated. Flow control should be implemented as a credit control mechanism. Current reforms to treat water departments as business units within municipalities, with transparency in reporting and a single point of accountability, should be continued in the larger municipalities at least. This should not, however, compromise entrenched social justice commitments to meeting the water consumption needs of those who cannot afford market-related tariffs. A nation-wide campaign should be implemented to address non-payment for water services, with strong political backing.

Pass the Development Charges legislation: Draft legislation to govern and regulate the standardized manner in which municipalities should levy Development Charges has been in place since 2013 but has yet to be promulgated. This legislation should be finalised as a matter of urgency.

Require reporting on the allocation of the Equitable Share to services: The Equitable Share is an unconditional grant and recommendations on changing this cannot be made without a full review of the local government fiscal framework. That said, to ensure greater accountability, municipalities should be required to report on how they allocate the Equitable Share between each basic service (which includes water and sanitation), community services and institutional costs.

Mobilise public and private sector investments: A set of formal engagements should take place under the auspices of the NPC between water-related policy makers in government and the financial sector. The aim will be to develop the most appropriate institutional mechanisms for effectively leveraging substantial increases in private sector co-funding for water and sanitation infrastructures through to 2050.

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Abbreviation list

CoCT	City of Cape Town
CoGTA	Department of Cooperative Governance and Traditional Affairs
CIDMS	City Infrastructure Delivery Management System
CSIR	Council for Scientific and Industrial Research
CPAF	Contract Price Adjustment Formula
CSP	Cities' Support Programme
DBSA	Development Bank of Southern Africa
DWS	Department of Water and Sanitation
EI	Ecological Infrastructure
GHG	Green House Gas
GTAC	Government Technical Advisory Centre
IAP	Invasive Alien Plant
ICM	Intermediate City Municipality
JMP	Joint Monitoring Programme
MDGs	Millennium Development Goals
MSFM	Municipal Services Financial Model
NDC	Nationally Determined Contribution
NDP	National Development Plan
NPC	National Planning Commission
NPV	Net Present Value
NRW	Non-Revenue Water
NT	National Treasury
NWSMP	National Water and Sanitation Masterplan
PCC	Presidential Climate Commission
PPP	Public Private Partnership
RCP	Representative Concentration Pathway
RMSC	Regional Management Support Contract
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SA-TIED	Southern Africa: Towards Inclusive Economic Development

SDG	Sustainable Development Goals
SIV	System Input Volume
StatsSA	Statistics South Africa
TNC	The Nature Conservancy
UN	United Nations
WCDM	Water Conservation and Demand Management
WCWSS	Western Cape Water Supply System
WEF	Water-Energy-Food
WEF CC	Water-Energy-Food in the context of Climate Change
WRC	Water Research Commission
WWF	World Wildlife Fund

1 Introduction

The National Development Plan 2030 (NDP), adopted in 2012, outlines a set of goals to be achieved by the water sector in South Africa by 2030. South Africa has also committed to achievement of the Sustainable Development Goals (SDGs) by the same date.

A partnership between the Development Bank of Southern Africa (DBSA), National Treasury's (NT) SA-TIED[3] research projects, the National Planning Commission (NPC) and the Presidential Climate Commission (PCC), was formed to assess what level of investment is required between now and 2030 to achieve the Sustainable Development Goals (SDGs) related to access to adequate water and sanitation as well as the water sector objectives of the National Development Plan 2030 (NDP), and to ensure these service levels are met up to 2050. This work will also feed into the broader SA-TIED workstream related to Water-Energy-Food (WEF) in the context of Climate Change (WEF CC) with a particular focus on the WEF nexus. The study does not yet deal with WEF nexus issues but forms part of the groundwork for future work to come on this topic.

1.1 Project background and research questions

South Africa is, and always has been, a water scarce country. As a result, it has progressively had to develop new resources and increasingly more complex and integrated bulk water supply systems to meet the growing demand. This is further complicated by the significant spatial dislocation between sources of supply and sources of demand, the most extreme example being the Gauteng province which is the economic heart of the country but is located on a continental divide. As a result, water has been transferred from distant sources for over 100 years since the development of the Vaal Dam and most recently from international basins by way of the Lesotho Highlands Water Project. The same is true for all other major economic centres in South Africa including Cape Town, eThekwini, Mangaung, and Nelson Mandela Bay, all of which are dependent on water transfer from outside their municipal areas. Other bulk water uses including the mines, large industry, agriculture and power generation, are also dependent on the development of large dams and inter-basin transfers. As a result, South Africa ranks sixth globally with respect to the largest number big dams globally and it has the largest number of big dams in Africa.

[3] Southern Africa: Towards Inclusive Economic Development, https://sa-tied.wider.unu.edu//

Like all other countries, South Africa is now facing the challenge of continuing to provide the water necessary to support a growing population and economic development in the face of potentially declining water availability due to climate change.

Regarding the provision of basic services, South Africa has performed well since democracy at delivering infrastructure for new services and has significantly expanded access to both water and sanitation from 1994 to the present. The greatest gains have been made in urban areas, largely through the housing process. Most households now have access to a high level of service (waterborne sanitation and piped water in the household) in these areas. Service challenges that remain in urban areas are related largely to informal settlements and informal backyard dwellings. Informal settlements comprise 13.6% of total number of households in South African urban areas.

Progress in rural areas has been slower than in urban areas. There have been some advances made but these have been impeded, at least in part, by the high marginal cost of serving more remote settlements. Rural sanitation programmes have focussed largely on on-site facilities. The ongoing management of these facilities has been inadequately addressed and faecal sludge management is a pressing issue in these areas.

While the roll-out of infrastructure has largely been successful, there have been failures regarding adequately managing the assets created. Maintenance and renewal have been under-provided for, resulting in declining asset condition and increased failure, evidenced in the high levels of water services interruptions. This means that there is a so-called ‘renewal backlog’ and capital expenditure is required to renew (refurbish, rehabilitate or replace) a large proportion of existing infrastructure to return it to adequate condition.

The poor condition of water and wastewater treatment works is a particular concern. The Blue Drop and Green Drop Certification Programmes were reinstituted in 2022 after a hiatus since 2014[4]. Both the Blue and Green Drop reports indicate a regression in the overall quality of service provision and infrastructure condition between 2013 and 2022, with 34% of the country’s water supply systems (DWS, 2022a) and 54% of its wastewater systems (DWS, 2022b) in high or critical risk condition. The current trajectory is thus antithetical to achieving the NDP and SDGs, not towards achieving them, and urgent change is therefore required.

4 The reports were produced in 2016 but not released to the public.

Recent events such as the water supply crises in Cape Town, Nelson Mandela Bay, and Gauteng and floods in KwaZulu-Natal and the Eastern Cape; the need to provide additional water to improve access to basic water and sanitation services in meeting the NDP goals and SDGs; and growing concerns around the human, economic and environmental impacts of the failure of water and wastewater treatment plants have highlighted the need for additional investments not only in providing new and alternative water sources, but also in the maintenance, rehabilitation and repair of existing systems. The first step to achieving the SDGs is to stop the current decline in water systems.

Box 1: Lessons from the Cape Town drought

The drought that resulted in the water supply crisis for Cape Town developed over a period of three years from June 2015 through to June 2018, with successive years of below-average rainfall. Rainfall over this period was 50 to 70% of the long-term average, and many rainfall records were the lowest ever recorded since the first written records in the 1880s (Wolski, 2018). The water supply crisis was triggered by the rapid drop in dam levels from being over 100% full and spilling in 2014 to a low of 29% in May 2017 and to below 20% in May 2018.

While the rapid drop in dam levels is primarily attributed to the very low rainfall, there were several other factors that contributed to the crisis and could potentially have been avoided. Some of these include:

- A failure to monitor and update hydrological information and models used for analysis;
- A failure to initiate the Berg River Supplement scheme when required due to lack of trained staff, specifically a qualified electrician required to switch on the pumps for the scheme;
- A failure to effectively clear and maintain the catchments free of invasive alien plants (IAPs);
- A failure to initiate restrictions, particularly for agriculture use, when required (these were later implemented, but only later in the summer after the peak of the agricultural water use); and
- Initial challenges with the communication of information between technical and political decision makers. These were addressed in the latter half and had a significant impact on reducing demand.

Several efforts were made to boost supply during the crisis, but these were too little and too late. What ultimately saved the City of Cape Town was the ability to drastically reduce demand. During the drought crisis, demand was reduced by almost half as a result of the heavy restrictions and messaging of the drought crisis. It is quite clear that without this effort, Day Zero would have been reached. This demand reduction is something that Nelson Mandela Bay has been unable to achieve in a similar water supply crisis.

Prior to the crisis the CoCT had already been making significant progress on reducing demand, leakages and unaccounted for water (UAW) and even received a global award for its successful WCDM efforts. During the first phase of the drought, however these efforts were stepped up and several additional measures were employed, including (as compiled by Taing *et al.*, 2019): limiting supply through manual valve closing and installing of water management devices; reducing water pressure wherever possible, especially in areas with high leakage; sharply increasing the existing stepped tariffs, particularly for high volume users; and an information, education, and communication (IEC) campaign to influence consumer behaviour.

Lessons learnt from the Cape Town water supply crisis relate to both the physical systems and analytical approaches used to support water resource planning, but also the institutional and governance of water security in an increasingly volatile, uncertain, complex, and ambiguous world (Ziervogel et al, 2019). Many of these lessons have been included in the development of a New Water Strategy for the City of Cape Town (CoCT, 2020). A critical part of this new strategy is pushing ahead with the development of alternative water supply options including several groundwater projects, sea water desalinisation and direct potable re-use. The City is also making a significant contribution to assist in the clearing of IAPs from its dam catchments.

In addition to the clearing of IAPs and the development of alternative water supply options, the City has also developed a 'Bulk Water Decision Support System (DSS)' to aid in the collection, management, analysis and interpretation of a large amount of data. Some of the Bulk Water DSS's tools that have been developed included: a water quality tool to monitor and warn of non-compliance within the bulk water supply system; a water resource planning tool to support operational decisions; a system water resource model to track the status of the water supply system (both in terms of demand and availability); and the development of a "Digital Twin" of a city's water reticulation system which is currently being implemented (i.e. allowing the Water Department to contemplate ways to improve the system, apply those improvements in the digital version, track the responses and then carry the lessons learnt over to the 'real-world'). While a large portion of the DSS is focused on the CoCT's operations, there are portions of the DSS which may assist other stakeholders, including the DWS and other water users, in fulfilling their responsibilities within the WCWSS.

In terms of forward planning, the City of Cape Town, is now considering a potential further reduction in the yield from the WCWSS of up to 25% due to climate change, but that some of this can be offset by significant additional investments in the clearing of IAPs and in developing alternative supply options. The City of Cape Town is also considering changing to a higher level of assurance of supply based on a 1 in 200-year recurrence interval, rather than the current 1 in 50 years, given the fact that it is anticipated that in future it will be harder to reduce demands when water restrictions are required.

Many of the catchments that supply water in South Africa are already highly developed and will be under stress by 2035 (DWS, 2012). Continued population growth, climate change and environmental degradation are likely to have a significant impact on water resource quality and availability going forward, impacting on South Africa's ability to meet the objectives of the NDP and SDGs.

As can be seen in Figure 1 below, agriculture is currently the largest user of water in South Africa. Direct industrial use makes up only 3% of demand while industrial and commercial users supplied with potable water through municipal systems are included in the municipal use category[5]. The allocation of water to agriculture is critical not only in terms of national food security, but also because agriculture is a major contributor to foreign earnings and a significant employer, particularly of unskilled labour.

While energy makes up only 2% of the total water usage in the country, the energy transition to lower cost renewable energy technologies is critical for ensuring energy security by 2030. Furthermore, decarbonisation of the energy system is critical in terms of South Africa achieving its objectives of a Just Transition to significantly lower levels of greenhouse gas (GHG) emissions under the Paris Agreement and its Nationally Determined Contributions (NDCs).

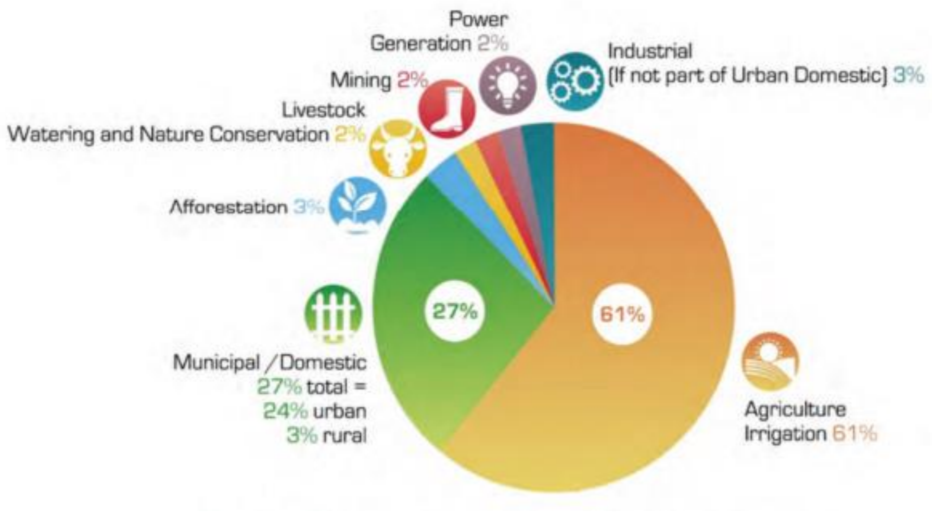

Figure 1: Current water use in South Africa by sector (DWS, 2018)

Average water use in the country is high, with municipal/domestic water use per capita of 237[6] litres per person per day compared to a world average of 173 litres per person per day (DWS, 2018). A significant driver of this is high levels of municipal Non-Revenue Water (NRW), currently estimated at around 41% compared to a global average of 37%[7] (McKenzie, Siqalaba and Wegelin, 2012).

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5 Municipal use includes household use as well as industrial and commercial potable water supplied through municipal systems.

6 Again, bear in mind that the South African figure includes commercial and some industrial use and is not purely household use.

7 NRW levels in some other developing countries such as Armenia and Albania are as high as 70% but NRW in developed countries such as Austraila and New Zealand is only 10%.

Against this background, DBSA, the NT SA-TIED, PCC and NPC partnership appointed PDG and Zutari to estimate the level of investment needed to achieve the water and sanitation SDGs and NDP goals in South Africa. The primary research question for the work is:

Taking into account the future impacts of climate change on South Africa's water resources, what investments are required between now and 2050 to ensure that it will be possible to achieve the water targets as specified in the National Development Plan (NDP) and the Sustainable Development Goals (SDGs).

To answer the primary research question, the following supplementary questions will also be addressed:

- What is the funding gap between current levels of investment in water infrastructure and what will be required to achieve the relevant water and sanitation SDGs and NDP goals by 2030 (and extended to 2040 and 2050), covering capital, operations and maintenance spending?
- What policy and regulatory frameworks are in place that govern the flow of public and private investments in water resources and service delivery with respect in particular to technologies, service levels and resilience in the face of climate change?
- Given the probable impacts of climate change on water resources, what should the funding targets be for optimizing achievement of the water and sanitation services SDGs and NDP goals by 2030, 2040 and 2050 respectively?
- What policy and institutional changes will be required to enable this increased level of investment in climate resilient water resources infrastructure and water services[8] to achieve the NDP and SDG targets?

1.2 Scope

This research paper builds on work undertaken previously by the project team, which quantified the costs of achieving SDGs 6.1 (adequate water) and 6.2 (adequate sanitation) by 2030 (DBSA and World Bank, 2022). This previous study did not cover the entire water sector as it omitted investments required in water resources infrastructure for *non-potable uses* (mainly agriculture, but also including

[8] In this report, as in South African law, the phrase 'water services' is the collective term used to describe the provision of both the water and sanitation services, together. Where references to individual services are made, the report will specify the 'water service' or the 'sanitation service'.

energy generation and industry). This new study therefore extends the previous work to include all water resources and extends the timeframe of the analysis to 2050.

There are eight targets within SDG 6. The study focuses primarily on the first two targets, with reference made to the achievement of SDG 6.4 as this is seen as an essential part of achieving SDG 6.1 and SDG 6.2.

Box 2: SDGs covered in the study and alignment between the SDGs and NDP objectives

SDG 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

There is largely good alignment between SDG 6.1 and the equivalent NDP objective that “all South Africans will have affordable, reliable access to sufficient safe water and hygienic sanitation by 2030” (NPC, 2013, p.65) but there is some discrepancy in the definition of adequate access. SDG 6.1 uses a definition of ‘safely managed’ which includes the requirement that water should be accessible on the premises. The NDP does not define ‘affordable, reliable access to sufficient safe water’ in detail but, when summarising enabling milestones for the Plan, it says that “all South Africans have access to clean running water in their homes” (NPC, 2013, p. 34). This is aligned with the definition applied by SDG 6.1. However, elsewhere in the NDP document it is acknowledged that service provision arrangements will vary in different parts of the country, with different approaches adopted for densely built-up urban areas and scattered rural settlements. This latter statement is in line with the national Department of Water and Sanitation’s (DWS) historical approach of targeting differing service levels at different settlements, with access to ‘basic’ services (improved but not necessarily located on the property) being the initial goal and progressive provision of higher levels of service where appropriate.

SDG 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

For sanitation to qualify as a safely managed service according to the SDG 6.2 requirement, effluent from wastewater treatment works, sludge from treatments works, and faecal sludge removed from on-site sanitation facilities must be properly treated, managed, and safely returned to the environment. In addition, people should use improved sanitation facilities which are not shared with other households. As was the case for water, the NDP is not clear on its definition of access to hygienic sanitation, and DWS policy is not clear on the use of shared as opposed to unshared services. The NDP does not mention hygiene specifically and an exercise conducted to map the NDP to the SDGs noted that “equitable sanitation and hygiene was not prioritised in the NDP” (NPC, 2021, p.115). South Africa does not have an explicit policy on hygiene, although aspects related to hygiene are included in the Sanitation Policy (DWS, 2016), which states that basic sanitation includes “appropriate health and hygiene awareness and behaviour” and a hand washing facility.

> In sum, SDG 6.1 and 6.2 are largely aligned with the NDP but with the NDP targets being somewhat less stringent than the SDGs, if historic DWS policy regarding basic services are used as the definition for the 'reliable access to sufficient safe water and hygienic sanitation' specified as the objective by the NDP.

Although water demand requirements, and the water sources supplying this demand, are considered in the study, water resources planning, and the investigation of alternative water resource options is outside the scope. That said, current and planned availability of water resources were taken into consideration, including a spatially differentiated investigation into the water resources availability and cost, how this might vary with increased climate change, and due to improved investments in ecological infrastructure.

Meeting the water and sanitation SDG targets and NDP goals in South Africa will require strong institutions, staffed with capable people, and with sound operating systems. Building capable institutions is a critical issue in the country. The capacity needs in the South African public service to deliver a full spectrum of services are large, but for the purposes of this study, the capacity assessment is limited to planning and programme management capacity to roll out water and sanitation infrastructure, and the capacity to operate and manage the services.

Climate resilience must be at the forefront when considering investments in the water sector. This requires changes to how systems are managed, increased redundancy to allow for risk, and careful technical choices related to water augmentation options. This is accommodated in the study where possible (primarily with regard to water augmentation options and the magnitude of augmentation required) but much of the work on climate resilience must be undertaken at an individual system level and is not easily quantified at country level. Further investigation of climate resilient needs for individual systems is required to supplement the estimates in this report.

2 Methodology

The research methodology was adapted from the World Bank's Beyond the Gap methodology (see Rozenberg and Fay, 2019). The modified approach applied can be broken down into the following steps[9]:

- **Identify objectives:** The SDG objectives were interpreted for South Africa through a review of national water sector policy and informed by engagements undertaken as part of the previous study with the Department of Water and Sanitation, Water Research Commission (WRC), and a broader Water Sector Working Group.
- **Identify exogenous factors:** Exogenous factors that might influence the magnitude of funding required were identified from the literature. Socio-economic trajectories were included in the previous study but were found to have only a small impact on investment need. These were therefore excluded from this study. Climate change impacts were included as an exogenous factor, as well as whether or not an energy transition takes place. The latter is influenced by the policy of the South African government but is largely exogenous to the water sector, which is the focus of this paper.
- **Identify policy choices:** Policy choices that might affect the magnitude of funding required were identified and used to specify scenarios. Policy choices were identified from the literature and based on the experience of the project team and input from a steering committee including DBSA, SA-TIED, the PCC and NPC. The policy choices considered are not an exhaustive list but are considered to include those most pertinent to the research questions.
- **Estimate investment requirements for achieving objectives:** A set of scenarios was developed that encompassed the range of outcomes possible based on the policy choices and exogenous factors identified. The cost of achieving the identified objectives under each scenario was modelled using two bespoke Microsoft Excel models. The first, a Water Services Model, calculated potable water demand requirements, and water services capital and operating costs from 2023 to 2050. The second, a Water Resources Model, quantified the additional capital and operating expenditure that would be required to be spent on water resources

[9] This modification excluded two steps in the original Beyond the Gap methodology, namely review of technical servicing options and identification of metrics. These steps had been adequate covered in the first phase of the research and were not required for the quantification of investment need undertaken in this phase, and so were not repeated.

infrastructure to meet potable and non-potable water demand. The models are described briefly later in this section, and in more detail in Annexure A.

- **Estimate the funding gap:** The investment requirements for achieving the objectives is compared to the magnitude of available public funding in the water sector to determine the size of any funding gap. Available funding is considered both in terms of current actual funding flows, but also as an optimising funding mix assuming existing funding sources.

The **Water Services Model** is a modified version of PDG's Municipal Services Financial Model (MSFM). The model uses a unit-cost approach to determine infrastructure investment need. The unit costs used represent an average cost of providing infrastructure, and adequately maintaining this service in different geographies (urban-formal, urban-informal, rural formal and rural informal). The starting point for the model is a projection of the number of consumers of the municipal service/s under investigation, based on household and economic growth rates. A service delivery programme is then used to determine the numbers of consumers that have different levels of service in each year of the model run. Once the number of consumers with different service levels has been calculated, the model estimates operating expenditure and capital expenditure required using unit consumptions, operating costs per consumer and capital costs per new consumer connected for each level of service. The costs of both new and existing infrastructure for both water and sanitation are considered in the analysis.

The **Water Resources Model** is developed based on similar principles applied by DWS for the planning of future water resources infrastructure investments as part of the Reconciliation and Planning Studies, known as the Recon Studies. The Recon Studies consider the current water availability of a system and then make projections about the likely future growth in demand from all water users as well as for international obligations and environmental flow requirements. An example of this is shown in Figure 2. The Recon studies consider a range of potential augmentation options that are in various phases of development from conceptual to detailed design and implementation. By comparing the current yield of the system with the expected growth in demand, the Water Resources Model determines when each system goes into deficit (when demand exceeds supply) and then selects the next available intervention to close the gap between demand and supply. This is done on an annual basis and has been extended to run from a base year of 2022, with projections from 2023 to 2050. The model considers each of the seven major water supply systems separately and aggregates all other areas into a single 'rest of country' system.

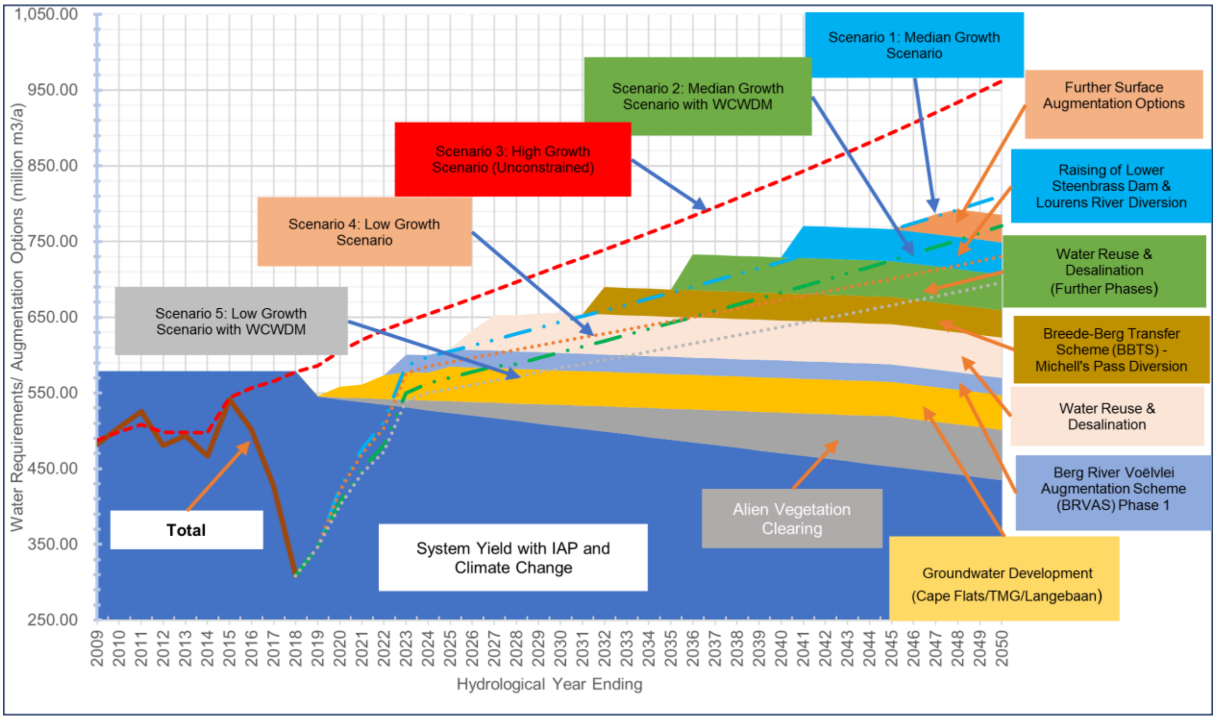


Figure 2: Example of a Reconciliation Study showing projected water demand and water sources

In total 157 individual potential water supply augmentation options were identified across the seven major water supply systems and in the rest of country with a total capital cost estimate of around R610 billion. Fifteen of these have been identified as national priority strategic infrastructure projects (SIPs) with a total capital cost estimate of around R106 billion. This list of water supply options, however, does not necessarily include options for all towns and for all water users and as a result is not sufficient to completely close the gap for water security. To account for this a final 'catch all' option was considered in the modelling to address any remaining shortfalls. As a result of this there is likely to be considerable uncertainty in the total investment requirements to close the water security gap for all water uses, particularly those not part of major supply systems.

2.1 A comment on costs

Estimating water sector investment requirements entails estimating what must be spent to operate, maintain and renew existing infrastructure; what must be spent on new infrastructure going forward; and what will need to be spent to operate, maintain and renew this future new infrastructure. There are many uncertainties regarding the cost data to inform these estimates, particularly those related to operating expenditure required. While data is available on what is currently spent to operate and maintain water sector infrastructure, it is widely accepted that current levels of expenditure are inadequate. In some cases, benchmarks for optimal levels of expenditure are available, and these have been applied. In other areas, benchmarks do not exist, and some level of judgement has been necessary in determining the extent to which current expenditures should increase. Of particular concern regarding operating costs is the increase in the cost of electricity which makes alternative water supply options such as desalination and re-use significantly more expensive unless these are done in conjunction with improved energy efficiency or conjunctive use of alternative energy supply options.

When estimating capital expenditure needs, future infrastructure costs will vary from project to project according to local factors, such as the topography and geology of the area, density, local material content costs, localised labour dynamics, and so on. A comprehensive database of infrastructure costs across the country does not exist and the project team has drawn from numerous sources to come up with best estimates of aggregate costs. Infrastructure costs have also increased rapidly over the past decade and are likely to continue to do so in future, and so cost data is rapidly outdated.

Data sources utilised for the estimation of water services costs in the study included a detailed costing study of municipal infrastructure undertaken by PDG in 2018, the Municipal Infrastructure Investment Framework, DWS Cost Benchmarks for water services projects (last updated in 2016), and the National Water and Sanitation Masterplan. The costs of alternative technologies have been drawn from various research papers and Gates Foundation research. This data consolidation exercise was undertaken in 2021 for the previous research project. Where possible, these costs have been updated from primary or secondary sources for this study. In most cases this was not possible, and costs were inflated using the Contract Price Adjustment Formula (CPAF), a formula based on StatsSA data, developed by the Association of South African Quantity Surveyors to track the cost of infrastructure projects and assist in the negotiation of construction industry contracts.

The list of potential water resource augmentation options was sourced from a review of available Recon Study Reports. Only some of the Recon Study reports included cost estimates for these proposed options and where possible updated cost estimates were obtained from other sources including a comprehensive study of future water supply augmentation options that was undertaken by the then Department of Water Affairs (now DWS) in 2010 to determine the ultimate marginal cost of water supply for all systems across the country. The available cost estimates were escalated to equivalent 2022 costs using the CPAF.

Additional energy cost, particularly those associated with alternative water source options such as desalination and re-use and for major inter-basin transfers, were determined based on standard energy rating (kWh.m^3) for the different supply options and multiplied by an assumed energy price, which was kept constant for this study. The operation and maintenance (O&M) of existing bulk water supply systems was estimated based on the average unit cost for new surface water schemes (around R5/m^3). This cost could include some of the requirements for rehabilitation and repair of the existing system, but this is an important cost consideration that has not been sufficiently accounted for in national or local level infrastructure budgets. Approximate costs for the clearing of invasive alien plants (IAPs) were obtained from a study by Marais et al (2007) and compared with more recent estimates for the Greater Cape Town Water Fund (TNC, 2019) and from data on general clearing costs provided by World Wildlife Fund (WWF) and South African National Biodiversity Institute (SANBI). While the focus of this study was only on the impact of IAPs, it is also important to consider investments for other catchment management activities such as the protection and rehabilitation of wetlands, also critical for future water security.

3 Sector objectives

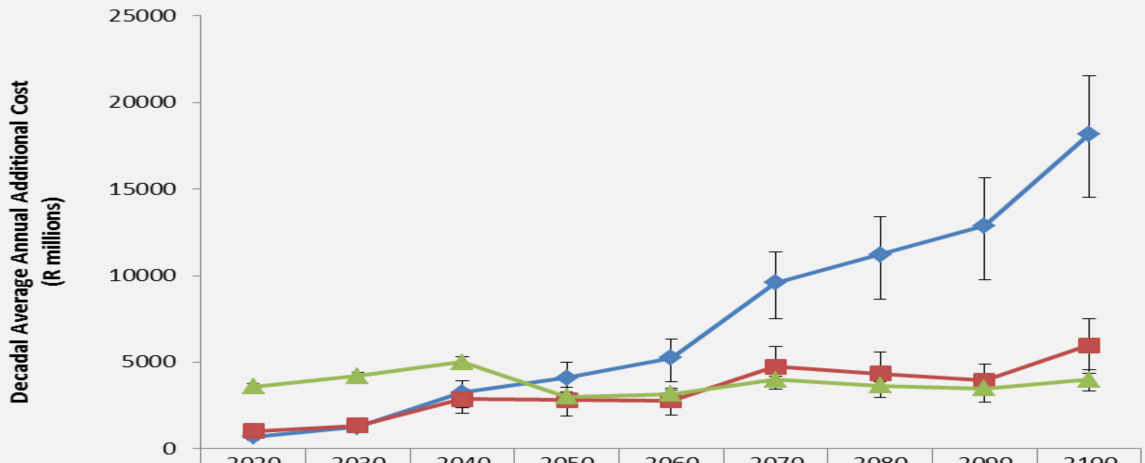
The following sector objectives have informed the specification of scenarios in the study:

- **Universal access to safe and reliable water and hygiene services:** This is clearly defined as the primary objective in the SDG targets as well as South African policy.
- **Affordable and financially sustainable water services:** This implies the need for the lowest life-cycle cost intervention and a financing arrangement that equitably distributes the incidence of that cost.
- **Reduced demand on freshwater resources:** The expansion of water services must happen in a manner that is resource-efficient and does not exceed available resources.
- **Increased water resilience:** The ability of water resources and water services to withstand the shock of droughts, particularly in the context of climate change, must increase.
- **Minimising or reducing the environmental impact of service delivery:** Greenhouse gas emissions from water services provision must be reduced, and the sector must become more resilient to climate change impacts.
- **Building adequate institutional capacity:** The South African public sector, and specifically the local government sector, must have sufficient institutional capacity to expand water services access and to operate and maintain these services sustainably.

Box 3: Disaster risk reduction

Disaster risk reduction was not included in the scope of this study but is a key emerging issue .

Recent events across the country have highlighted the increasing risk associated with climate disasters such as floods, droughts, landslides, and fires with these events expected to become increasingly more frequent and more sever (Engelbrecht et al, 2021). Research undertaken as part of the Long-Term Adaptation Scenario (LTAS) program noted that more than half of the countries' critical infrastructure, including bridges, dams, and powerline crossings, are likely to experience a moderate to severe increase in flood risk because of climate change (DEA, 2013). This will have a significant impact on the long-term cost for maintenance and rehabilitation of critical infrastructure as shown in the figure below for roads (Cullis et al, 2015).



	2020	2030	2040	2050	2060	2070	2080	2090	2100
UCE No Adapt	708	1263	3236	4109	5266	9583	11215	12891	18152
L1S No Adapt	1023	1349	2873	2832	2788	4748	4358	3944	5983
UCE Adapt	3599	4202	5021	3012	3174	4010	3649	3480	3991

UCE and L1S are different global emissions scenarios (unconstrained emissions and Level 1 stabilisation). 'Adapt' and 'no adapt' refer to whether roads are actively adapted for the future climate or not. The figure therefore shows the long-term benefits of pro-active adaptation planning and investments as well as the benefits from climate change mitigation. What is not shown is the significant economic impact associated with the disruption caused by the loss of critical infrastructure. This is particularly concerning in Africa where there is limited redundancy and diversification in the system, for example with many settlements only connected by a single road or having only a single water supply pipeline. The risk of damage to critical infrastructure is further increased through a lack of maintenance and operational capacity, as well as failure to effectively manage upstream catchment conditions, ecological infrastructure, and urban planning.

Research in the SADC region has shown that while climate related disasters do have a significant short term economic impact, if there are sufficient systems, capacity, and resources in place to facilitate a relatively fast and effective recovery then this could potentially have a net positive economic impact (Owusu-Sekyere et al, 2021), particularly if they can achieve the objective to "build back better".

The Beyond the Gap (BtG) study (World Bank, 2023) found that all water and sanitation assets in South Africa are exposed to severe drought events, while flooding affects up to 13% of treatment plants and up to 17% of the distribution network. The investment cost for hardening the exposed existing wastewater and water treatment plants, and sewer and water distribution pipes against flooding and earthquakes was estimated to be close to R82 billion, but this was largely due to the significant exposure of the water distribution network to earthquake risk, with only limited investment costs required for hardening against flooding.

4 Scenarios

The scenarios modelled for this research tested the impact of the exogenous factors and potential policy levers on the costs of achieving the identified objectives.

Two exogenous factors, namely climate change impact and whether or not an energy transition takes place, were modelled.

Six policy levers were considered, namely:

- Service level goals;
- Water services technology options;
- Timing of achievement of service level goals;
- Extent of Invasive Alien Plant (IAP) clearing;
- Allocations of water to agriculture; and
- Operational efficiencies in the bulk water supply system.

Each of these scenarios is described briefly in the remainder of this section. More detail on scenario definitions is provided in Annexure B to the report.

4.1 Climate scenarios

Climate change impacts water availability through multiple pathways: water demand is impacted by increasing evaporation while water availability, both surface and groundwater, is impacted by changes in evaporation, precipitation and runoff. There is a large range in the extent of potential climate impacts, and impacts are expected to be experienced differently in different parts of South Africa, and under different global emission scenarios. In this study, three potential climate change scenarios are considered representing a wet, median, and dry climate scenario. These have been applied to each municipality in South Africa primarily as part of work done for the CSIR Green Book (CSIR, 2019) and used to assess the potential impacts on water supply (Cullis et al, 2019). The results from this study are then used to determine the potential impact on both water demand and water supply in each water supply area. This impacts on the need for augmentation and associated investment needs. The impacts considered here are initial high-level impact at a national scale and do not include a detailed analysis of the specific impact of different climate scenarios on the yields from individual systems.

Using the results from the Greenbook, three scenarios were considered for this study, namely:

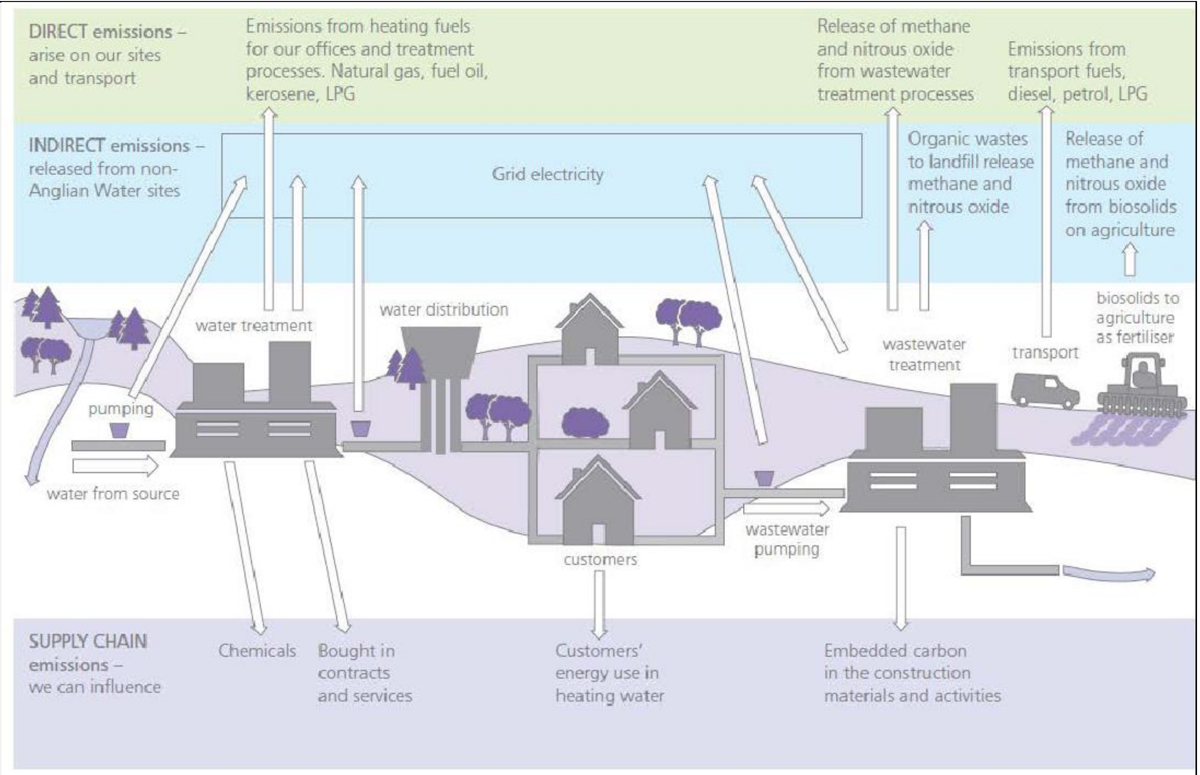
- A **wet** scenario based on the 90th percentile under RCP 8.5 by 2050;
- A **median** scenario based on the 50th percentile under RCP 8.5 by 2050; and
- A **dry** scenario based on the 10th percentile under RCP 8.5 by 2050.

The above three scenarios were selected from the results of six global circulation models (GCMs) that were downscaled by CSIR using the CCAM regional climate model (RCM) for South Africa. Additional information on the models used and approach to determining the potential impact on water demand and availability are given in Appendix B and in CSIR Greenbook water narrative (Cullis et al, 2019).

Box 4: Carbon emissions from the water sector

The water and wastewater sectors globally contribute significant amounts of greenhouse gas emissions, around 3-7% of a country's total (International Water Association, 2015). Emissions can occur at all stages in the water value chain: the impoundment or abstraction of raw water, the treatment of raw water to potable standards, the distribution of treated water, the collection of wastewater, and the treatment and disposal of wastewater and its byproducts (Pereira, 2009). For each of these stages there are both direct and indirect emissions. Direct emissions are from sources that are owned or controlled by water institutions, while indirect emissions are a consequence of the activities in the water value chain but occur at sources owned or controlled by another entity. Indirect emissions in South Africa are mostly related to the use of coal-fired electricity by the water sector. Most of the emissions are indirect.

The diagram below shows the typical direct and indirect emissions for a Water Utility (in this case Anglian Water in the United Kingdom), and also introduces the concept of supply chain emissions. The diagram is largely applicable to a Water Service Provider in South Africa but omits non-sewered sanitation which emits methane and nitrous oxide due to anaerobic digestion of faecal waste.



Source: Chartered Institution of Water and Environmental Management, 2013

In South Africa, the 'wastewater treatment and discharge' category represents 0,9% of national emissions (4 458 Gg CO_2e) (Department of Fisheries, Forestry and the Environment, 2023). This figure represents the direct emissions only (uncaptured and unflared methane and nitrous oxide). As the provision of services extends, and more wastewater is treated at conventional wastewater treatment facilities, this figure will increase. The 8th National Greenhouse Gas Inventory Report estimates that this will increase at more than 5% per annum given the expected growth in the provision of sanitation services.

What can be done?

Many of the interventions required to reduce the indirect carbon emissions in the water sector are the same as those required for the efficient management of a water and wastewater system and should therefore be implemented for multiple reasons, in line with the DWS policy position of the mainstreaming of climate change in the sector (DWS, 2017). Examples include *reductions in real water losses*, which reduces the amount of water abstracted, treated and pumped, in turn reducing the embedded carbon in surface water systems (if applicable) and transferal and distribution systems and the energy required to treat and pump this water; *demand side management*, which could be targeted at both the residential and commercial and industrial sectors and include many of the learnings from the City of Cape Town drought management programme; and *water re-use* (in potable or non-potable form) which both reduces demand on water resources, and reduces the use of energy-intensive potable water for non-potable uses (although the scope for this is relatively limited as noted in Kalebaila and Bhagwan (2019)). The *replacement of older pumps and motors with energy efficient electro-mechanical equipment* when the technology reaches the end of its useful life is a further example.

To reach net-zero water production (where there is no net carbon emitted from the water and wastewater sectors) the water sector will need to reduce both its direct and indirect emissions. The largest source of direct emissions are methane and nitrous oxides. The capture of these gases produced by the wastewater treatment process and their use in energy production will be necessary to achieve net-zero. This is a specific policy focus in the DWS Climate Change Policy (DWS, 2017) and has potential in urban areas with large, centralised wastewater treatment systems, but there is limited scope in areas with non-sewered sanitation systems outside of a roll-out of next generation sanitation systems. Algal ponds may play a role in areas with relatively low volumes of wastewater and sufficient space for ponding (Pereira, 2009). A second, and significantly larger, investment would be for the water sector to reduce its reliance on non-renewable energy sources by investing in decentralised renewable energy sources (primarily solar photovoltaic systems or the combination of water storage and water use in hydropower or pumped storage systems). A third intervention would be the water sector using its influence over suppliers and customers to reduce their greenhouse gas footprint. Finally, where there are difficult-to-eradicate emission sources (embedded carbon, transport-related emissions) the sector would need to offset these carbon emissions.

4.2 Energy transition

Coal currently dominates the South African energy mix, providing over 80% of the total system load (CSIR, 2022). South Africa has committed to an energy transition to reduce greenhouse gas emissions. The effect of coal mining and power generation on local water quality and quantity has been well-documented in South Africa (see Water Research Commission, 2018), with several rivers suffering from poor water quality and decreased water availability. Water for energy consumes approximately 2% of the water use in the country, with a high concentration in the Mpumalanga highveld area (DWS, 2018).

Research by the CSIR has shown that a decarbonised economy would use a quarter of the water of the base case assumed in the 2016 Integrated Resource Plan by 2050 (CSIR, 2017). The World Bank's Thirsty Energy Study (World Bank, 2013) showed that, in addition to reducing water demand, an energy transition could potentially shift the location of water demand, for example from the coal fired power stations of Mpumalanga to concentrated solar power generation along the Orange River in the Northern Cape, or even to nuclear located along the coast. This highlights the importance of considering the impact of energy and environmental policy on water resources planning and policy.

While the extent to which an energy transition takes place is influenced by the policy of the South African government, it is largely exogenous to the water sector, which is the focus of this paper, and is thus treated as an exogenous variable here. An **energy transition** scenario was specified, assuming the retirement of five coal-fired power plants including Komati, Hendrina, Camden, Kriel and Grootvlei. The combined average annual water usage of these power plants is around 145 Mm^3/a (DWS, 2018). While this only represents a small percentage of the total water requirement for South Africa and only 5% of the water requirements for the Integrated Vaal River System (IVRS), it is the equivalent of 60% of the total water use requirement for the municipalities in Mpumalanga.

4.3 Service level goals

South Africa has committed to the SDGs, which define service level goals clearly, including a requirement of universal access to individual services *on the property*. Only about 54% of South Africans currently have a ‘safely managed’ water service as defined by the SDGs and 51% have access to safely managed sanitation (DBSA and World Bank, 2022). Achieving the SDGs will have implications both for volumes of water consumed (as households with on service property access typically consume more than those with shared access) and for cost (as on property services cost more to install and to operate and maintain on an ongoing basis than shared services). South African water sector policy has historically targeted basic service access (described in Annexure C), which allows for some degree of shared services, particularly in urban informal or rural areas.

Two service level goals were tested to demonstrate the potential impact that this policy decision has on expenditure needs and funding requirements, namely **universal basic servicing** and **achievement of SDG6.1 and 6.2**. Universal basic services allows for water and sanitation services to be shared between up to five households in urban informal and rural traditional areas, in line with historic DWS policy, while achieving SDG6.1 and 6.2 requires universal access to individual services on the property.

Of those households in South Africa with an inadequate water supply, 48% have issues related to the quality and reliability of services, 33% are accessing an unimproved water source, and 19% (mostly in rural areas and urban informal settlements) currently access water via shared services. Of those with inadequate sanitation supply, 44% have issues with quality of service (largely related to faecal sludge management at on-site facilities), 33% require improved access, and 23% currently access shared services. The largest share of both backlogs is thus related not to the lack of services but to the quality and management of existing services. Achieving service goals is thus not only about rolling out new infrastructure; the greater challenge, in fact, is managing existing infrastructure better. This was captured in the modelling by specifying the achievement of service level goals to require eradication of the renewal backlog mentioned in the introduction to this report, to bring existing infrastructure up to adequate condition and eliminate service interruptions. The models also assume adequate expenditure on the ongoing operation and maintenance of services.

In addition, it is assumed that **SDG6.4** ("By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity") will be achieved by 2030. Therefore, the water conservation and demand management (WCDM) target outlined in DWS's National Water and Sanitation Master Plan (175 litres per capita per day), and the 15% reduction below the business-as-usual scenario outlined in the NDP, are also specified to be achieved by 2030 in both service level scenarios.

Finally, the specification of all service level goal scenarios includes an allocation towards capacity building for water and sanitation professionals in the public sector. Capacity interventions are aimed at addressing a wide range of the objectives (improved capacity to manage non-revenue water and intermittent water supply, improve water quality, revenue management, etc.). Further capacity building for elected political leadership would be beneficial, but a cost allocation towards this is not assumed in the modelling.

4.4 Technology options

Service level goals can be met through a range of technology options. Current technologies typically include in-house connections, yard taps or public standpipes fed from municipal supply for water; and either full waterborne sanitation or ventilated improved pit latrines for sanitation. There are lower cost options available and, for sanitation in particular, alternative technologies such as on-site treatment or so called 'Next Generation Sanitation' are emerging. These different technologies will have different implications for water use and for cost.

The extent of WCDM implemented is also a key consideration. It has already been noted in the introduction to this report that current levels of NRW in South Africa are in the region of 41%. The implementation of WCDM to reduce demand and bring down these losses will be critical for achieving several of the identified water sector objectives, including affordability, reduced demand on surface water resources, and resilience. The service level goals have included some implementation of WCDM, to achieve SDG6.4 and the improvement specified in the NDP. The impact of more extensive WCDM implementation is regarded as a technology option and is included as a scenario here.

Box 5: The importance of reducing Non-Revenue Water

'Non-revenue water' (NRW) refers to the difference between the volume of water entering a system (the System Input Volume, or SIV) and the volume of water sold. NRW is comprised of 'real' losses due to leaks, pipe bursts and reservoir overflows, and 'apparent' losses due to inaccurate meter reading and unauthorised use. It is estimated that 85% of NRW in South Africa is due to real losses (DWS, 2019). While some level of real losses is unavoidable, most are due to poorly maintained infrastructure or slow responses to reports of leakage (McKenzie, 2014).

Reductions in real and apparent losses have different impacts. Reducing real losses reduces SIV and therefore overall water demand. Reducing apparent losses has no impact on demand, as this water is being consumed, it is simply not being accounted for. It does, however, strengthen water revenues by ensuring payment for all water consumed.

Both technical and non-technical interventions are required to reduce real losses. Non-technical interventions include community awareness and education campaigns. Technical interventions must start with sound data management to ensure accurate diagnosis of where problems lie. The most used technical interventions are leak management and repair, bulk metering, pressure management and pipe replacement. These measures can be reactive, however. Sound asset management to ensure that infrastructure is in good condition and well maintained is an often overlooked response, necessary to effectively manage losses on a sustainable basis.

Four scenarios were therefore tested to determine the impact of policy choices regarding water services technology to be applied:

- A **full conventional** option provides services using the current technology mix (status quo).
- A **low-cost** option prioritises the lowest cost technologies, and shared services wherever possible (given the applicable goal).
- An **alternative technologies** option attempts to minimise water use and energy use in the collection, storage, transport and treatment of water and wastewater.
- A **WCDM** option is specified with the same technology mix as the alternative technology scenario but pushes demand reduction measures to what can be considered the maximum feasible level. All other scenarios contain a target to reduce technical losses to 26% (i.e., a 15% reduction from 41%) and demand management to limit excessive consumption. The WCDM scenario reduces technical losses further, down to 20% by 2030 with this level maintained thereafter.

The specific technologies applied in each scenario are presented in Annexure B.

4.5 Timing

The SDGs are intended to be met **by 2030**. Anticipating that this might not be affordable for South Africa, a scenario was added to test the impact of delaying the achievement of the targets linked to the servicing goal to **2040**.

4.6 Invasive alien plant clearing

Invasive Alien Plants (IAPs) have been shown to have a significant detrimental impact on water resource availability across South Africa as shown in Figure 3 (Le Maitre, 2016). It has been estimated that IAPs in high rainfall catchments and riparian areas currently account for around 4% of total registered water use across South Africa and if not suitably managed could increase to around 16% of total registered water use (Cullis et al, 2007). Studies have also shown that current investments are insufficient to meet the spread of IAPs and that significant additional up-front expenditure and improved co-ordination is required in order for the current efforts to become more effective in helping improve water security and biodiversity (Le Maitre et al. 2019). There are also concerns that warmer temperatures and increased carbon dioxide levels are contributing to increase spread of IAPs and bush encroachment into grassland and savannas (O'Conner et al, 2014). This is likely to not only impact on grazing for livestock, but also potentially further impact on hydrology.

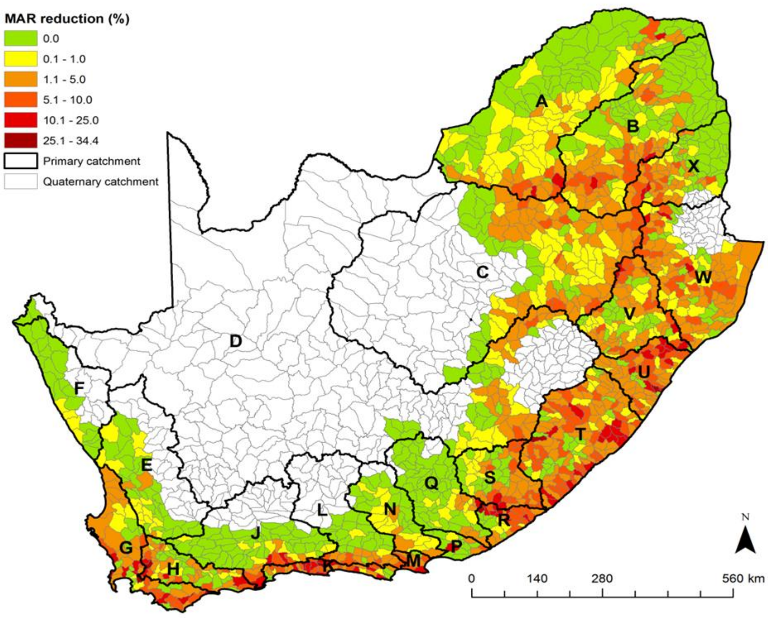


Figure 3: Impact of current level of IAP invasion on mean annual runoff

IAP clearing is thus a critical option being considered to augment or restore surface water capacity in South Africa. Three scenarios for IAP clearing are considered in the modelling, namely:

- A ‘**do nothing’** scenario which results in continued spread and further infestation of catchment areas and a further reduction in surface water yield in affected catchments;
- A **maintenance** scenario whereby the levels of infestation are maintained at current levels; and
- An **active clearing** scenario where IAPs are cleared to produce a maximum increase in surface water yield in affected catchments based on the current estimated IAP impacts.

4.7 Agricultural allocations

As noted in the introduction to this paper, agriculture currently uses 61% of all water use in South Africa. The NWSMP notes that agricultural consumption is largely unmetered and there are concerns about unauthorised abstraction and wastage in the sector (DWS, 2018). Apart from one or two specific schemes, the latest National Water Resources Strategy does not consider significant additional allocations of water to the sector, on the basis that any increases in demand should be met through improved efficiency. We know, however, that crop water requirements will likely increase by on average around 6% across the country because of climate change (Cullis et al, 2015) and simply to maintain current crop yields and crop areas might require some additional allocation of water to agriculture. The NDP proposes substantially increasing land under irrigation by 500 000 hectares (33%). DWS could choose to either further increase allocation to agriculture to support economic growth and improved food security, or reduce allocations to agriculture even further in the face of increased water scarcity and consider re-allocating water either to meet the growing demand from municipalities, which would otherwise have to develop higher cost alternative sources, or to ‘higher value’ production potential, and find other ways of maintaining food security through for example increased reliability on food imports and regional production from countries with fewer alternative economic options.

To capture the impact of these choices, three scenarios were considered:

- A **moderate increased allocation** scenario, that assumes an increase in the allocation of water to agriculture of 6% to accommodate the potential impacts of climate change;
- A **significant increased allocation** scenario, that assumes an increase in the allocation of water to agriculture of 15% to support increased production and job creation; and
- A **reduced allocation** scenario that assumes a reduction in the allocation of water to agriculture of say 15% in general across the country and reallocation to other sectors.

4.8 Operational efficiencies

The importance of WCDM for water services has been noted under the discussion of technology options. There is also the possibility of efficiency improvements in the integrated bulk water supply system that would reduce current losses resulting from unlined canals or inefficient operating policies. Conversely there are concerns that, due to a lack of resources and capacity, the DWS and other partners may no longer be able to effectively operate these complex systems, and this could lead to a reduction in efficiency and reduced water availability and reliability of the system.

In terms of improved operational efficiencies, there has already been pilot implementation of real time operational decision-making systems implemented for example on the Sundays Irrigation scheme that have realised savings of up to 20% in water use efficiencies and similar systems using improved digital technology have been suggested to improve operational efficiency of other systems including the Integrated Vaal, Orange, uMgeni, and the Western Cape Water Supply System.

At the other end of the scale, it is quite possible to consider a reduced efficiency scenario where the systems are not operated optimally. This is particularly true of the more complicated systems where there are efficiencies to be gained from collectively managing dam storage levels that result in an overall system yield that is greater than the sum of the individual dam yields. It is also quite likely that leaks and losses from the canals and bulk connectors could increase due to poor maintenance.

Two scenarios regarding operational efficiencies were modelled:

- An **efficiency improvement** scenario, assuming a 15% increase in the water availability from the existing systems due to improved operational efficiency and real time decision making; and
- An **efficiency decline** scenario, assuming a 15% reduction in yield by 2030 due to a failure to effectively operate the existing system and or due to increased leaks and water losses.

In all cases, the efficiency levels achieved by 2030 will be assumed to be maintained until 2050.

4.9 Presentation of scenario results

There are 11 664 possible combinations of the scenarios outlined above. A ‘base scenario’ has been used as a starting point to present the results in an intuitive and methodical manner. The base scenario is specified as follows:

- **Median climate change** impacts (climate change);
- **Current allocations to energy** (i.e. current energy supply mix);

- **Achievement of the SDGs and NDP goals** (service level goal);
- With **full conventional** technologies (water services technology option);
- By **2030** (timing of achievement of service level goal);
- Maintenance of the **current level of IAP** infestation (IAP clearing);
- Current allocations to energy (i.e. current energy supply mix);
- **Current allocations to agriculture** (allocations to agriculture); and
- **Current efficiencies** in the integrated bulk supply system (operational efficiencies).

This scenario can be thought of as 'achieving the SDGs without any other major policy or operational interventions.' A sensitivity analysis is conducted to demonstrate the impact of each policy lever or exogenous factor against the base case, independently of the others. A **'lowest cost'** and **'highest cost'** scenario are also shown, to demonstrate which combination of scenarios will result in the lowest and highest water sector expenditure needs until 2050.

5 Findings on investment needs and funding gaps

5.1 What investments are required to achieve the identified sector objectives?

A total investment of R256 billion on average per annum (real 2022 Rands) will be required between 2023 and 2050 to achieve water sector objectives under the base scenario (achieving the SDGs without any other major policy or operational interventions). This translates into a R7.16 trillion investment requirement (real 2022 Rands) through to 2050.

This investment requirement is reduced to R214 billion on average per annum (real 2022 Rands) under a combination of a wet climate, an energy transition, universal basic servicing, aggressive WCDM, increased clearing of IAPs, reduced allocations to agriculture, and improved system efficiencies. This translates into a R6.0 trillion investment requirement through to 2050 (real 2022 Rands).

The investment requirement increases to R314 billion on average per annum (real 2022 Rands) under a combination of dry climate, no energy transition, achieving the SDGs with full conventional technologies, no management of IAPs, increased allocations to agriculture, and a decline in system efficiencies. This translates into a R8.79 trillion investment requirement through to 2050 (real 2022 Rands).

When evaluating these figures, it is important to note that this report uses the term 'investment requirement' to refer to both the operating and capital expenditures that must be incurred. This takes a funding perspective, rather than a financing perspective, and considers all expenditures that must be incurred and how they must be funded. This differs from some other estimates of investment need, which often refer to investment to cover capital expenditures only[10].

The investments required are significant. When considering them, it is important to bear in mind that while investments in water and sanitation infrastructure are to a great extent an investment in the health and dignity of the users of the people of South Africa, they also have a significant economic impact. Research conducted in the United States of America found that closing the investment gap in that country would result in USD220 billion economic activity and create and sustain about 1.3 million jobs over 10 years (Value of Water Campaign, 2017). Equivalent research does not exist for South Africa at present and is currently being undertaken, but existing research on the impact of water scarcity as a result of lack of investment in the water sector suggests that a 17% increase in water scarcity results in a 0.34% decrease in the country's gross domestic product by 2030 (Briand et al, 2021).

Investment required increases over time. The average expenditure per annum required by time period is shown in Figure 4 below. The bars show the expenditure required for the base scenario, while the whisker plot on each of the time periods show the highest and lowest total expenditure required. Total expenditure (operating plus capital) increases from R210 billion per annum on average from 2023 to 2030 to R242 billion per annum on average from 2031 to 2040 and R306 billion per annum on average from 2041 to 2050. The maximum expenditure for these three time periods is R256 billion, R287 billion and R386 billion per annum on average respectively; while the minimum is R192 billion, R198 billion and R248 billion per annum on average.

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[10] The most notable alternative estimate of investment needs for the water sector is the National Water and Sanitation Plan (NWSMP) (DWS, 2018). That plan quotes a R899 billion investment need from 2018 to 2028. This figure refers to capital expenditure only. This is approximately 32% lower than the capital expenditure needs estimated under the base scenario for this study, after allowing for inflation and converting to equivalent time bases. The NWSMP also includes a figure of R571 billion in its Plan for Action. This is largely operating expenditure but also appears to include some capital. Combining the two figures, adjusting for inflation and converting to equivalent time bases gives an investment need of R1.4 trillion from 2023 to 2030, compared to the R1.68 trillion estimated under the base scenario this study. This is a 17% difference to the base scenario (although only a 7% difference to the low cost scenario). The difference highlights the complexity in estimating investment needs and the impact of different methodologies and cost assumptions.

The World Bank's Country Climate Development Report (CCDR) for South Africa (World Bank, 2022) quotes an investment need for resilient water of R720 billion between 2022 and 2050, on an NPV basis. The report indicates that this was drawn from the NWSMP. It is significantly lower than the NWSMP figure and it is assumed that some water investments have been included in the CCDR figures for resilient agriculture and resilient cities.

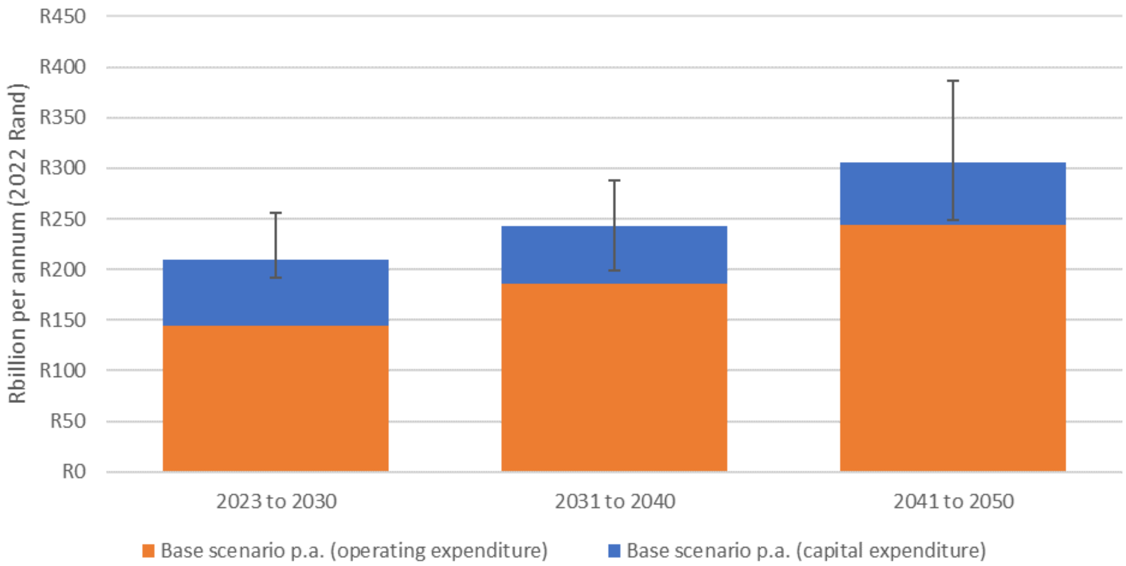


Figure 4: Average annual capital and operating expenditure for base scenario, highest, and lowest cost scenarios by time period

There is a 46% difference in the investment requirements between the lowest cost and highest cost combination of scenarios. **The large range in investment requirements is driven largely by sensitivity to the scenarios in the expenditure needs for water resources, rather than water services**, as can be seen in Figure 5 below. The water services expenditure need under the highest cost scenario is 21% higher than in the lowest cost scenario, while the water resources expenditure need is 115% higher under the highest cost scenario compared to the lowest cost scenario. This is because the costs of water resources augmentation options differ significantly. Scenarios that result in higher water demand over time mean that higher cost augmentation options must be implemented sooner, significantly increasing both the capital and operating expenditure needs for water resources.

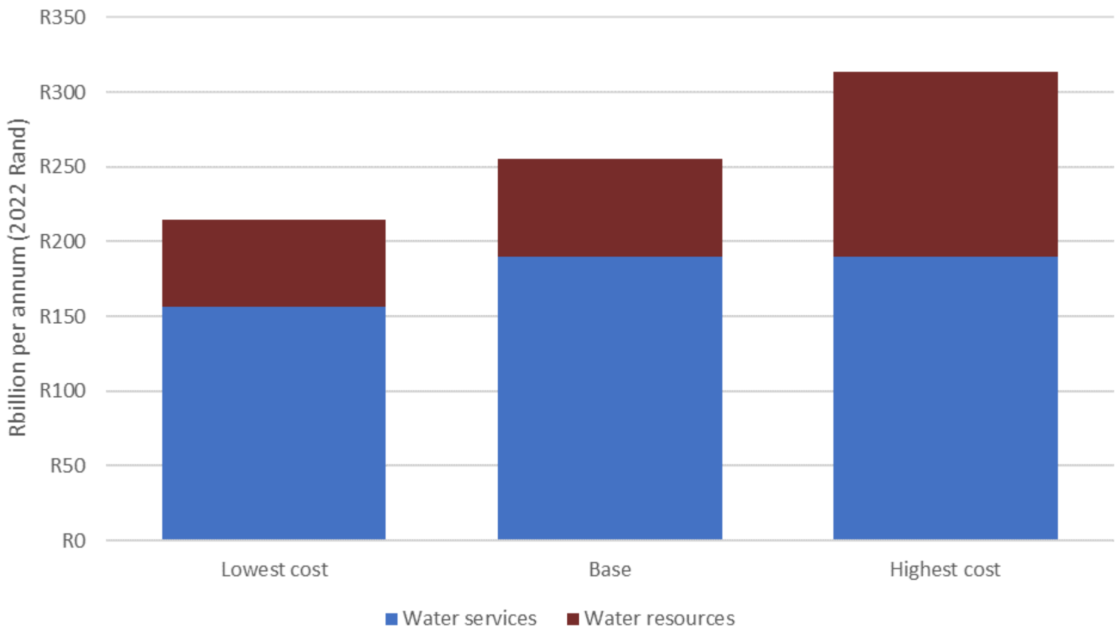


Figure 5: Average annual total expenditure for base scenario, highest and lowest cost scenarios between 2023 and 2050, disaggregated by water services and water resources

Expenditure needs increase over time largely due to growth in the operating expenditures required. Approximately 76% of the expenditure required between 2023 and 2030 is operating expenditure and these expenditures increase over time due to growth and as services are rolled out or service levels improved. By 2041 to 2050, operating expenditure makes up 80% of the total investment requirement.

Figure 6 disaggregates the operating expenditure required under the base scenario. It is notable that **WCDM and capacity building are a small proportion of the overall costs** (so small compared to other costs that they are in fact invisible in the figures below). These expenditures support achievement of several of the water sector objectives and the potential impact of WCDM and capacity building interventions is thus large for relatively low levels of expenditure.

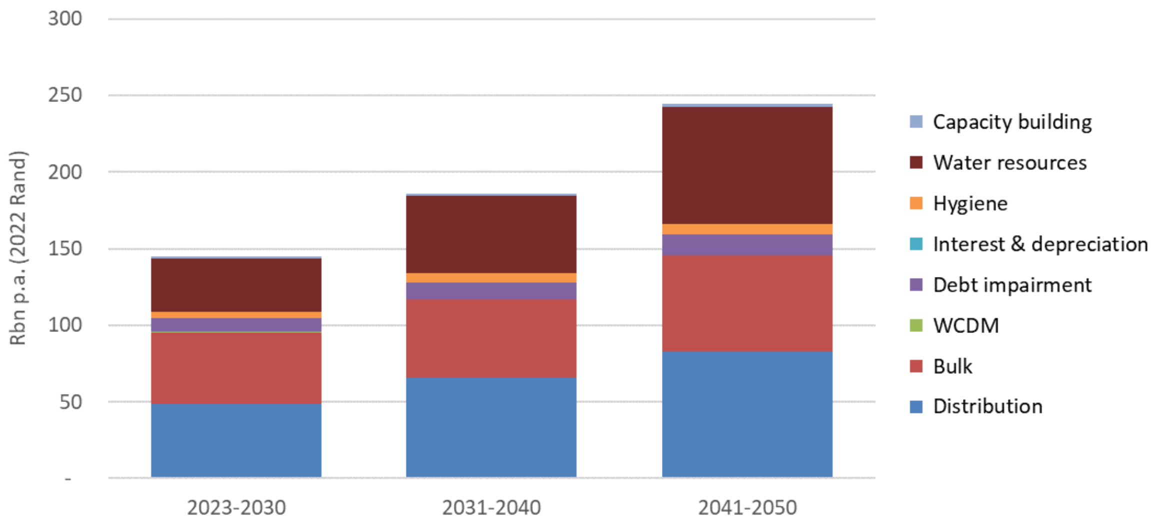


Figure 6: Disaggregation of average annual operating expenditure for base scenario by time period

Box 6: Technical capacity building for local government with an emphasis on water services

No nationally developed strategy for building technical capacity in municipalities currently exists but a proxy strategy emerged as an outcome of a workshop held in February 2020 at the Vulindlela Academy at DBSA. This strategy has no formal status but has been supported by SALGA through its Infrastructure Budget Legotla. It includes six primary interventions, two in the form of 'supporting the supporters' and four in the form of infrastructure support programmes:

1. Provide **technical assistance to the public private partnership (PPP) unit in the Government Technical Advisory Centre (GTAC)** at National Treasury to increase its capacity to develop partnerships with a 'supply driven' approach and including management contracts and operating contracts.
2. Provide **technical assistance to the Municipal Infrastructure Support Agency (MISA)** to turn around the current situation with a lack of professional engineers.
3. For metros: **Increase the capability of the existing City Support Programme (CSP)** to focus on water supply and sanitation services and facilitate partnerships with private sector organisations, including management contracts.
4. For Intermediate City Municipalities (ICMs): **Implement the currently conceived ICM Support Programme** but with an increased emphasis on technical capacity building for water and sanitation services and the related establishment of partnerships, where appropriate.
5. For Towns and Rural Local Municipalities: For these smaller municipalities **establish a new support programme** with specific roles for MISA and Provinces and framework contracts for private partnerships focused on specific types of infrastructure with wastewater treatment works being an important example.
6. For Rural Districts: The 21 districts which are water services authorities for mostly rural areas have the biggest technical capacity constraints associated with water supply and sanitation service provision. A **programme to set up regional management support contracts (RMSCs)** for these districts was conceived and accepted by government in 2015 but was implemented in different form by MISA. It is essential that this is re-established and applied according to the approved business plan.

Detailed costing has not been undertaken but a high-level costing for this strategy, including professional staff and overheads for all six interventions, transaction costs for private partnerships, costs of specialist consultants to supplement in-house capacity, and actual management contractor costs for the RMSCs, suggests that it would cost in the region of R1.5 billion per annum (Palmer, 2021).

Water resources represents approximately 31% of total operating expenditure need between 2023 and 2030 but 46% of operating expenditure need by 2041 to 2050. **Water resources operating expenditures grow more rapidly than those associated with water services**. This is because, like water services, water resources operating expenditures increase over time due to growth and roll-out of services (which drives a demand for more water), but they also increase due to the higher operating costs of future water resources schemes, particularly those associated with water re-use or desalination. These higher operating costs are often driven by high energy demands.

Capital expenditure need is highest in the first period (2023 to 2030) under the base scenario, as shown in Figure 7 below. This is due to the up-front capital expenditure required to achieve service level goals in this period (seen in the provision of new internal infrastructure and the eradication of the water services renewal backlog in the figure) and to close the current deficit on water resources in some of the major water supply systems and in general for the 'rest of the country'. Capital expenditure need increases in the third period (2041 to 2050). This is due to the continued growth in the cost of providing bulk and connector water services infrastructure, driven by population and economic growth.

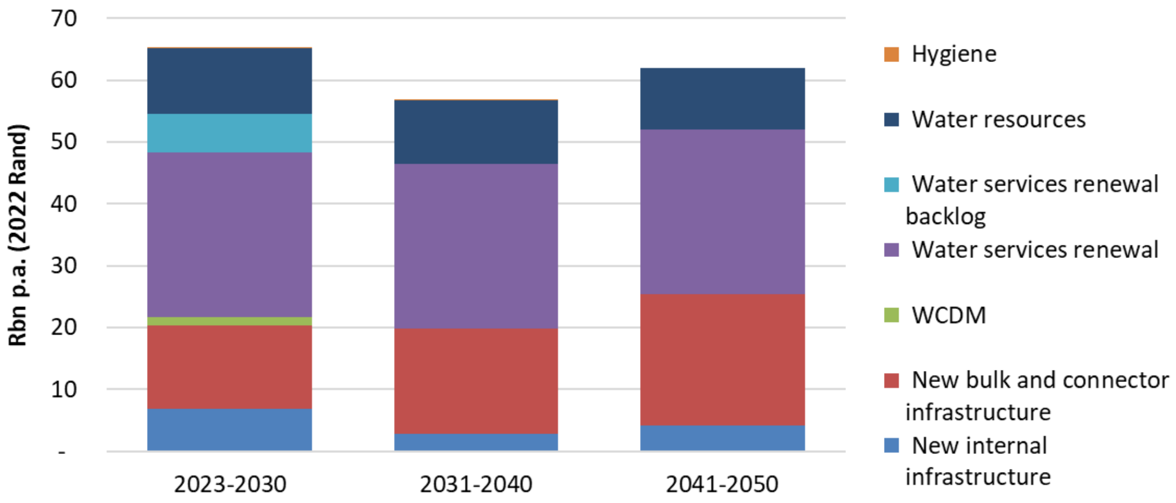


Figure 7: Disaggregation of average annual capital expenditure for base scenario by time period

It is clear from Figure 7 that **capital expenditure need is dominated by the renewal of existing infrastructure**, at least up until 2040. The study estimates that the value of water services assets in

South Africa is almost R1 trillion (Current Replacement Cost)[11]. These assets must be renewed on an ongoing basis. This is not happening adequately at present, as evidenced by a decline in asset condition and experienced through declining compliance with water and wastewater quality standards, rising services interruptions, and high levels of technical water losses. The renewal backlog in Figure 7 is the expenditure required to bring infrastructure conditions up to required levels to meet the SDGs. This is a smaller, but not insignificant, portion of the capital expenditure need from 2023 to 2030.

5.2 What additional funding is required?

The funding gap is the difference between the total expenditure required under a scenario and the available funding. **The funding gap for the base scenario is R91 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 37% of the total required investment.**

A funding gap remains under the lowest cost scenario but is reduced to R75 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 36% of the total requirement investment.[12]

The funding gap increases under the highest cost scenario to R149 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 49% of the toral investment requirement.

Figure 8 below shows the funding gap in each time period considered. **The gap grows over time because growth in available funding does not keep pace with growth in expenditure.**

[11] The National Water Investment Framework estimated a current replacement cost of R833billion in 2017 (DWS, 2017).

[12] As a proportion of cost, this is similar to the base scenario, as the revenue incurred through the use of universal basic servicing, assumed under the low cost scenario, is significantly less.

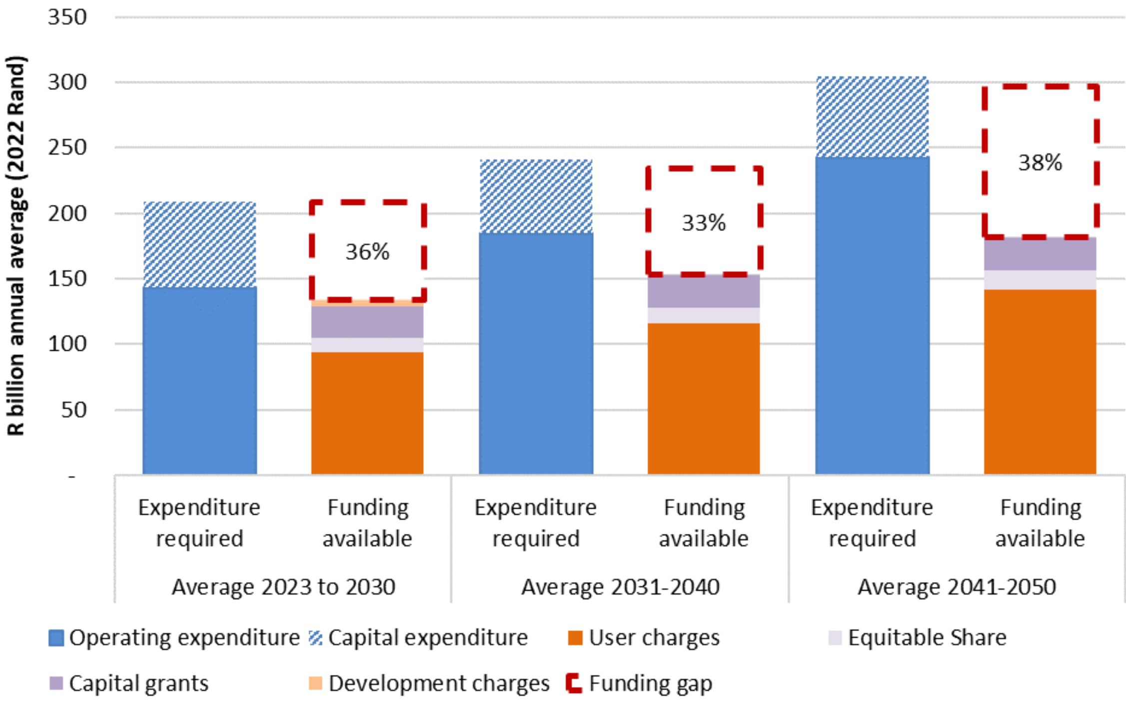


Figure 8: Investment requirement compared to current funding available in each time period

5.3 What is the potential to increase available funding?

The available funding gap shown in Figure 8 is based on current funding flows into the sector. There is some potential for a degree of optimisation in this funding, as discussed in the paragraphs that follow.

The most significant source of funding for the water sector is user charges received from end users of potable water. These are tariffs set and collected by municipalities. Water tariffs in South Africa are relatively low on average by international standards but there is great variability between municipalities. Increasing tariffs is the obvious option for increasing sector funding but needs to be considered against customer affordability. There is a prevailing narrative that water services tariffs are unaffordable in South Africa, but this has not been robustly tested and is based largely on perceptions of affordability. There may be some scope to increase water services tariffs but this study did not assess the affordability of existing tariffs, and so the available revenue from this source is assumed to be the current revenues from water and sanitation tariffs. Even if tariffs are not increased, there is potential for optimisation of the collection of this revenue. It is not possible from nationally available data to determine what proportion of water services tariff revenue is in fact currently collected, but the average collection rate on all municipal service charges was 90% in 2018/19, according to the National Treasury's Local Government Database, and is likely to have declined significantly in recent years due to the impacts of the COVID19 pandemic and governance failure. Collection rates are very variable, with relatively high rates in the larger cities, and rates as low as 40% in some small, rural municipalities. The funding gap between 2023 and 2050 can be reduced by R2.8 billion per annum (real 2022 Rands), or 1.2% of expenditure, if a 95% collection rate is achieved nationally.

User charges include raw water tariffs for non-potable water received from farmers, large industry and Eskom[13]. These have been historically under-priced (DWS, 2013; DWS, 2018). A Draft Revised Water Pricing Strategy has been published for comment but not yet approved. The extent of increase possible here is not known and so no optimisation has been assumed.

From a WEF Nexus perspective, the reduced water requirements for alternative energy supply options such as solar PV and wind should also be considered as reasons to support an energy transformation in South Africa, which in turn will have an impact on water requirements in different parts of the country. In some locations, such as Mpumalanga, there could be additional water made available from the closing of coal fired power stations, which in others, such as along the Orange River there could be increased demand for water for cooling of CSP or for new hydrogen generation.

The fiscal framework in South Africa makes provision for a transfer from national government to cover the cost of providing services to indigent households in the form of the Equitable Share and so tariffs are not required to cover all water services operating costs. The Equitable Share is an unconditional grant and municipalities may allocate it between services as they choose. The transfer is distributed between municipalities based on a formula, which allocates 46% of all funding to water services and this is the amount assumed to be available funding for the water sector. There is no clear reporting on how much Equitable Share is actually allocated to water services, but this can be estimated based on reporting to National Treasury to be between 18% and 26% of the total allocation. The modelling suggests that available allocations of Equitable Share, together with tariff revenues, are sufficient to fund the full operating costs of water services[14] but this requires municipalities to make adequate allocations of Equitable Share to water services. This does not always happen in practice, due to issues with the underlying financial viability or financial management of some municipalities. The funding gap

[13] DWS also charges raw water tariffs to water boards and to municipalities, but these are priced into the tariffs charged by municipalities to end users and are not a separate funding source to the sector.

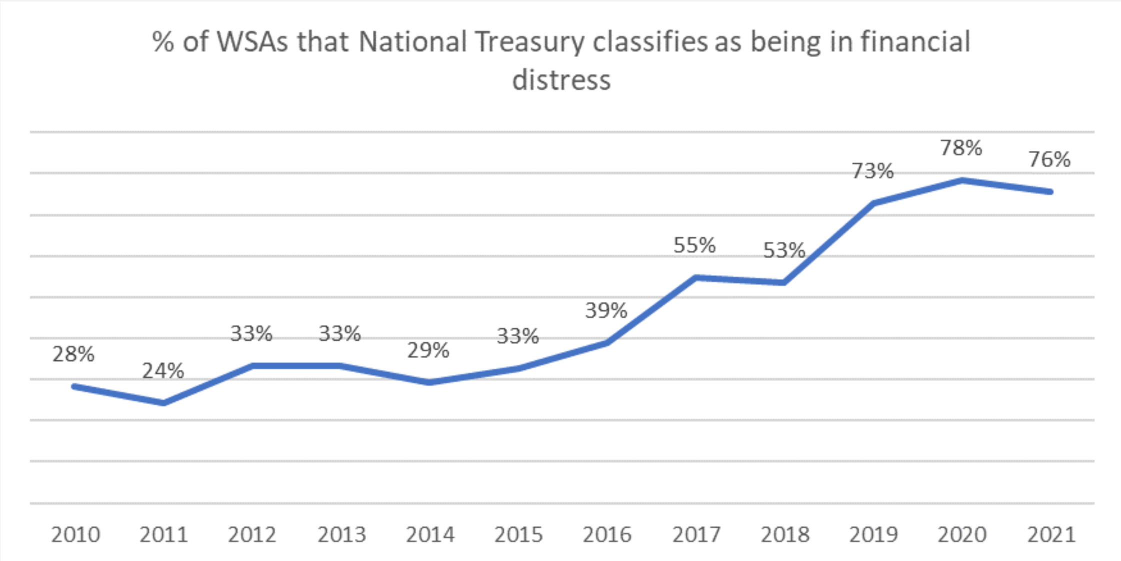
[14] Note that tariffs and Equitable Share are sufficient to cover the operating costs of water services, but not necessarily all capital or water resources costs, hence a funding gap remains even with optimised tariffs and Equitable Share allocations.

between 2023 and 2050 could be reduced by R40 billion per annum (real 2022 Rands), or 16%, if municipalities made the full allocation of 46% of their Equitable Share to water services.

Box 7: Financial and governance challenges at municipalities

The discussion above mentions three interventions by municipalities that could improve funding flows for water services, namely increased or optimised tariffs, improved cash collection, and increased internal allocation of the Equitable Share to water services. The fact that these issues exist speaks to the overall financial management and viability of municipalities, but also to critical issues related to governance and leadership.

National Treasury undertakes an annual assessment of the state of local government finances and uses a set of indicators to classify municipalities as being in financial distress. The results are alarming. As the figure below shows, the share of WSAs that National Treasury classifies as being in financial distress has grown steadily since 2010, with 3 out of 4 WSAs in financial distress in the most recent assessment in 2020/21.



A comprehensive set of good indicators of municipal governance is not publicly available, but audit findings are one commonly used measure. 99 of the 257 municipalities in South Africa, 39%, received qualified or adverse audit opinions in 2021/22. 32% of municipalities had a vacant Municipal Manager position and 22% had a vacant Chief Financial Officer position during this year. The AG noted that 'in many cases the councils could not adequately fulfil their oversight role because of a lack of stability and political uncertainty, resulting in delayed consequence management processes' (AGSA, 2022).

The evidence speaks to a crisis in governance, leadership and management in municipalities. A recent review of Water Services Authority (WSA) arrangements undertaken for the WRC noted issues with senior staff turnover, poor leadership, political interference and local politics, corruption, inadequate capacity of councillors to provide oversight, lack of political support for payment by consumers, and failed local accountability mechanisms as governance issues that are among the root causes of WSA dysfunction (Graham et al, 2022). The result is a negative downward spiral: poorly performing institutions are not able to deliver high quality services; this results in a decline in willingness to pay and reduced collection rates; which in turn exacerbates underinvestment and leads to further declines in the quality of services.

Municipalities are run as integrated entities providing a range of services, and individual services are not accounted for separately. This means that the financial health of the municipality as a whole impacts the financial health of water services. The allocation of the Equitable Share is a good example here: municipalities are not allocating sufficient Equitable Share to water services because they are instead allocating it to other services or to cover the governance and administration costs of municipalities. Improving the allocation of the Equitable Share would therefore require improving the financial management of municipalities as a whole and the financial viability of all of the services provided by municipalities. This is unlikely to happen without first resolving issues with leadership and governance.

In addition to the Equitable Share, municipalities receive several conditional grants that are intended to subsidise the capital costs of the provision of water services. DWS also receives capital grants for specific projects and these are included in the analysis, but these are small relative to the funding flowing to municipalities for water services. Given the constraints on the national fiscus, it cannot be assumed that the level of capital grants will increase and so no optimisation of this funding source has been assumed.

Development charges are capital contributions by private developers to the costs of bulk infrastructure. They are treated as a public funding source here because they can be required based on municipal policy. Reporting on current levels of development charges generated is poor but for water services it is estimated to be in the region of R4.5 billion per annum in 2023. There is scope to increase this figure and National Treasury is currently in the process of drafting legislation in this regard. Optimised funding from development charges has been estimated assuming that the full cost of bulk and connector infrastructure to high-income households and non-residential customers is covered through development charges. If current levels of development charge generation persist, the funding gap between 2023 and 2050 will be R4.7 billion per annum (real 2022 Rands), or 1.9%, larger.

Together, these funding interventions reduce the funding gap for the base scenario to R43 billion per annum on average (real 2022 Rands), which is 18% of investment requirements.

Figure 9 shows that the optimisation of funding reduces the funding gap to R29 billion per annum in the first period (14% of need), R30 billion per annum in the second period (12% of need) and to R56 billion per annum in the final period (19% of need) (all real 2022 Rands).

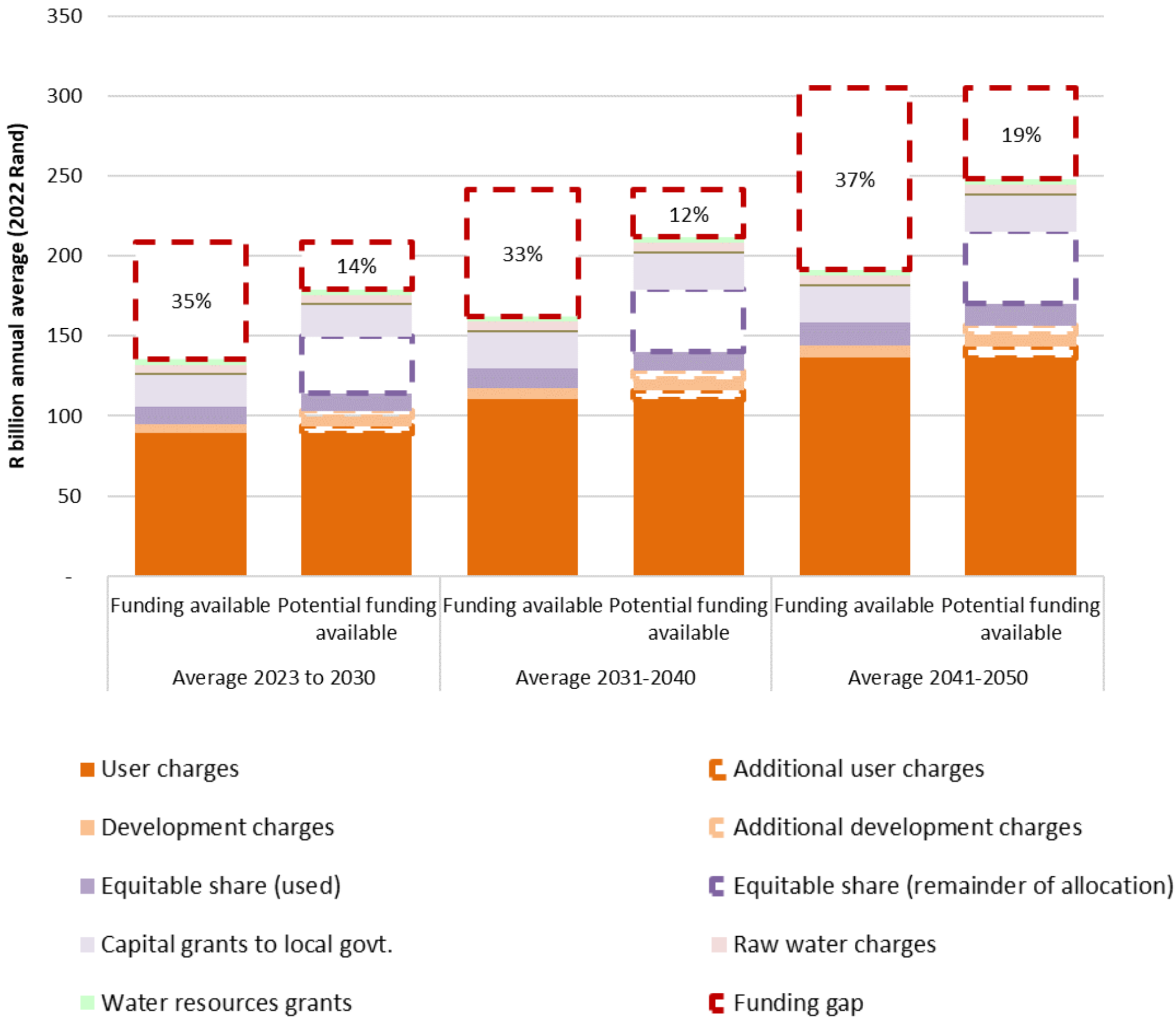


Figure 9: Required investment compared to optimised funding available in each time period

Even with optimisation of available funding, a funding gap remains and must be filled through a significant increase in tariffs and/or an increase in fiscal transfers to the water sector. Both options are unlikely to be affordable in the current economic climate and reducing the size of the expenditure need is thus critically important.

5.4 How do exogenous factors influence expenditure needs?

The expenditure needs and funding gap for the highest and lowest cost combination of policy choices and exogenous variable have been presented in Sections 5.1 and 5.2. Table 1 below shows the impact that each modelled exogenous variable has in isolation on the expenditure need.

Table 1: Sensitivity analysis demonstrating impact of each exogenous variable on the total average annual expenditure required from 2023 to 2050

	Average expenditure required per annum				***% increase or decrease compared to base***
	2023 to 2030	***2031 to 2040***	***2041 to 2050***	***2023 to 2050***	
	Real 2022 R billion pa				
Base	210	242	306	**256**	
Lowest cost	192	198	248	**214**	-16%
Highest cost	256	287	386	**314**	23%
Impact of climate					
Wet climate	207	229	289	**244**	-4%
Dry climate	224	255	341	**277**	8%
Impact of energy transition					
Energy transition	210	242	305	**256**	-0,1%

The impact of each exogenous variable is discussed below.

5.4.1 Impact of climate change

Climate impacts have a significant impact on investment requirements, with the dry climate scenario resulting in an increase in total capital expenditure need between 2023 and 2050 of 8% compared to base, while the wet scenario results in a reduction in the need by 4%, noting that there is a high degree of uncertainty in the future impacts of climate change particularly with regards to water security. More detailed analysis is required to confirm these impacts for individual systems.

South Africa is a water-scarce country with a highly uneven distribution of surface water resources. The NWSMP (DWS, 2018) warns of a 17% water deficit by 2030. Options for augmenting the supply of water (at any significant scale) include surface water augmentation, groundwater, direct potable water re-use, or desalination of seawater. The costs of these options differ both regarding up-front capital investment required and on-going operating cost. Water re-use and desalination are typically higher cost, with costs associated with energy use in particular being notably higher.

Water supply from existing surface water schemes is reduced under scenarios with a drier climate, meaning that new schemes must be brought online sooner, and that a larger proportion of future supply must come from more expensive augmentation options. Conversely, a wet climate scenario delays the need to implement new water resource schemes and introduce higher cost water resource options. Studies have shown that the impact of climate change can be in part mitigated through the benefits of the existing integrated bulk water supply systems (Cullis et al, 2019), as this allows water to be accessed from different catchments that may experience differential impacts of climate change and where additional storage capacity and the ability to move water from one catchment to another can be used to balance increased variability.

5.4.2 Impact of an energy transition

Retiring the five old coal fired power stations currently planned for decommissioning has only a small impact on water sector investment requirements at the national level, reducing the investments required until 2050 to achieve and then maintain the SDGs and NDP objectives by 0.1%. The five retiring coal fired power stations however together consume on average 145 million m^3 pa In comparison the total estimated municipal water requirement for Mpumulanga is only 241 million m^3 pa. This suggests that the energy transition could have a significant impact at local level in the catchments were the existing coal fired power stations are located.

Water demand in the energy sector is reduced by 34% due to the retiring of the five thermal power stations considered in the energy transition scenario. However, given that energy makes up only 2% of total water demand in South Africa (as shown in Figure 1) the impact on total water demand and hence the potential savings in capital expenditure to meet this demand, is small. This is a national picture as the potential impact in an individual system could be significant. The energy sector draws 95% of its water from the Vaal water supply system, with the remainder coming from the Limpopo system. A reduction in demand by the energy sector thus has significant impacts on water availability in these two systems: total water supplied by the IVRS systems is 3 120 million m^3 pa, of which approximately 5% is consumed by the energy sector (primarily Eskom). Although not captured in this analysis, the production of coal and its use in coal fired power also has significant negative impacts on water quality, which will be reduced if these plants and their mines are retired.

A more aggressive energy transition that involves the complete phasing out of all coal fired power stations as well as reduced demand from other high GHG emitting industries would result in additional savings on water resource infrastructure, although these may be partially offset by increasing demands in other systems as a result of new energy technologies such as concentrated solar power and hydrogen production in the Northern Cape using water from the Orange River.

The price of electricity will also have an impact on the cost of future water supply options, particularly alternative options such as desalination and the re-use of either treated wastewater or of acid mine water for which the energy cost are a significant contributor to the overall cost of supply. It is important therefore to also consider options for improved energy efficiency of these alternative technologies and the potential to combine these with renewable energy supply options such as wind and solar as well as energy recovery, hydropower and the use of biogas digesters to reduce the overall energy requirement of the water sector and to reduce its contribution to GHG emissions.

5.5 How do policy choices influence expenditure needs?

Table 2 below shows the impact that each modelled policy choice has in isolation on the expenditure need.

Table 2: Sensitivity analysis demonstrating impact of each policy choice on the total average annual investment required from 2023 to 2050

	Average investment required per annum				*% increase or decrease compared to base*
	2023 to 2030	***2031 to 2040***	***2041 to 2050***	***2023 to 2050***	
	Real 2022 R billion pa				
Base	210	242	306	**256**	
Lowest cost	192	198	248	**214**	-16%
Highest cost	256	287	386	**314**	23%
Impact of service level goals					
Universal basic servicing	190	219	273	**230**	-10%

	Average investment required per annum				***% increase or decrease compared to base***
	2023 to 2030	***2031 to 2040***	***2041 to 2050***	***2023 to 2050***	
	Real 2022 R billion pa				
Impact of technology choice					
Low cost	196	228	288	**240**	-6%
Alternative technologies	198	232	293	**244**	-5%
WCDM	194	225	280	**236**	-8%
Impact of timing					
Delay SDGs to 2040	206	243	306	**255**	-0,2%
Impact of IAP clearing					
Do nothing	211	239	308	**256**	0,0%
Active clearing	216	239	297	**253**	-0,9%
Impact of agricultural allocations					
Moderate increase	209	245	308	**257**	0,7%
More substantial increase	216	241	308	**258**	0,9%
Substantial decrease	211	241	300	**253**	-0,9%
Impact of operational efficiencies					
Improved efficiency	212	234	298	**251**	-2%
Efficiency decline	235	251	334	**276**	8%

The impact of each policy choice is discussed below.

5.5.1 Impact of service level goals

South Africa has committed to achievement of the water-related SDGs, which specify universal access to services on the property. However, in practice, DWS policy has been focussed on from achieving universal access to basic services and not universal access to services on the property. **This has a significant impact on the investment requirements, with the universal basic servicing scenario costing 10% less than the base scenario with achievement of individual access over the full period modelled.**

Individual services typically have higher operating and capital costs than shared services. In addition, water use is higher with individual on-site services, resulting in higher water demand than a universal basic servicing scenario. This has several impacts on expenditure needs, increasing operating expenditures on bulk water treatment and purchases, as well as capital expenditures required to increase the capacity of connector, bulk and water resources infrastructure to supply this higher demand, compared to universal basic servicing.

It is important to note that, as shown in Figure 10 below, while water demand projections with achievement of the SDGs is higher than with universal basic servicing, it is still lower than a projection of the current status quo. This is because all service level scenarios have assumed some implementation of WCDM, as noted in Section 4.3.

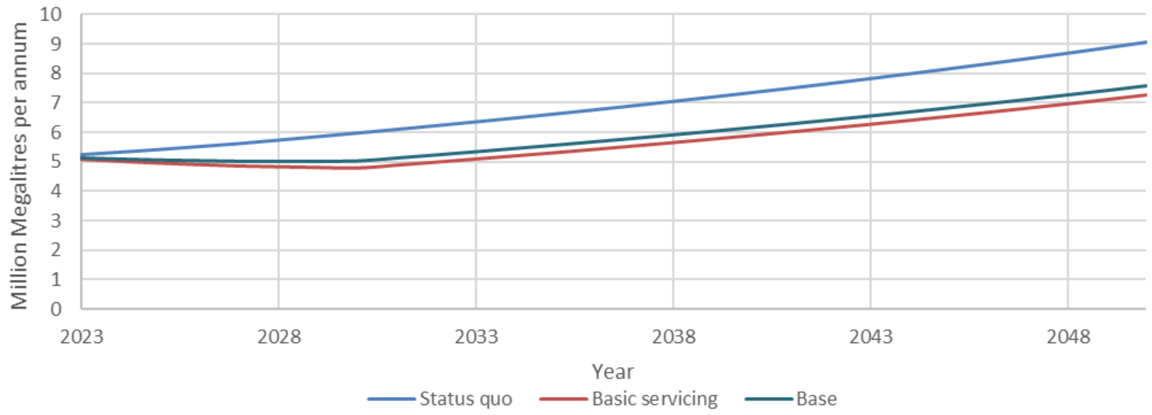


Figure 10: Total water demand projections for the two service level scenarios compared to status quo

5.5.2 Impact of technology options

The base scenario has assumed 'full conventional' services, similar to the technology mix currently provided. The other technology scenarios considered show that **investment requirement up until**

2050 can be reduced by 6 or 5% respectively if lower cost or alternative technologies are considered. Demand reduction if more aggressive WCDM is carried out is larger, at 8%. This indicates that implementing more aggressive WCDM is among the most impactful policy interventions that can be made to reduce the expenditure needs associated with achieving the SDGs and NDP goals.

The WCDM option assumes the current high-cost, individual technologies of the base scenario but is the lowest cost option because the reduction in water demand reduces bulk water treatment and purchases costs, as well as the need for investment in new infrastructure to supply the higher demand. It thus results in expenditure reductions along the full water value chain. As shown in Figure 11, the water demand reduction achieved through WCDM with achievement of the SDGs/NDP goals is even greater than resulting from universal basic servicing without extreme WCDM measures.

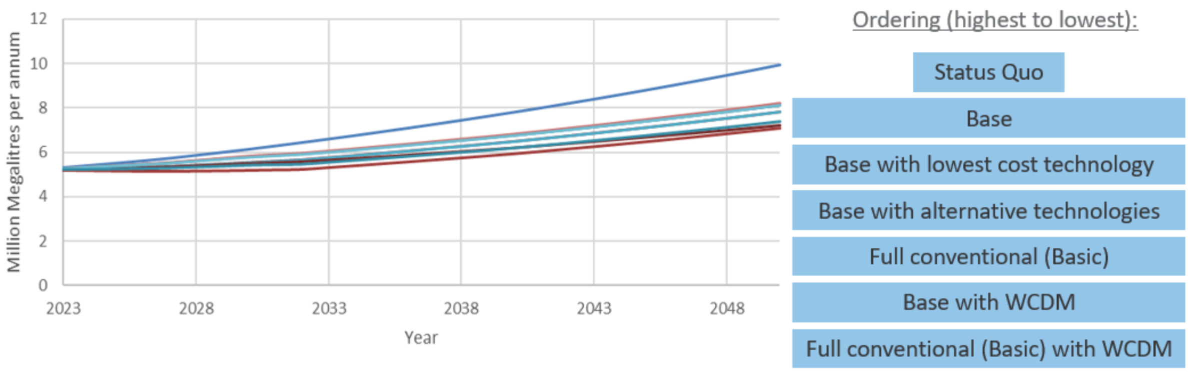


Figure 11: Total water demand projections for technology scenarios compared to status quo

The contexts in which alternative technologies can be implemented are relatively limited, meaning that these technologies can often be implemented only at relatively low scale, and so **a mix of low cost and alternative technologies, combined with aggressive WCDM, provides the lowest water services cost pathways to achieving the SDGs and NDP goals.**

5.5.3 Impact of timing

Delaying achievement of the SDGs/NDP goals to 2040 reduces total expenditure required by approximately 0.2%. Achievement of the SDGs/NDP goals includes the implementation of WCDM to achieve a 15% reduction in water use. Delaying this reduction means that water demand levels remain high for longer, with implications for the need to invest in additional water resource augmentation. However, these increases in expenditure are offset by the lower operations and maintenance costs of the inadequate services that remain in place for longer.

5.5.4 Impact of IAP clearing

The impacts of IAP clearing on investment requirements shown in Table 2 are less significant than anticipated. Investment requirements decrease under the 'active clearing scenario compared to the base scenario. They increase under the 'do nothing' scenario but by only 0.03%. The reason is the relative timing of capital and operating expenditures required. The 'active clearing' scenario requires higher operating expenditures than the base scenario to keep pro-actively clearing current IAP and then for continuous maintenance of the catchments, but it reduces the future capital expenditures required for water resources augmentation. The 'do nothing' scenario, on the other hand, requires no operating expenditures on IAP clearing, but a greater need for water resources augmentation and the resulting need to operate and maintain the new systems brought online. Because the expenditures associated with the IAP scenarios are incurred at different times, a comparison of the Net Present Value (NPV) of the costs gives a clearer picture of their relative benefits. This is shown in Table 3 below.

Table 3: Sensitivity analysis demonstrating impact of IAP scenarios on the NPV of expenditure required from 2023 to 2050

	Capital	***Operating***	***Total***	***% increase or decrease compared to base***
	2022 R billion			
'Active clearing'	1 106	533	**1 640**	-9%
Base ('Maintain')	1 216	580	**1 797**	
'Do nothing'	1 473	563	**2 036**	13%

Active clearing of IAPs results in a 9% reduction in the NPV of expenditures by 2050; while allowing IAPs to continue to spread results in increases in the NPV of these expenditures required by around 13% in total for the whole country. There are also significant co-benefits associated with IAP clearing including improved biodiversity, reduced fire risks and job creation. It is also important to note that the investment required for the pro-active clearing (around R8bn per year to clear by 2030) is significantly more than is currently being spent on IAP across the country with recent estimates indicating that DFFE spends around R1.2 bn per year on bio-control (Christo Marais, pers comm).

The importance of investing in ecological infrastructure (EI), particularly the protection of water supply catchments, is being recognised by policy makers as crucial to improved water security and resilience against the impacts of climate change. This would require municipalities and the private sector taking a greater interest in supporting the efforts to remove alien trees to improve water security. For many years South Africa has been a leader in this regard through innovative programmes such as the Working for Water Programme. There are costs associated with IAP clearing, but the analysis suggests that there is a net gain in terms of a reduction in investment requirements over the long term. When assessed on an individual system, as has been done for the Western Cape Water Supply System, the pro-active clearing of IAPs is shown to be the least cost alternative water supply option and to also prevent much higher future costs (TNC, 2019).

5.5.5 Impact of agricultural allocations

Increasing agricultural allocations of amounts of water by 6% in order to accommodate climate change impacts only increases the required investments by 0.7%. A 15% increase in total water allocations to agriculture increases investment requirements by 0.9%, while a 15% decrease in water allocations to agriculture reduces investment requirements by 0.9%.

It is also important to consider differences in the level of assurance of supply, in particular for agriculture. For some forms of water intensive agriculture there may need to be increased assurance of supply as well as increased allocations, particularly when taking into consideration the increased variability due to climate change coupled to rising demand.

While reducing allocations of water to agriculture results in a reduction in investment requirements, it is relatively small and only recommended if it can be achieved through efficiencies in the sector, and not through a reduction in agricultural production. Efficiencies need to be achieved without impacting employment. Reduced employment in agriculture has a disproportional impact on rural areas, with the potential to further contribute to inequality unless other policies were implemented to mitigate these impacts.

5.5.6 Impact of efficiency improvements

A 15% improvement in operational efficiencies in the bulk water system reduces investment requirements in the sector by 8%. A 15% decline in efficiencies, however, increases investment requirements by only 2%.

This highlights the importance of investing in the technical and operational capabilities of the bulk water supply systems. South Africa faces a huge risk if these systems are neglected. As mentioned previously, the effective operation of these existing integrated bulk water supply systems and inter-basin transfers are critical when it comes to adapting to climate change. While it might not be possible to achieve an overall improvement in efficiencies of 15%, there are several opportunities to make substantial improvements to the operation of individual systems across the country.

It is notable that the negative impacts of operational efficiency declines are much greater than the potential benefits from efficiency improvements. This can partly be attributed to the pace at which improvements in efficiency can be achieved. This is also true for other positive interventions such as the clearing of IAPs. If the pace at which the benefits are realised is too slow, then it might still be necessary to add additional water supply capacity to the system to meet increasing demands. If the efficiency gains are then realised, it will be too late to realise any potential savings in terms of reduced capital expenditure as these investments have already been made. As a result, there is a risk of stranded assets no longer required to meet the increasing demands. This observation provides a motivation for achieving these benefits as soon as possible and, if necessary, making additional upfront investments which could lead to long-term savings.

5.6 Summary of findings

A summary of the findings in the preceding sections is provided below.

Expenditure needs to achieve water sector goals

- The total investment requirement through to 2050 is R256 billion on average per annum (real 2022 Rands) to achieve water sector objectives under the base scenario (achieving the SDGs/NDP goals without any other major policy or operational interventions). This translates into a R7.16 trillion investment requirement (real 2022 Rands) through to 2050.
- This investment requirement is reduced to R214 billion on average per annum (real 2022 Rands) under a combination of a wet climate, an energy transition, universal basic servicing, aggressive WCDM, increased clearing of IAPs, reduced allocations to agriculture, and improved system

efficiencies. This translates into a R6.00 trillion investment requirement through to 2050 (real 2022 Rands).

- The investment requirement increases to R314 billion on average per annum (real 2022 Rands) under a combination of dry climate, no energy transition, achieving the SDGs with full conventional technologies, no management of IAPs, increased allocations to agriculture, and a decline in system efficiencies. This translates into a R8.79 trillion investment requirement through to 2050 (real 2022 Rands).
- The large range in investment requirements is driven largely by the sensitivity of expenditures for water resources (as opposed to water services) to exogenous factors and policy choices. The costs of water resource augmentation options such as re-use and desalination are high, particularly their operating costs associated with energy use, and so scenarios that bring these options on earlier drive expenditures up significantly.
- For the same reasons, investment requirements for water resources grow more rapidly over time than those for water services, and the share of investment requirements that are due to water resources is higher in 2041 to 2050 than it is in 2023 to 2030.
- Investments required to support WCDM and capacity building are a small proportion of the total cost but support achievement of several water sector objectives and have high potential impact for relatively low levels of expenditure.
- Capital investments are dominated by the renewal of existing infrastructure rather than by the demand for new infrastructure.

Additional funding required

- The funding gap for the base scenario is R91 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 37% of the total required investment.
- A funding gap remains under the lowest cost scenario but is reduced to R75 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 36% of the total required investment.
- The funding gap increases to R149 billion per annum under the highest cost scenario on average between 2023 and 2050 (real 2022 Rands), which is 49% of the total required investment.
- The funding gap grows over time because growth in available funding does not keep pace with growth in investment requirements. Under the base scenario, the gap is 35% between 2023 and 2030 but 37% by 2041 to 2050.

- The funding gap can be reduced through improvement in the collection of water and sanitation tariffs, more extensive use of the Equitable Share for water services, and the increased use of development charges.
- This optimisation of funding closes the gap under the base scenario to R43 billion per annum on average between 2023 and 2050 (real 2022 Rands), which is 18% of the expenditure required.

Impact of exogenous factors on expenditure needs

- Climate impacts have a significant impact on investment requirements. Investment requirements will be higher under a drier climate but lower under a wetter climate.
- The implementation of an energy transition reduces water use in the energy sector by 34% but has a very small impact on total water sector investment requirements, because water use by the energy sector is currently only 2% of total water use in the country. However, the potential beneficial impacts of coal closure on Mpumalanga’s available water resources are significant.

Impact of policy choices on expenditure needs

- The individual services required by the SDGs are significantly more expensive to provide than the shared services allowed under the current ‘universal basic access’ policy pursued by the DWS.
- Implementing aggressive WCDM has a large impact in terms of reducing investment requirements.
- A mix of low cost and alternative technologies, combined with aggressive WCDM, provides the lowest water services cost pathway to achieving the SDGs and NDP goals.
- Delaying achievement of the SDGs/NDP goals to 2040 has a very small impact on expenditure needs.
- Active clearing of IAPs reduces expenditure need.
- Reduced water allocations to agriculture reduce expenditure needs but may come at some risk to agricultural production and therefore food security.
- A reduction in operational efficiencies in the integrated bulk water supply system increases the investment requirements significantly. The negative impact of efficiency losses is greater than the positive impact of efficiency gains.

6 Policy priorities to be balanced

The analysis has made it clear that available funding is insufficient to achieve the SDG goals and NDP goals. There are several policy priorities that trade off against each other to some extent when achieving the goals. These priorities must be balanced. These are highlighted in this section.

6.1 Cost recovery and user affordability

The obvious intervention to close the water sector funding gap is to increase water services tariffs. Increasing tariffs and therefore revenues, however, has a negative impact on the affordability of services for customers. Sound assessment of the affordability of tariffs is seldom undertaken, and there may be scope to increase tariffs. It may also be possible to improve the affordability of tariffs through changes to their structure. Improving metering and billing, and limiting consumption where water is being charged below cost or free of charge, are other mechanisms to improve cost recovery, but require considerable political will to implement. Similarly, more stringent implementation credit control and debt collection will require strong political support. Overall improvements in the financial management of municipalities and the financial viability of services other than water will increase the extent to which municipalities are able to allocate Equitable Share to water services.

6.2 Individual and shared services

Shared basic services are more affordable and easier to implement in the short term to achieve universal access but may not be safe or financially and socially sustainable over the longer term. Individual, safely managed services, on the other hand, provide safe, sustainable access to SDG/NDP standard services, but are more expensive and require higher levels of management capacity to implement and maintain. They may also be difficult to implement in informal settlements due to constraints on physical space. The greatest barrier to achievement of the SDGs/NDP goals is probably the provision of individual sanitation facilities in dense, urban informal settlements, and more pragmatic solutions than individual, sewered or on-site facilities, need to be found. It is important to note, however, if individual services are pursued, that a global study by the World Bank shows that basic services as an intermediate step towards an SDG-standard service level is more expensive overall (Rozenberg & Fay, 2019). 'Intermediate' or 'emergency' measures such as chemical toilets often have low capital but high operating costs, and often remain in place for longer than initially intended.

6.3 Improved access through new infrastructure and improved services through better management

Access statistics show that the biggest issue in achieving the SDG/NDP goals for water and sanitation is not the lack of access, but the quality and, more importantly, the continuity of service. While the importance of increasing access to currently unserved households cannot be ignored, policy must also allocate adequate resources to improved management to those households that already have access. Improved management of services has the additional advantage of reducing overall costs over time, and the potential to increase revenue.

6.4 New water resource development, climate resilient infrastructure, ecological infrastructure, and improved catchment management, regulation and operational efficiency

The cost of new water resource development increases in future as more expensive augmentation options (including re-use and desalination) become necessary. Investment in new water resources is needed to improve water security and achieve growth but the amount of investment required can be deferred or reduced through improved catchment management (including clearing IAPs) and the achievement of operational efficiencies. The benefits of these interventions are greater the sooner they are implemented. This will require considerable state capacity at all spheres of government, as well as improved inter-governmental relations. In addition to the need for augmentation of existing sources is the need to improve the resilience of existing infrastructure and systems through better protecting them against increasing climate related shocks and also providing increased redundancy, early warning, and improved operational efficiencies to respond to periods of drought and/or floods.

6.5 Reduced availability of water and increased needs from agriculture

Climate impacts both reduce the availability of water and increase the demand for water by the agricultural sector in particular. In a water-scarce environment, policy makers must trade off increasing allocations of water to agriculture for food production against allocations to other sectors of the economy. Reductions in water allocations to the agricultural sector can be accommodated to at least some extent by increased efficiency in water use in the sector but more extensive reductions may increase the requirements to import food, which may drive higher prices and reduce food security, and have a negative impact on equality due to high levels of employment in the agricultural sector. Interventions that reduce the demand for water in other sectors or in the system overall, such as WCDM and the introduction of operational efficiencies, will free up water for use in the agriculture sector, although this will still need to be balanced against the requirements of other productive sectors.

7 Conclusion

South Africa has committed to the achievement of the SDGs and NDP goals by 2030. Some progress is being made towards achieving these goals in some cases, but recent evidence from the Blue Drop and Green Drop watch reports shows that we are moving backwards in others. Meeting these targets will become increasingly difficult due to continuing population growth and climate change.

The costs of achieving these goals are high, and exceed the available funding by a significant margin, even after assuming some optimisation of current funding. Achieving targets will require a significant increase in tariffs and/or an increase in fiscal transfers to the water sector. Both options are unlikely to be affordable in the current economic climate and reducing the size of the expenditure need is thus critically important.

The aggregate expenditure required to achieve water sector objectives will be impacted by exogenous factors, most notably climate change, but it is also impacted by policy and operational decisions by the various actors in the water sector. Delaying achievement of the SDG and NDP goals will not reduce the required investment. However, a mix of low cost and alternative technologies combined with aggressive WCDM can reduce it significantly, as can improvements in catchment management and regulation, and in operational efficiencies in the bulk water supply system.

Technical and management capacity is a constraint in the system across all three spheres of government. The development and supplementing of capacity is of critical importance to ensure adequate planning and implementation of new infrastructure, improved management of existing infrastructure, and the introduction of efficiencies in future.

Private sector support will be important in supplementing public funding for the water sector. Accessing this support will depend on having credible, credit-worthy institutions in the sector, and so interventions to strengthen the functioning of municipalities are vital.

It is notable in the modelling that the increase in expenditure needs due to *not* implementing interventions related to WCDM, IAP clearing, capacity, catchment management, and/or operational efficiencies is greater than the magnitude of the decrease due to implementing them. In other words, if improvements cannot be achieved, it is vital that things are not allowed to get worse. Similarly, the impact of improvements is far greater if they are achieved earlier, and so there is some urgency in implementing change in order to limit the size of the funding gap.

8 Recommendations

Two broad issues that will affect the efficacy of the report's recommendations are noted: 1) the stagnant economy; and 2) overall leadership and governance of the local government sector. Shifts on these two issues are important but fall outside the scope of this study.

A stagnant economy with rising unemployment and poverty impacts the financial viability of water services as it reduces ability to pay for services, increases the number of households that must be subsidised, and limits the scope for increases in transfers from the national fiscus and from private sector funders. Continued efforts to reignite the national economy are crucial for improvements in the availability of funding for water services.

The overall leadership and governance of the local government sector has been identified as a key constraint on the sustainability of water services (DWS, 2023). Leadership and governance must be addressed if other interventions are to be effective but are largely the mandate of the Department of Cooperative Governance and Traditional Affairs (CoGTA). They are noted here as a binding constraint on the effectiveness of some of the recommendations proposed in this report, but detailed recommendations on resolving issues of leadership and governance at municipalities, or indeed reviewing the local government system in its entirety, are outside the scope of this report.

Recommendations emerging from the analysis presented in this paper are listed below. Most of these recommendations will have a larger impact in terms of reducing investment requirements if they are implemented sooner, and so an over-arching recommendation is to act on them with urgency.

The recommendations are organised into three broad groupings, related to improved management of water services; reduced water demand; and closing the financial gap.

8.1 Improve the management of water services

There are three recommendations related to improving the management of water services.

8.1.1 Proceed with proposed reforms to introduce Water Operating Licences for Water Service Providers

DWS has made proposals to introduce Water Operating Licences under the Water Services Act and use the regulation of these to strengthen the management and governance of water services (DWS, 2023). These proposals are aligned with those emerging from a review of the Water Services Authority system, undertaken for the WRC in 2022 (Graham et al, 2022). Implementing this will require amendments to the Water Services Act to introduce a legal requirement that water services can only be provided by an entity that has an operating licence. Details of licencing requirements will be gazetted by the Minister and will include minimum competency requirements and minimum performance levels. These will be tailored to account for differences in municipal contexts. A municipality must meet these licence conditions if it provides the service itself or must contract with a licenced Water Services Provider (WSP). The Water Services Act will also be amended to strengthen enforcement through directives, and to define the functions that a WSP is accountable for. These proposals are supported by this study. Their implementation should be expedited through Operation Vulindlela[15] if necessary. It is important to note that the introduction of Water Operating Licences will only be effective if these can be adequately monitored and enforced. This recommendation is thus strongly linked with other recommendations that follow, related to capacity building at DWS (see sub-section 8.1.2) and the establishment of an economic regulator for water services (see sub-section 8.3.1).

8.1.2 Implement a nationally coordinated capacity building and institutional strengthening strategy

Most of the interventions required to reduce the size of the water sector funding gap can only be implemented with increased institutional capacity. Specific recommendations regarding local government capacity building are outlined in Box 6**Error! Reference source not found.** earlier in this report and include: 1) Providing technical assistance to the PPP unit in GTAC; 2) Providing technical assistance to MISA; 3) Increasing the capability of the CSP; 4) Implementing the Intermediate City Municipalities' Support Programme; 5) Establishing a new support programme for towns and rural local municipalities; and 6) Re-establishing regional management support contracts (RSMCs) for rural district municipalities. Minimum competence requirements for heads of technical services, and the enforcement of these, are covered under the proposals for Water Operating Licences in the previous sub-section. The draft National Infrastructure Plan 2050 Phase 2 (Republic of South Africa (RSA), 2023) also makes a proposal for the establishment of a Municipal Engineering Academy, which is supported by this study.

[15] Operation Vulindlela is a joint initiative of the Presidency and National Treasury to accelerate the implementation of structural reforms and support economic recovery. Addressing institutional efficiencies in municipal water and sanitation services is a key reform identified under Operation Vulindlela and these proposed DWS reforms would support this priority.

Capacity building is not required only at local government level. DWS' capacity to monitor municipal performance and to intervene where necessary must also be strengthened. This includes creating the capacity for economic regulation.

8.1.3 Incentivise proper integrated asset management

Capital expenditure needs are dominated by renewal, and ongoing maintenance expenditures must be increased. The draft National Infrastructure Plan 2050 Phase 2 (Republic of South Africa (RSA), 2023) makes several recommendations regarding asset management, which are supported by this study. These include: 1) The development by National Treasury and CoGTA of an integrated infrastructure delivery system, drawing on current best practices. This should include the Cities' Infrastructure Delivery and Management System (CIDMS) in metros and customisation of this system for other types of municipalities. 2) The design and implementation by Infrastructure SA, together with NT and CoGTA, of an annual awards system to recognize best practices and improvements in infrastructure delivery and asset management. 3) Infrastructure SA, in consultation with CoGTA and SALGA, to establish three learning networks for the different categories of municipalities and collaborate with the South African Cities Network regarding infrastructure related peer learning for metros.

With specific regard to water services, the recommendations outlined in therecently re-established Blue Drop and Green Drop monitoring programmes must be implemented, together with increased monitoring of water quality downstream of water treatment works to ensure early detection of non-compliance with effluent discharge standards.

8.2 Reduce water demand

Four recommendations are made regarding reducing water demand.

8.2.1 Prioritise WCDM

WCDM contributes to multiple water sector objectives, including improvements in access (through reductions in intermittent supply), financial sustainability (through cost savings and revenue improvements), resource efficiency, increased water resilience and reduced environmental impact. Specific recommendations regarding WCDM include: 1) putting municipal standards for acceptable losses in water supply systems in place and enforcing these through the proposed Water Operating Licence system introduced in item 8.1.1; 2) reviewing Water Services By-laws to ensure that they require water efficient fittings in new buildings; 3) clarifying the position on Performance Based Contracts (PBCs) for NRW reduction; and 4) accelerating the introduction of DWS's proposed National

NRW Programme. The possibility of a nationally funded Working on Leaks programme, linked to the Community Works Programme, could also be explored.

8.2.2 Improve operational efficiencies in the bulk water supply system

Improved efficiencies in operating the bulk water supply system and reducing losses from bulk conveyance systems have significant benefits in terms of reducing water sector expenditure needs, particularly if implemented soon. Efficiency declines have even larger negative impacts. Operational decision-making systems have been piloted in some systems and have been recommended for other systems. These should be developed and implemented to improve overall operational efficiency.

8.2.3 Coordinate efforts on IAP clearing and investments in EI

Reduced IAP infestation can improve surface water availability and are the least cost option for augmentation in most systems. DWS, in collaboration with other sector stakeholders, should identify priority areas for IAP clearing and develop catchment management plans that include IAP management planning at a catchment level. In addition, institutional responsibilities and the funding models for IAP clearing should be clarified. While the focus of this study was only on the impact of IAPs, it is also important to consider investments for other catchment management activities related to EI, such as the protection and rehabilitation of wetlands, critical for reducing climate related risks. The current spending on clearing of invasive alien plants is insufficient to address the increasing spread and the associated impact on reducing the yield from critical water supply systems. The clearing of IAPs is the least cost option for augmenting water supply from existing systems and if not managed could result in a significant loss of systems yield requiring the development of much more expensive alternative water supply options including desalination and re-use. There is significant interest in investing in ecological infrastructure including from the private sector and these should be encouraged and better co-ordinated. The clearing of IAPs should also become a requirement in the costing of new water supply investments. Providing support for follow up clearing and maintenance of the catchments is also critical, as is increasing investments in the protection and rehabilitation of wetlands, catchments and riparian areas which are critical in addressing other climate related hazards such as declining water quality and flood risk. The current water resources management charge is considered to be insufficient to cover the costs of effective catchment management.

8.2.4 Better manage water resource allocations

There are competing uses of water and clear allocations and agreements on the levels of assurance of supply are required to ensure adequate water for all requirements including for the environment.

Catchment Management Agencies (CMAs) should be established in all nine catchments. Specific recommendations to overcome the issues that have delayed the establishment of CMAs to date were made in Munnik (2020): 1) DWS should commit to a clear strategy for establishment; 2) Document and present the achievements of the two existing CMAs; 3) Develop a clear and mutual understanding of CMAs with trade unions; 4) Work with stakeholders to win back their trust; 5) Make sure that CMAs are oriented towards and willing to effect transformation in Water Use Allocations and in the institutions managing water; and 6) DWS should present a clear case to NT on funding and supporting CMAs to address NT concerns.

DWS and its CMAs should review current water allocations and assurances of supply, with due consideration to climate change impacts, and strengthen regulation of the abstraction of raw water.

8.3 Close the financial gap

Five recommendations are made regarding closing the financial gap.

8.3.1 Establish an economic regulator for water services

The need for improved economic regulation of water services has been acknowledged for many years, with a business plan for an independent economic regulator first released in 2017 (DWS, 2018). The establishment of an independent economic regulator for water was identified as a priority reform under Operation Vulindlela. Progress has, however, been limited. Engagements are currently underway to find a practical pathway forward, including the establishment of the Regulatory Commission, an advisory body to the Minister of DWS on strengthening water regulation. The establishment and capacitation of the regulator is a key priority. Several of the other recommendations made under this study will not succeed if stronger regulation is not in place, notably the proposals around introducing Water Operating Licences made in sub-section 8.1.1, as well as those around enforcing standards for water losses in 8.2.1. Given that the establishment of the regulator has not progressed, the key recommendation here is to undertake a high-level assessment to understand what the blockages are and put a plan in place to overcome these.

The regulator must also be adequately capacitated, as noted in sub-section 8.1.2.

The regulator should review and regulate water and sanitation tariffs (including the bulk tariffs charged by water boards), as well as the Water Operating Licences proposed under item 8.1.1.1. Audits should be undertaken to ensure that all connections are billed and metered. Municipalities with poor cost recovery should be supported to move towards cost-reflective tariffs.

8.3.2 Make appropriate service level choices

A mix of low cost and alternative technologies provides the best value-for-money way of achieving the SDGs and NDP goals. 1) The national policy position on housing provision and the servicing of informal settlements is unclear and should be clarified regarding whether the SDG standard of individual service is required, or whether shared services can continue to be provided; it is the position of this study that some degree of shared sanitation services is necessary in urban informal settlements; 2) 'Interim' or 'emergency' services with low capital but high operating costs should be avoided; 3) Faecal sludge management should be improved, particularly in rural areas; and 4) Alternative technology options, particularly for sanitation, should be used where they are available and can be delivered at scale, and research and development in this field should continue to be supported.

8.3.3 Strengthen all links in the revenue value chain

The revenue value chain includes metering, billing, credit control, debt management, indigent management and customer care. Improvements are required at municipal level at all steps of this chain. Much of this is currently outside the control of water services departments but specific recommendations relating to water services include: 1) All connections should be metered and 'deemed' consumption should be eliminated; and 2) Flow control should be implemented as a credit control mechanism.

Current reforms to treat water departments as business units within municipalities, with transparency in reporting and a single point of accountability, should be continued, in the larger municipalities at least. This will increase the control that water departments have over billing, credit control and debt management.

A nation-wide campaign should be implemented to address non-payment for water services, with strong political backing. Such campaigns have been undertaken before with little notable impact (although formal evaluations have not been undertaken). Non-payment speaks to long-term behaviour change and, to be effective, such a campaign must be well-resourced and long-term, with approaches, messages and mini-campaigns customised to different communities. This should not, however, compromise entrenched social justice commitments to meeting the water consumption needs of those who cannot afford market-related tariffs.

8.3.4 Pass the Development Charges legislation

Draft legislation to govern and regulate the standardized manner in which municipalities should levy Development Charges has been in place since 2013 but has yet to be promulgated. This legislation should be finalised as a matter of urgency.

8.3.5 Require reporting on the allocation of the Equitable Share to services

The Equitable Share is an unconditional grant and recommendations on changing this cannot be made without a full review of the local government fiscal framework, but it is recommended that municipalities should be required to report on how they allocate Equitable Share between each basic service (which includes water and sanitation), community services and institutional costs. This is a necessary step in improving financial transparency and accountability for water services, which in turn is required to improve their financial management. It is also a necessary step in a sound tariff-setting process, as tariffs should be set with consideration to any external subsidies allocated to a service. The current spending on clearing of invasive alien plants is insufficient to address the increasing spread and the associated impact on reducing the yield from critical water supply systems. The clearing of IAPs is the least cost option for augmenting water supply from existing systems and if not managed could result in a significant loss of systems yield requiring the development of much more expensive alternative water supply options including desalination and re-use. There is significant interest in investing in ecological infrastructure including from the private sector and these should be encouraged and better co-ordinated. The clearing of IAPs should also become a requirement in the costing of new water supply investments. Providing support for follow up clearing and maintenance of the catchments is also critical, as is increasing investments in the protection and rehabilitation of wetlands, catchments and riparian areas which are critical in addressing other climate related hazards such as declining water quality and flood risk. The current water resources management charge is considered to be insufficient to cover the costs of effective catchment management.

8.3.6 Mobilization of all public and private sector investments

The most significant conclusion reached in this report is that total investments in water and sanitation infrastructure need to increase by between 37% and 49% compared to current levels of investment depending on the scenario selected. This increase cannot be carried by the public fiscus which is already over-stretched. It follows that it will be necessary to put in place institutional arrangements that will make it possible to design and implement blended finance solutions. Blended finance refers to the blending of public and private sector investments in order to invest in a desired set of public goods. This usually means using public sector funding (both grants, equity and low-cost debt) to leverage private sector investments. For-profit private sector investors look for low risk and relatively high return environments for their investments. Public sector funding needs to be tailored to achieve this environment, without artificially subsidized unacceptably high private sector returns. Furthermore, if savings in pension funds are to be used, then it will need to be recognised that these funds can only invest in listed assets. It is, therefore, clear that new institutional configurations will be required. The Infrastructure Fund set up by the DBSA is a good example of such an institutional configuration.

In light of the above, it is recommended that a set of formal engagements takes place under the auspices of the NPC between water-related policy makers in government and the financial sector. The aim will be to develop the most appropriate institutional mechanisms for effectively leveraging substantial increases in private sector co-funding for water and sanitation infrastructures through to 2050.

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Annexure A: Description of water services and water resource models

Water services model

The water services model is a modified version of the municipal services financial model, which was developed by PDG over the best part of a decade. This model is designed to assist local government in the development of infrastructure investment plans, and undertake national analyses of infrastructure investment requirements. The water services model concept is shown in Figure A1.

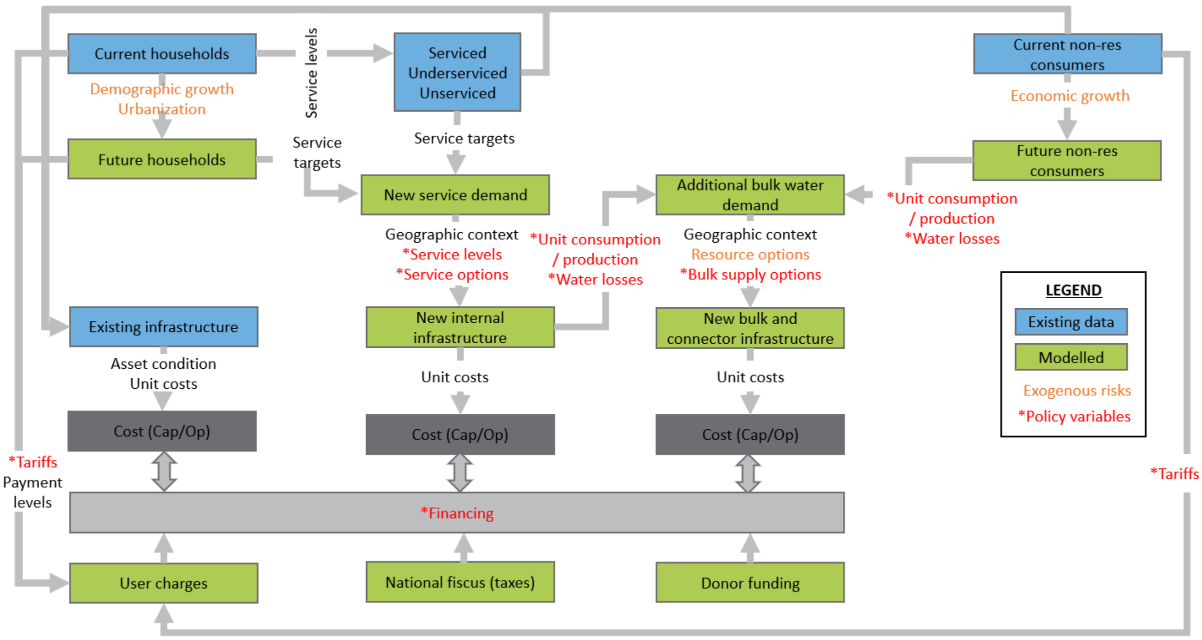


Figure A1: Water services model concept

The model projects the full operating and capital accounts associated with infrastructure provision in a municipal area over 10 years. The user can choose to model all infrastructure provision (by municipal and external service providers) or to model provision by the municipality only. In this case, only the water and sanitation services were modelled, for all actors (including private sector concessions and water boards that supply potable bulk water to municipalities).

The model uses a unit-cost approach to determine infrastructure investment need. The unit costs used in the model have been developed by a consulting engineering firm, and represent an average cost of providing infrastructure, and adequately maintaining this service (see costs in Annexure D). The starting point for the model is a projection of the number of consumers in a municipality, based on household and economic growth rates. A user-defined service delivery programme is then used to determine the numbers of consumers that have different levels of service in each year of the model run, as well as the numbers of consumers that are provided with different levels of service in each year. Once the service delivery programme is known, the model estimates operating expenditure and capital expenditure required using unit consumptions, operating costs per consumer and capital costs per new consumer connected for each level of service.

The model also projects the financing of the capital account (and its corresponding impact on the operating account), but this was not considered for the SDG 6 analysis, as the focus of the study is on the funding that is required to achieve SDG 6.

The following operating costs are included in this total cost:

- Operations and maintenance costs of existing water services;
- Operations and maintenance costs of new water services;
- Operations and maintenance costs of water resources (pro rata for potable water only);
- Operating expenditure on WCDM; and
- Operating expenditure on capacity building.

On the capital side, the total costs include the following capital expenditure:

- Capital costs of new internal, connector and bulk water services infrastructure;
- Renewal of existing water services assets;
- Renewal backlog on existing water services assets;
- Capital costs of new water resources infrastructure (pro rata for potable water only); and
- Capital costs of WCDM.

The funding sources included in the analysis are the following:

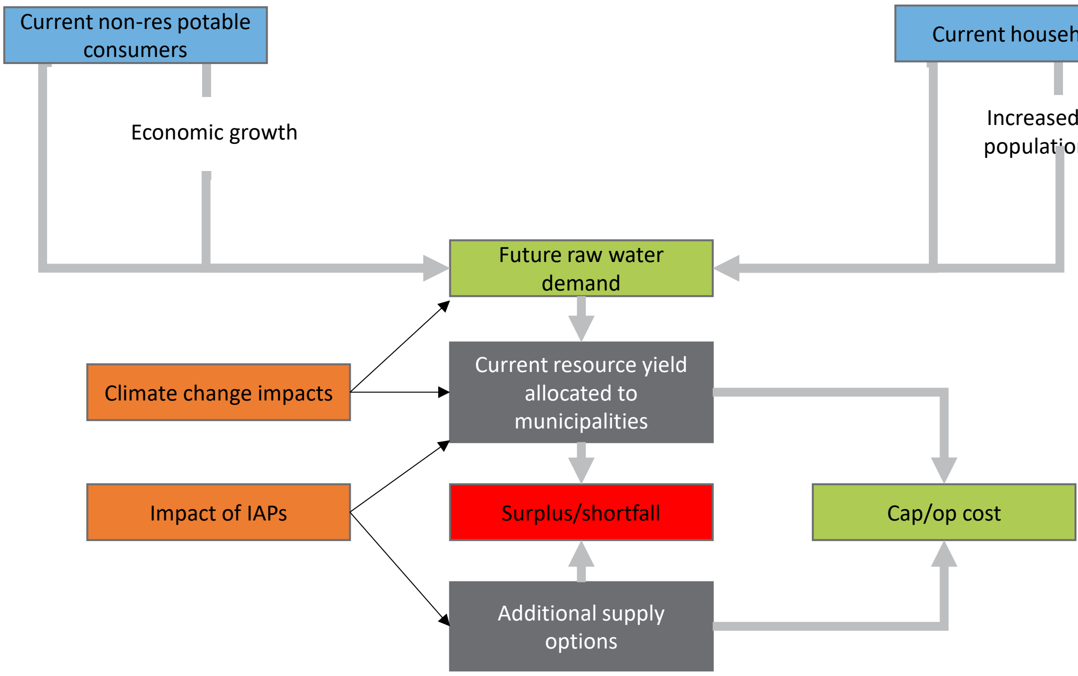
- User charges: Municipal water and sanitation revenue, less bad debt;
- Development charges: Capital contributions by developers to municipalities for new bulk services (either in cash or in kind), estimated as at 60% of the capital cost of bulk and connector infrastructure attributed to high income residential and non-residential customers;
- Equitable share: an unconditional transfer from the national fiscus to local government, calculated as the difference between reported municipal expenditure on water services and user charges revenue;
- Capital grants: from national to local government, including portions of the Urban Settlements Development Grant, the Integrated Urban Development Grant, the Municipal Infrastructure

Grant, the Regional Bulk Infrastructure Grant, the Human Settlements Development Grant, and the Water Services Improvement Grant;

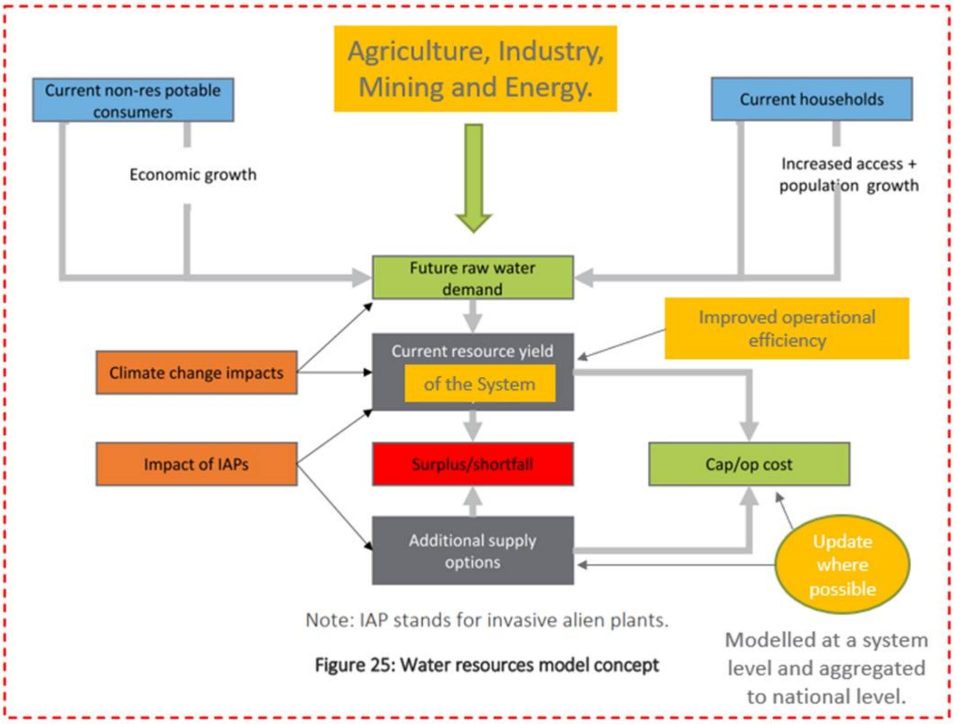
- National government capital expenditure directly from the fiscus by DWS and its agencies (for water resources), with 40% of the current capital expenditure of R2.1 billion per annum assumed to be for potable; i.e., approximately R860 million per annum[16].

Water resources model

The water resource model is a bespoke tool developed specifically for this project. The model concept is shown in Figure A2.



[16] National government operational funding from the fiscus has not been included due to a lack of clarity on the direct operating costs of water resources for potable supply and the proportion of these costs that are covered by raw water tariffs.



Note: IAP stands for invasive alien plants.

Figure A2: Water resources model concept showing the updates from the BtG I models

The model classifies the municipalities in South Africa into each of the 10 main water supply areas (WSA), with municipalities outside of this allocated to the 'rest of country' water supply area. These water supply areas provide an amount of water to these municipalities, known as their 'potable yield.' The changes in the municipal water demand to each of these WSA and the Rest of Country over time is then determined by the water services model based on the scenario considered.

The demand from other sectors within each of these WSA was determined from the available Reconciliation Studies which provide alternative scenarios for both current and future demands. The estimated non-potable demand from each sector for the Rest of Country was determined by subtracting the total demands for each sector from the individual WSA from the estimated total national water demand for each sector given in the National Water and Sanitation Master Plan.

The current available yield for each WSA and for the Rest of Country was obtained from the available reconciliation Studies and the National Water and Sanitation Master Plan. The available yield is affected by the prevalence of invasive alien plants, and the impacts of climate change. The impact of these changes is considered under the different scenarios and varies between the different WSAs based on the spatial variability of both potential climate change impacts and IAP impacts.

For each of the water service areas, the Department of Water and Sanitation has identified a pipeline of projects that can be used to augment the supply of water in advance of an anticipated shortfall.

These identified water supply augmentation options for each WSA and of the Rest of Country were compiled from the individual Reconciliation Studies and other studies were available. The DWS is currently updating all the Reconciliation Studies, but the updated results are not yet available. In addition, not all of the Reconciliation Studies included cost estimates for the augmentation options.

The water services model projects an overall potable water demand by geography type (Urban-Formal, Urban-Informal, Rural-Traditional and Rural-Farms) which is disaggregated to municipalities, and reaggregated to water service areas based on the location of the municipalities, with a factor to increase demand based on the increased temperature due to climate change, and a further factor to account for technical losses in the raw water systems (primarily leaking pipes during the conveyance of raw water). From data compiled for the All Town's Study, It is known what proportion of demand for each municipality is surface water, with this demand deducted from the yield available from the water service area. The groundwater demand is allocated to the 'rest of country' water service area.

For the climate change and IAP scenarios, the relative impact on the available yield is determined based on the estimated impact on water availability over a defined period for each WMA and for the Rest of Country. For example, the impact of climate change are realised proportionally till 2050 as is the reduction in water availability due to a lack of clearing of IAPs. Conversely the benefits of clearing of IAPs which results in an increase in systems yield are assumed to be realised by 2030. The current and future impacts of IAP scenarios on available yield were derived from Cullis et al, 2007. The potential impact of climate change on the available yield for each municipality were determined from the CSIR Greenbook Study (Cullis and Philips, 2019) which included a range of potential impacts representing a 10^{th} percentile dry scenario, a median 50^{th} percentile scenario and a 90^{th} percentile "wet" scenario. These are based on the overall impact on mean annual precipitation for the country.

The potential impact of climate change on municipal demand was also considered taking into consideration the potential increase in mean annual evaporation due to increasing temperatures.

The costs associated with the IAP clearing scenario were based on an estimated average IAP clearing costs of R6,353/ha which includes initial clearing and three follow ups (from Hassan and Mahlathi, 2020). For the pro-active clearing scenario, it was assumed that the existing IAP invaded areas of around 10 million ha (Le Maitre et al, 2016) would be cleared by 2030 at an average cost of R 8 bn per year which is significantly more than the current spend on IAP clearing across the country.

For the scenarios that affect non-potable demands (i.e. agriculture, energy and improved operational efficiency), these affect the total demand on the system when combined with the water services scenario impacts. For the Water Resources model only two water services scenarios were modelled.

The water resources model then deducts demand from the available yield of each of the WSA (the ‘potable yield’). If there is no shortfall, then no intervention is required to increase the available yield. If there is a shortfall, the model will calculate the extent of the shortfall, and identify the next project (or projects) that should be implemented to satisfy the shortfall. For the ‘rest of country’ water service area, the marginal costs of new interventions are applied to eradicate the shortfall. The interventions are assumed to be fully implemented in a single year, and implemented in their entirety, which results is most likely to result in a surplus for the following years.

This process is repeated annually for the 33-year period of analysis (2022 - 2050). The operating and capital costs of these interventions are then fed back into the water services model and aggregated with the cost of water services to determine the total cost of achieving SDG 6.1 and 6.2.

Annexure B: More detail on scenario definitions

Climate scenarios

The climate scenarios used in the water resources model draw heavily from the work done for the CSIR Green Book, both in localising global climate projections (Engelbrecht et al., 2019), as well as in assessing the impact of climate change on water supply and demand (Cullis & Phillips, 2019). The Green Book presents two of the globally agreed Representative Concentration Pathways (RCPs) (Intergovernmental Panel on Climate Change, 2007), namely RCP 4.5 and 8.5, and assessed the impact on average temperature, mean annual evaporation (MAE), mean annual precipitation (MAP), and mean annual runoff (MAR) for every municipality in the country. For this study, a range of the results from the worst-case RCP 8.5 scenario, are used to provide the clearest indication of how climate change may impact on the costs and policy choices. From the RCP 8.5 scenario, the 10%, 50% and 90% percentile figures are used for the three scenarios. The scenarios selected representing an overall dry (10^{th}), median (50^{th}) and wet (90^{th}) future climate change scenario with significant variability across the country and for different water supply systems. Changes in water demand were linked to changes in the MAE, changes in surface water supply are linked to changes in MAR, and changes in ground water supply are linked to changes in MAP. The resulting projections of available surface and ground water supply have been used as inputs into the water resources costing model to assess against the projected increase in municipal potable water demand. These results also indicate the potential benefits of the regional bulk water supply systems as it compares the potential impacts of climate change based on the impacts on local water resources (defined here as E1), compared to the potential impact on average annual water availability through a regional water supply system (defined here as E2), which is derived from a study of the potential impacts of climate change on water supply using a national configured water resources system model (Cullis et al 2015). For this study we have based the potential impacts of climate change on the estimated impacts on local water availability only (i.e. E1) as a first order estimate. Given the potential benefits of an integrated water supply systems, our results are therefore likely to not fully account for the benefits of an integrated bulk water supply system, but this is counted by the fact that we are also basing our estimates on the potential impact of average annual water supply and not in terms of system yield.

It is acknowledged that this is a very simplistic assessment of the impacts of climate change, particularly as it does not consider changes in seasonality or inter-annual variability, which are particularly relevant for water security, but it is sufficient for a first order assessment at a national level. Where more detailed modelling studies of climate change impacts on individual water supply systems are available, including one study of the national system (Cullis et al., 2015) that shows the significant benefits for resilience, these are considered when interpreting the results of this study. It is also assumed that there are no changes in the allocation of raw water between the different types of users (agricultural, municipal, energy generation, ecological reserve, etc.).

Service level goals

The 'basic service level' scenario allows for water and sanitation services to be shared between up to five households in urban informal and rural traditional areas, corresponding to the Joint Monitoring Programme (JMP) definition of 'basic' and 'limited' services for water and sanitation respectively (Table C1 in Annexure C).

Table B1: 2030 service level targets for the two service level goals

Settlement type	***Universal basic services***		***Achievement of SDG 6.1 and 6.2***	
	Water	**Sanitation**	**Water**	**Sanitation**
Urban formal	Safely managed	Safely managed	Safely managed	Safely managed
Urban informal	Basic (shared)	Limited (shared)	Safely managed	Safely managed
Rural traditional	Basic (shared)	Limited (shared)	Safely managed	Safely managed
Rural farms	Basic (shared)	Safely managed	Safely managed	Safely managed

Water services technology

The current technology mix is shown in Table B2 for water and Table B3 for sanitation, below. This technology mix is drawn from Community Survey 2016 (StatsSA, 2016), which is the most recent statistically relevant survey at municipal level. Where the full conventional scenario is applied, the inadequate technologies are upgraded into either basic services, or technologies that achieve the SDGs, depending on the scenario being modelled. More information on how the technologies, as defined by StatsSA, are mapped onto the achievement of the SDGS, as defined by the JMP, is available in Annexure C.

Table B2: Current access to services and level of service for new service to achieve SDGs (water)

	Current service mix	Assumed service level for new services to achieve SDG			
		Urban-Formal	Urban-Informal	Rural-Informal	Rural-Formal
Metered household from municipal supply	46%	100%			52%
Onsite supply from own borehole	2%				39%
Onsite supply from well/spring	4%				9%
Metered yard tap from municipal supply	27%		100%	100%	
Roof tank from municipal supply (i.e. regulated supply)					
Public/communal standpipes from municipal supply	15%				
Inadequate	6%				
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table B3: Current access to services and level of service for new service to achieve SDGs (sanitation)

	Current service mix	Assumed service level for new services to achieve SDG			
		Urban-Formal	Urban-Informal	Rural-Informal	Rural-Formal
Full flush system, connected to sewer	57%	100%	70%	2%	9%
Full flush system, connected to decentralised treatment					
Full flush system, connected to septic tank	4%			1%	13%
Pour flush system, connected to sewer			15%		
Pour flush system, connected to septic tank					1%
Pour flush with soakaway/leech pit					
VIP with emptying and treatment	21%			95%	77%
VIP double pit (i.e. no emptying and treatment)					
Dry pit with biochar treatment					
Containerised (chemical, container) i.e. requiring offsite treatment	2%	0%	15%	2%	0%
No water, onsite treatment (e.g. composting, UD toilets)					

	Current service mix	Assumed service level for new services to achieve SDG			
		Urban-Formal	Urban-Informal	Rural-Informal	Rural-Formal
Water, onsite treatment within unit (most likely NGS)					
Water, onsite treatment (Biodigester/biogas systems)					
Inadequate	16%				
Total	**100%**	**100%**	**100%**	**100%**	**100%**

The specification of the options is summarised in Table B4 and Table B5 respectively.

Tabble B4: Technology option specification for water

	Full conventional	Low cost	Alternative technologies	WCDM
Urban formal	In-house connection	In-house connection or yard tap	In-house connection or on-site borehole	As for alternative, but with more stringent WCDM measures
Urban informal	Yard tap or public standpipe	Public standpipe or on-site well/spring	Yard tap or public standpipe	As for alternative, but with more stringent WCDM measures
Rural traditional	Yard tap or public standpipe	Local borehole or spring to yard tap or standpipe	Yard tap, public standpipe with decentralised abstraction and treatment, on-site borehole, on-site well/spring	As for alternative, but with more stringent WCDM measures
Rural farms	In-house, on-site borehole, on-site well/spring	Yard tap or public standpipe	On-site borehole or on-site well/spring	As for alternative, but with more stringent WCDM measures

Table B5: Technology option specification for sanitation

	Full conventional	*Low cost*	*Alternative technologies*	*WCDM*
Urban formal	Flush toilet connected to sewerage	Pour flush toilet connected to sewerage	Combination of flush toilets connected to sewerage and some on-site treatment, and maximum realistic uptake of Next Generation Sanitation (NGS) and with decentralised treatment.	As for alternative
Urban informal	Flush and pour flush toilets connected to sewerage, on-site containerised	Pour flush toilet connected to sewerage	Combination of pour flush connected to sewerage with some on-site treatment and NGS.	As for alternative
Rural traditional	VIP	VIP (single and double), on-site dry (composting and UD)	On-site NGS and on-site treatment	As for alternative
Rural farms	VIP and septic tank	Pour flush toilet connected to septic tank	On-site NGS and on-site treatment	As for alternative

Annexure C: Alignment of JMP and StatsSA categories

The mapping of the JMP and StatsSA categories for water access is shown in Table B1 below.

Table B1: Alignment of JMP facility types and StatsSA reporting categories

SDG/JMP classification	StatsSA classification
Improved	All piped water
All piped	Piped (tap) water on site or in yard Piped (tap) water in dwelling Neighbour's tap Public/communal tap Borehole on site Borehole in yard Rain-water tank on site Rainwater tank in yard
Non-piped	Other Well Spring Water vendor Borehole outside yard Water-carrier/tanker
Surface water	Flowing water/stream/river Stagnant water/dam/pool

The JMP also assesses access against the JMP drinking water ladder. The alignment of the reporting categories in shown in Table 2 below, indicating which StatsSA classifications are included in the definition of 'safely managed' required in the SDG target.

Table B2: Alignment of JMP drinking water ladder and StatsSA reporting categories (Source: South Africa SDG Country Report, StatsSA:2019)

SDG/JMP classification	StatsSA classification	Data source
Safely managed	**The lower of the following two options:** -Piped (tap) water in dwelling -Piped (tap) water on site or in yard -Borehole on site -Borehole in yard -Rain-water tank on site	StatsSA GHS Blue Drop

SDG/JMP classification	StatsSA classification	Data source
	AND No water interruptions, or a water interruption has been repaired, in the previous two days **OR** Water from the following water sources that has been determined safe to drink: -Piped (tap) water in dwelling -Piped (tap) water on site or in yard -Borehole on site -Borehole in yard -Rain-water tank on site	
Basic service	-Borehole outside yard <200m away -Neighbour's tap <200m away -Public/communal tap <200m away MINUS The proportion of the population using safely managed water sources (i.e., the lower of the two items mentioned above)	StatsSA GHS
No service/ Inadequate service	-Flowing water/stream/river -Stagnant water/dam/pool -Other -Spring -Well -Water vendor -Water-carrier/tanker -Improved sources >200m away	StatsSA GHS

The alignment of the JMP sanitation categories to the StatsSA reporting categories is shown in Table B3.

Table B3: Alignment of JMP sanitation water ladder and StatsSA reporting categories

SDG/JMP classification	StatsSA classification	Data source
Open defecation	-Other -Unspecified -None	StatsSA GHS

SDG/JMP classification	StatsSA classification	Data source
	-Open defecation (e.g., no facilities; field; bush)	
Unimproved sanitation	-Pit latrine/toilet without ventilation pipe -Bucket toilet (collected by municipality) -Bucket toilet (emptied by household)	StatsSA GHS
Limited sanitation	-Flush toilet connected to a public sewerage system -Pit latrine/toilet with ventilation pipe -Flush toilet connected to a septic tank or conservancy tank -Pour bucket-flush toilet connected to a septic tank (or septage pit) -Ecological sanitation system (e.g., composting toilet) -Chemical toilet/portable toilet AND Facilities are shared between two or more households	StatsSA GHS
JMP basic sanitation	-Flush toilet connected to a public sewerage system -Pit latrine/toilet with ventilation pipe -Flush toilet connected to a septic tank or conservancy tank -Pour bucket-flush toilet connected to a septic tank (or septage pit) -Ecological sanitation system (e.g., composting toilet) -Chemical toilet/portable toilet AND Facilities are not shared	StatsSA GHS

The metrics for the measurement of a quality water service are contained in the Blue Drop System, which measures services against the SANS 241 drinking standard and the National Norms and Standards for Domestic Water and Sanitation Services (DWS, 2017b). The Blue Drop reports have not been issued since 2014, although it is set to be revitalised in 2022. In the 2014 Blue Drop assessment, 86% of WSAs achieved good or excellent status for microbiological water quality compliance, but only 70% achieved good or excellent status for water quality operational compliance. Data from municipalities are still reported into the DWS's integrated regulation information system (IRIS) system, which has been used in the analysis for this report to estimate the expenditure required to upgrade water treatment works to produce water of the required quality. The NWSMP indicates that 44% of the 962 water treatment works are in poor or critical condition.

The General Household Survey (GHS) collects data on the reliability of water supply, asking whether there have been interruptions to water supply in the prior 12 months that have lasted two days or more. Overall, 25.8% of households in the country have experienced intermittent water supply (IWS). Notably, in metropolitan areas, only 12.2% of households have experienced water supply interruptions, indicating a significant disparity in the reliability of services between metropolitan areas and secondary cities and rural areas.