

Parched prospects II

A revised long-term water supply and demand forecast for South Africa

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Summary

It is likely that South Africa is overexploiting its water resources at the national level, as water withdrawals currently exceed reliable supply. Using the International Futures forecasting system, this paper forecasts that withdrawals in all three sectors (municipal, industrial and agricultural) will increase over the next 20 years. Proposed interventions for increasing supply and reducing demand are not enough to reconcile the gap between withdrawals and supply. More must be done to bring the South African water sector into balance and reconcile future national water withdrawals with future national supply.

SOUTH AFRICA IS overexploiting its water resources at the national level. This means that national water withdrawals for municipal, industrial and agricultural sectors exceed levels of sustainable supply. This is based on best estimates of current water withdrawals and current water supply.

‘In many parts of the country, we are fast approaching the point at which all of our easily accessible freshwater resources are fully utilised. All South Africans must recognise this situation so that necessary steps are taken to assess current and future demands for water. This will not be an easy task, but with the necessary resolve to plan and implement the required interventions, a secure water future can be achieved.’ – NWRS2, 2013, page 4

Overexploitation occurs when more water is withdrawn from a water source than is sustainable. The amount of water that can be reliably or sustainably extracted from a resource is called the yield. This is determined using a level of assurance. For example, a river may have a yield of 1 km³/year at a 98% assurance of supply. This means that one cubic kilometre can be extracted from this river for 98 out of 100 years. If there is above-average rainfall in a given year, more than 1 km³ of water may be extracted without immediate consequence. But when withdrawals exceed reliable supply, the system is being overexploited and becomes more vulnerable – this is especially a problem when there is below-average rainfall.

According to the NWRS2, ‘as at 2012, South Africa has had 16 consecutive years of above-average rainfall in the majority of summer rainfall areas and in these areas the last major drought

was more than two decades ago. This trend is unlikely to continue.¹

Although droughts are inevitable, a stable water sector can mitigate the negative consequences of droughts. South Africa is a dry country but through integrated long-term planning, it is possible to maintain a reliable supply of water for all.

Scope

This paper is an update to an earlier publication, 'Parched prospects: The emerging water crisis in South Africa',² which was published by the African Futures Project (AFP) in September 2014 (henceforth 'Parched prospects'). This revised paper is a product of a collaboration between the AFP and the Water Research Commission (WRC). The AFP is a partnership between the Institute for Security Studies (ISS) and the Fredrick S Pardee Center for International Futures, at the University of Denver. Parched prospects estimated current levels of water supply and demand (withdrawals) in South Africa, and forecasted them to 2035 using the International Futures (IFs) forecasting system. The 'Parched prospects' paper found that South Africa is currently overexploiting its water resources at the national level and that the gap between withdrawals and supply will increase until 2035. The paper presented a reasonable growth forecast (Mandela Magic Lite), which demonstrated that increased economic growth would be likely to exacerbate the water challenges already facing South Africa. It also presented a Closing the Gap scenario, where the gap between withdrawals and supply is closed by 2035. This positive future scenario requires additional increases in supply and decreases in withdrawals beyond the existing interventions outlined in the latest National Water Resource Strategy (NWRS2).

South Africa is a dry country but it is possible to maintain a reliable water supply for its population

Since the publication of the initial paper, water challenges in South Africa have become more pronounced. South Africa is facing its worst drought episode in several decades and in November 2015, five provinces were declared disaster areas.³ Looking to the future, the Intergovernmental Panel on Climate Change (IPCC) forecasts a downward trend in precipitation in western South Africa and that the south-western region will be at high risk of severe drought over the 21st century.⁴ That said, many of the water resource stresses caused by climate change can be mitigated through the long-term adaptation and planning approaches outlined in this paper.⁵

The aim of this study is to forecast quantities of renewable fresh water. This study is not currently able to forecast quality of water, nor is the IFs forecasting model (see annex) able to do so. Contaminated water as a result of untreated municipal wastewater and acid mine drainage is a challenge for South Africa, but those challenges are outside the scope of this paper.

It is also outside the scope of this study to outline the exact reconciliation measures that will be most suitable and cost-effective for each water catchment. There are, however, some interventions that could contribute to closing the gap above and beyond the plans outlined in the large-scale reconciliation strategies. Existing strategies focus mainly on increased use of surface water through large-scale infrastructure projects, like dams and water-relocation schemes. Use of groundwater, wastewater treatment and municipal water demand management will also be needed to close the gap between supply and demand.

Current water withdrawals

To estimate current levels of water withdrawals,⁶ this paper uses data from the UN Food and Agriculture Organization's Aquastat database. It is important to prioritise Aquastat data because the withdrawal categories in this dataset – agriculture, municipal and industrial – are mutually exclusive. By estimating and forecasting these categories separately, the model ensures that withdrawals are not double-counted or under-counted. Since much of the data in Aquastat for South Africa is outdated, this paper estimates current water withdrawals based on the changes in underlying variables (see appendix). The paucity of water withdrawal data also speaks to the need for more research on quantifying current levels of water demand.

The largest user of water in South Africa is the agricultural sector. The most recent data available on agricultural water withdrawals in the Aquastat database come from 2000, at 7.836 km³.⁷ The 2004 NWRS estimated that agricultural water withdrawals for irrigation were 7.92 km³ in 2000.⁸

Aquastat also has data on the area of land equipped for irrigation, which is strongly correlated with agricultural water demand. The area of land equipped for irrigation in South Africa in 2000 was 1.498 million hectares. Irrigation levels have increased in South Africa and Aquastat estimates that in 2012, 1.601 million hectares of South African land were equipped for irrigation. Therefore, agricultural water withdrawals are likely to have increased since 2000. This paper estimates current agricultural water withdrawals to be 8.9 km³ in 2014.

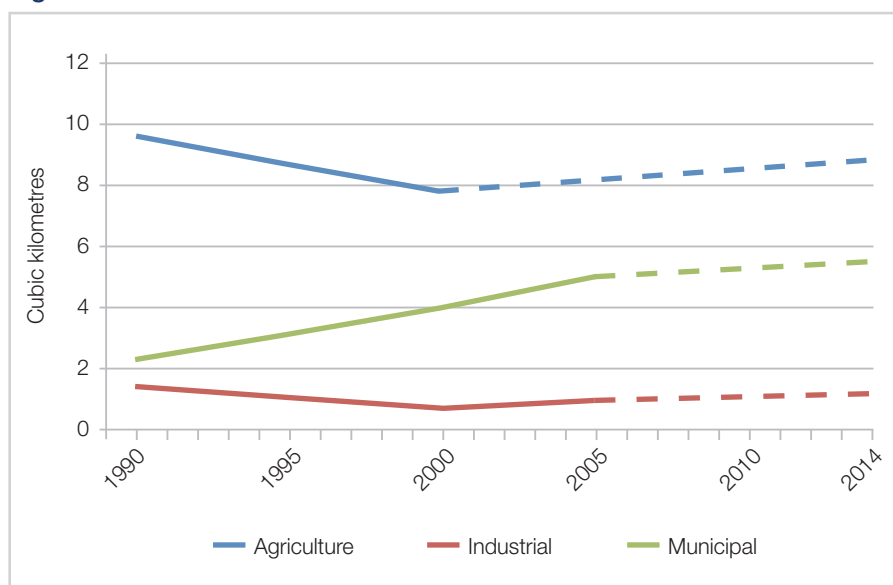
The second largest user of water in South Africa is the municipal sector. Municipal water withdrawals are usually calculated as the total water withdrawn by the public distribution network.⁹ The latest data for South Africa on municipal water withdrawals from Aquastat is from 2005. It is estimated that 4.893 km³ of water was withdrawn for municipal use in that year.¹⁰ Since 2005 the South African population has grown from 48.24 to 54 million people. In addition, incomes have increased, many more people have been connected to piped water and more people have moved to urban areas. For these reasons, municipal water withdrawals are likely to have increased since then. Using the same assumptions used to forecast municipal water demand, this paper estimates municipal water withdrawals to be 5.6 km³ in 2014.

South Africa's water challenges have become more pronounced and the country is facing its worst drought in several decades

The third largest user of water is the industrial sector. Aquastat defines industrial water demand as self-supplied industries not connected to the public distribution network. If an industry is connected to the public distribution network, it falls under the municipal water demand category. The latest data on industrial water demand from Aquastat is from 2005 and the estimate is that 0.9475 km³/year was withdrawn by industry.¹¹ The 2004 NWRS estimated that 0.755 km³/year went towards 'mining and bulk industrial' and that 0.297 km³/year went towards power generation.¹² The size of the manufacturing sector and the amount of thermo-electric power generation have increased since 2005, so this paper estimates that 1.1 km³ was withdrawn in 2014 for industrial purposes.

Therefore, the total volume of water withdrawal in 2014 in South Africa is estimated to be 15.6 km³.

Figure 1: Water withdrawals for the three sectors



Source: Historical data (solid lines) comes from the Aquastat database; forecasted values (dashed lines) are based on the authors' calculations.

15.6 km³

ESTIMATED TOTAL VOLUME
OF WATER WITHDRAWAL IN
SOUTH AFRICA IN 2014

Current water supply

Most water in South Africa is surface water – in other words, water that flows on the surface of the earth and is held in dams. Not all surface water is available for withdrawal, however. Some surface water must be retained in dams and rivers to maintain the ecological health of the water system or because of downstream requirements. Additionally, the level of water available varies throughout the year, and from year to year. Therefore, the amount of water that can be reliably extracted depends on this variability. Using these criteria, Aquastat estimates levels of exploitable annual surface water, or yield.¹³ Aquastat estimates that there is 10.93 km³/year of exploitable regular renewable surface water in South Africa, and this is the figure used to initialise the IFs model.¹⁴ The model forecasts that annual exploitable surface water increased to 11.14 km³/year by 2014, largely due to the construction of infrastructure, like dams. This figure, however, does not take into account any seasonal variation in water supply, such as droughts.

Over 80% of South Africans will live in urban areas by 2035, which should lead to better water-efficiency policies and technologies over time

Treated municipal wastewater is the second largest source of renewable water in South Africa. Of the 3.541 km³ of municipal wastewater that was produced in 2009, 1.919 km³ was treated.¹⁵ The model estimates that the amount of treated wastewater has increased and that the volume came to 2.1 km³ in 2014.¹⁶ Some of this wastewater is directly reused and some is released back into the system for use downstream. The portion of treated municipal wastewater that is not directly reused is considered secondary discharge and contributes to increases in surface-water yield.

Exploitable regular renewable groundwater was estimated by Aquastat to be 1.042 km³/year in 2012. According to the NWRS2,

the most recent estimate of sustainable potential yield of groundwater resources at high assurance is 7.5 km³/[annum], while current groundwater use is estimated at around 2 km³/[annum]. Allowing for an underestimation on groundwater use, about 3.5 km³/[annum] could be available for further development.¹⁷

This research estimates that current groundwater use is 2.04 km³/year in South Africa in 2014.

Desalination of seawater is the final source of renewable water in South Africa, though it constitutes a small portion of the total. This paper estimates/calculates that 0.024 km³ of desalinated water was produced in 2014.

Therefore, the overall annual water supply in South Africa is estimated to be 15.3 km³.

Forecasting water demand

Municipal

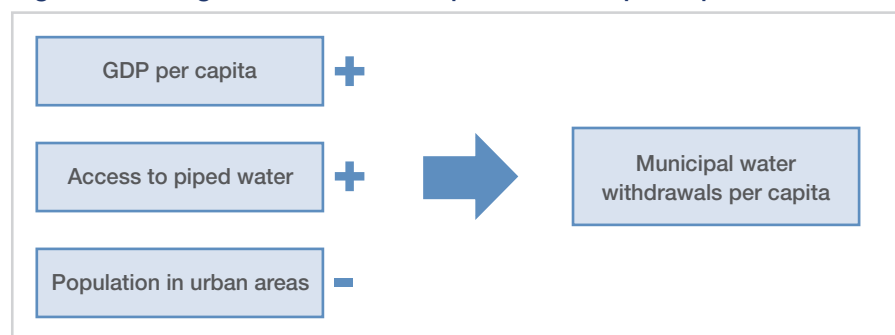
Since the publication of the 'Parched prospects' paper, further refinements have been made to the water sub-module of the IFs forecasting system. Along with using the size of the urban population to forecast municipal water withdrawals, the model also now

15.3 km³

ESTIMATED OVERALL
ANNUAL WATER SUPPLY
IN SOUTH AFRICA

includes three additional driving variables: GDP per capita (at purchasing power parity, PPP); access to piped water facilities; and the percentage of the population living in urban areas. Rather than merely using the size of the urban population to directly forecast municipal water demand, this new formulation uses these three variables to forecast municipal water demand per capita.

Figure 2: Driving variables of municipal water use per capita



Source: Authors' conceptualisation of connections in the IFs model.

Once municipal-water demand per capita is estimated, it is multiplied by the overall size of the urban population to estimate total municipal water withdrawals:

$$\text{Municipal water withdrawals} = \text{water use per capita} \times \text{urban population}$$

All three of these variables are statistically significant in forecasting per capita municipal-water withdrawals. Conceptually, as GDP per capita increases, people use more water. Likewise, people who have access to piped water rather than having to rely on shared water facilities use more water per capita. The larger the proportion of a country's population that lives in urban areas, the better developed the water saving technologies and policies for municipal-water demand generally become. Therefore, there is a negative correlation between the portion of a country's population that lives in urban areas and water use per capita.

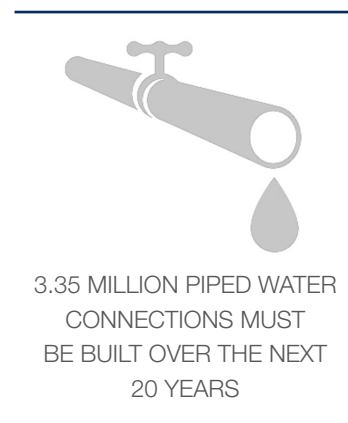
The model assumes that South African GDP per capita (at PPP) will increase by more than 50% over the next 20 years, from US\$12 390 to US\$19 110. Likewise, due to population growth, another 3,35 million piped water connections will need to be built over the next 20 years. Over 80% of South Africans will live in urban areas by 2035, which should lead to better water-efficiency policies and technologies over time.

Using this new formulation, municipal-water withdrawals will increase to even higher levels than forecasted in the original 'Parched prospects' paper. The model now forecasts that it will exceed 8 km³ by 2035. The original forecast was 7.2 km³ by 2035.

Industrial

Industrial-water withdrawal forecasts in IFs have also been refined. In addition to using thermo-electric power generation as a driving variable for industrial-water withdrawals, the model now includes water requirements in the manufacturing sector.

Thermo-electric power generation is a large consumer of industrial water withdrawals: water is required for cooling coal-fired power plants. In 2000, 2% of all water withdrawals in South Africa were used for power generation.¹⁸ Although this figure may not seem like much at the national level, power-generation water requirements often occur in catchment areas that are moderately or severely constrained.¹⁹



This updated industrial water withdrawal forecast has also taken into account research done by the WRC, published as 'Long term forecasts of water usage for electricity generation: South Africa 2030'.²⁰ The model assumes that thermo-electric power generation in South Africa consumes 1,85 litres/kWh (kilowatt-hours). This is assumed to decrease to 1,78 litres/kWh by 2035 due to the implementation of dry-cooling water-saving technologies.²¹

According to the 2010 Integrated Resource Plan, the national long-term energy plan, electricity-generating capacity will double by 2030, and nearly half of the new capacity will be from thermo-electric power plants (coal, gas and nuclear).²² The model estimates that current water consumption for thermo-electric power generation is 0.46 km³ and that it will rise to nearly 0.5 km³ by 2020.²³ Due to the onset of renewable energy and the increased penetration of dry-cooling technologies, water consumption for electricity generation will decrease after 2020. This is based on the assumptions used to forecast industrial water demand for electricity generation (see Appendix).

According to the 2010 Integrated Resource Plan, electricity-generating capacity in South Africa will double by 2030

Another component of industrial water withdrawals is the manufacturing sector. Although the size of the manufacturing sector in South Africa is likely to decrease in relative terms (i.e. as a percentage of total GDP), it is likely to grow in absolute terms. This translates into an overall increase in industrial water withdrawals for manufacturing purposes.

While the uptake of renewable energy will mitigate industrial water demand increases, the growth in thermo-electric power generation along with the increasing absolute size of the manufacturing sector will result in industrial water withdrawals to increase from 1.1 km³ in 2014 to 1.2 km³ by 2035.

Agriculture

The National Development Plan (NDP) sets a target of increasing the land under irrigation by 500 000 hectares.²⁴ The latest National Water Resource Strategy (NWRS2), however, has set a target of more than a 50% increase of land under irrigation in South Africa – which would be even greater than 500 000 hectares.²⁵ Yet the NWRS2 also states that 'additional water for increase in irrigation in South Africa is very limited and moving some water from irrigation to other use must already be considered in certain areas'.²⁶ Due to the constraints on water use, the scenarios in the NWRS2 do not foresee any increase in agricultural water demand.²⁷

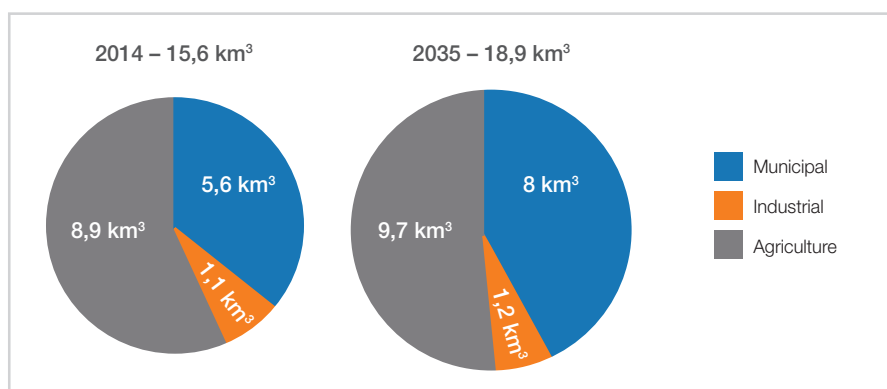
Since irrigation is the largest driver of agricultural water withdrawals in the IFs model, increasing the area of land equipped for irrigation leads to an increase in agricultural water withdrawals. In the Current Path scenario, agricultural water withdrawals increase to 9.7 km³ by 2035.

Overall water withdrawals will therefore increase from 15.6 km³ in 2014 to 18.9 km³ by 2035.



NEARLY HALF OF SOUTH AFRICA'S NEW ELECTRICITY CAPACITY WILL BE FROM THERMO-ELECTRIC POWER PLANTS

Figure 3: Total water withdrawals in 2014 and 2035 in the Current Path scenario



Source: IFs version 7.13. Area of pie charts scaled to overall water withdrawals.

Forecasting water supply

To refine the water-supply forecast the authors have looked at not only the NWRS2, but also every published large-scale water reconciliation strategy from the Department of Water and Sanitation (DWS) and other departments.²⁸ The NWRS2 includes reconciliation strategies for some large-scale water catchments, but additional studies have been conducted by the DWS since 2012. This research includes all of the available completed reconciliation strategies for all large-scale water catchments.

Although these reconciliation strategies do not cover the entire land area of South Africa, they do cover all of the main urban areas as well as the major sources of water supply (i.e. all major rivers). Therefore, while the sum of these interventions does not constitute a complete national water reconciliation plan, it does provide a good approximation.²⁹

Compiling all of the reconciliation strategies, the DWS plans for an increase in yield of over 3.5 km³/year by 2035. This increase would be achieved by implementing a number of large-scale infrastructure projects, like the LHWP2, as well as by raising and constructing dams throughout South Africa. This means the total system yield in 2035 will be 17.8 km³ (see Figure 4).

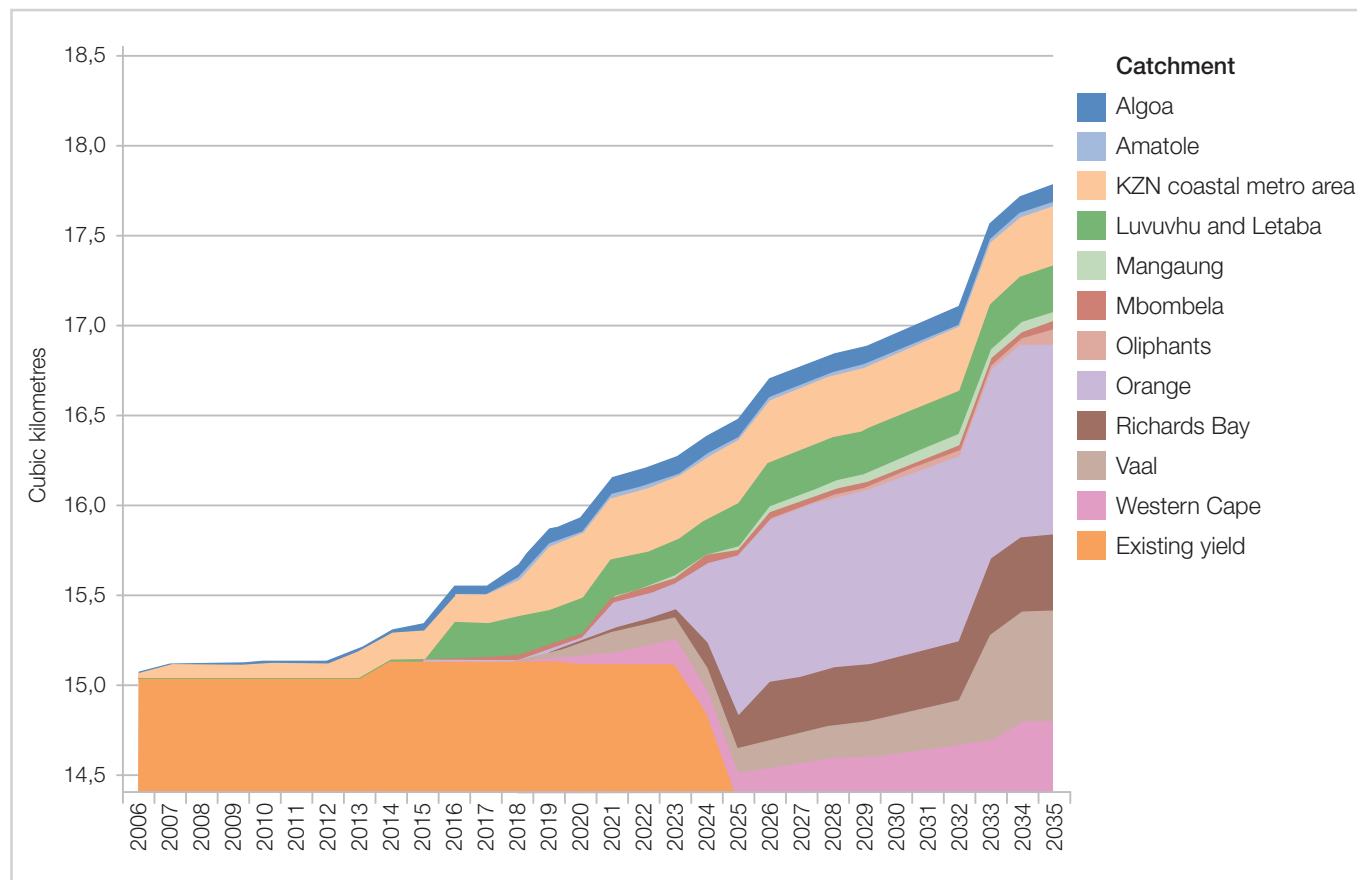
South Africa's latest National Water Resource Strategy has set a target of more than a 50% increase of land under irrigation

This supply forecast is considerably higher than the supply forecast presented in 'Parched prospects'. In that paper, supply was expected to increase only to 16.4 km³ by 2035. The original supply forecast relied on information explicitly outlined in the NWRS2, while the supply forecast in this paper relies on information extracted from every large-scale reconciliation strategy. It is important to recognise that this supply forecast is compiled using every single explicit yield increase from the reconciliation strategies and that some of these planned increases are actually only options, which may or may not be pursued.³⁰



OVERALL WATER WITHDRAWALS WILL INCREASE FROM 15.6 KM³ IN 2014 TO 18.9 KM³ BY 2035

Figure 4: Planned yield increases extracted from all published large-scale reconciliation strategies



Source: All large-scale reconciliation strategies, see endnotes for sources.

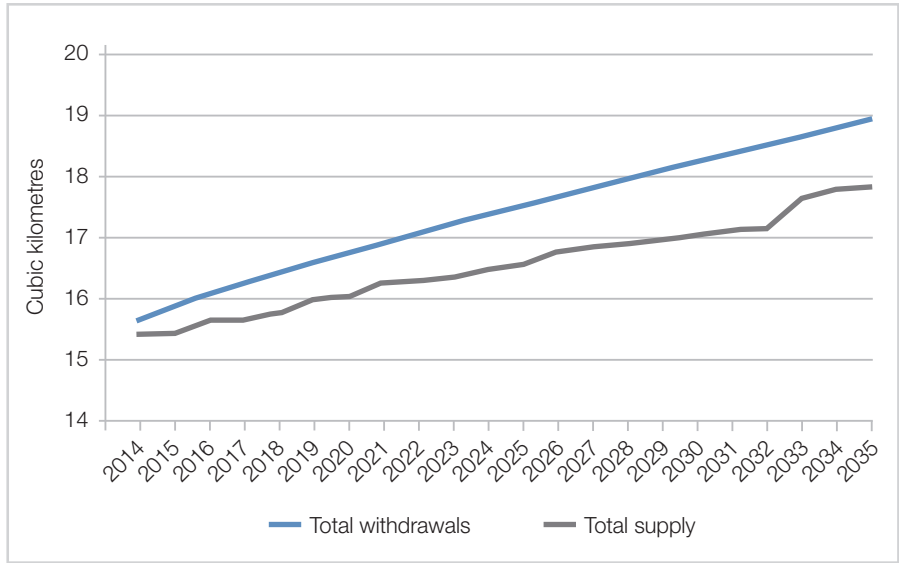
Note: The decrease in yield in 2024 is due to the completion of the LHWP2. It will initially decrease the yield as the dam is filled. It will also allow for more water to be used for ecological water requirements, further reducing existing yield.³¹

In addition to the planned yield increases, the reconciliation strategies also identify WCWDM interventions. These interventions occur in most catchments and account for a demand reduction of 0.571 km³ by 2035. These interventions are not included in Figure 4.

The Current Path scenario

The Current Path is a scenario in which water demand increases in line with the assumptions made above in Section 3.1, 'Forecasting water demand', and supply increases in line with all large-scale water reconciliation strategies. In this scenario, every single intervention aimed at increasing supply and every intervention aimed at reducing demand is successfully implemented on time. Although commendable, the proposed supply increases are not enough to meet rising withdrawals, however. Using the model assumptions described above, water withdrawals increase in the Current Path scenario to 18.9 km³ by 2035 (indicated by the blue line in Figure 5). All of the yield increases outlined in all of the water reconciliation strategies amount to a total of over 3.5 km³ by 2035, but after factoring in yield decreases, the total yield increases to 17.8 km³ by 2035 (indicated by the grey line in Figure 5). These yield decreases are largely due to increased ecological water requirements as well as yield loss sustained by the filling of dams.

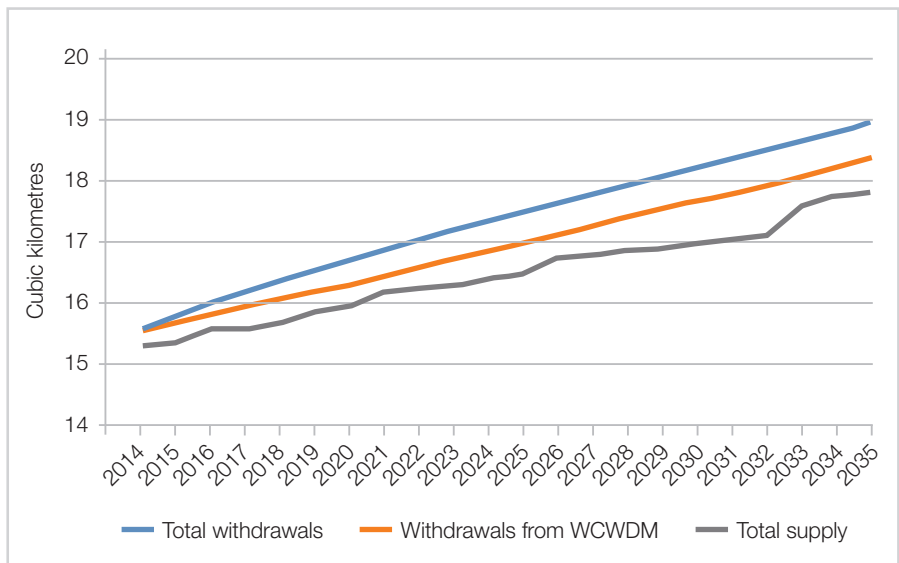
Figure 5: Total water withdrawals for all sectors forecasted to 2035 and total water supply, including yield increases from all large-scale water reconciliation strategies



Source: IFs version 7.13.

In addition to water supply increases, the large-scale water reconciliation strategies include interventions aimed at water conservation and water demand management (WCWDM). These interventions total about 0.57 km³ of water ‘savings’ by 2035. After accounting for the WCWDM interventions and the yield increases, the model still forecasts a gap between withdrawals and supply of 0.57 km³ by 2035. This forecasted gap between withdrawals and supply in 2035 is a significant decrease from the previous paper’s forecast, largely due to an updated supply forecast. The supply forecast used in this paper relies on all the large-scale reconciliation strategies that have been published, as opposed to relying on just the NWRS2.

Figure 6: Total water withdrawals, including WCWDM, and total water supply



Source: IFs version 7.13.

18.9 km³
 THE ESTIMATED WATER
 WITHDRAWALS BY 2035
 UNDER THE CURRENT
 PATH SCENARIO

StatsSA conducted a similar forecast in 2010, also based on data from 2000. They found that water deficits at the catchment level will increase by 2025 and that catchment-level surpluses will diminish. They forecasted that the national deficit will range from 0.234 to 2.044 km³ by 2025.³²

The Closing the Gap scenario

As shown, even with the successful implementation of every intervention in every large-scale reconciliation strategy, the gap between national water withdrawals and available water supply persists. This indicates that additional measures – above and beyond the interventions outlined in the large-scale reconciliation strategies – will be required to close the gap by 2035. In the Closing the Gap scenario, not only is every intervention in every reconciliation strategy pursued, but additional interventions entailing groundwater development, wastewater treatment and WCWDM are implemented.

The main reason groundwater sources fail is because of mechanical breakdowns

The largest increases in water supply outlined in the reconciliation strategies come from large-scale surface-water infrastructure projects, such as the Lesotho Highlands Water Project Phase 2 (LHWP2), the Vioolsdrift and Gariep Dams in the Orange River catchment, the Mielietuin Dam in the Richards Bay catchment, along with many others. Increases in yield from surface-water infrastructure account for about 86% of all planned increases in yield. Although such large-scale infrastructure projects are often necessary, there are additional ways to reconcile supply and demand rather than just by building dams. Additional measures must be taken to both increase available water supply and decrease demand.

Groundwater

Groundwater is an overlooked renewable water resource. This research (Parched prospects II) estimates that current groundwater use was 2.04 km³/year in South Africa in 2014. There is the potential to increase the sustainable extraction of groundwater to increase national water supply.

There are only three explicit targets for increasing groundwater extraction in the large-scale reconciliation strategies, which account for just 0.08 km³ by 2035. Groundwater is particularly well suited to meet agricultural demand and is therefore often ignored in large-scale urban reconciliation strategies. This is

a potential reason why groundwater is not prominent in these reconciliation strategies, which focus primarily on urban areas.

There is, however, a WRC project (K5/2158) aimed at 'producing research that will support Local Municipalities in developing groundwater resources for water supply, and at informing others in the field.'³³ This project has found that groundwater is a reliable source when managed properly, and that the costs are comparable with those of surface-water resources. The project argues that 'the main reason groundwater sources fail is because of mechanical breakdowns and other issues related to operations and management (O&M), and not a failure of the groundwater resource itself'.

Wastewater treatment

Treating wastewater increases the available supply of water (through direct reuse) and also the quality of water. According to the latest Aquastat data on wastewater treatment (from 2009), however, only 54% of municipal wastewater is treated in South Africa.

South Africa is at a 'tipping point' in terms of wastewater treatment.³⁴ Although the state of wastewater-treatment facilities in South Africa has been improving, according to the 2014 *Green Drop Report*, nearly one quarter of all wastewater-treatment systems are in a 'critical state'.³⁵ Seven of the large-scale reconciliation strategies reviewed for this paper set explicit targets for increasing the use of treated wastewater. These interventions amount to 0.22 km³ of increased yield by 2035.

The IFs model, however, forecasts that nearly 5.1 km³ of municipal wastewater will be produced in 2035, so there is certainly the possibility of increasing available yield through the treatment of municipal wastewater. Failure to treat this wastewater will endanger the quality of water resources in South Africa.

Water conservation and water demand management

Non-revenue water is both a challenge and an opportunity in South Africa. Non-revenue water refers to water that is either unbilled or 'lost' before it reaches the consumer. The DWS has instituted a 'War on Leaks' campaign to reduce municipal water that is lost annually through leaks. The recent drought is likely to further incentivise water-conservation policies.

According to a 2012 WRC report, the proportion of non-revenue water in South Africa is 36,8%,³⁶ most of which is the result of physical losses, or leaks. In fact, 25,4% of municipal water is lost through leaks. Although this level of non-revenue

water is in line with the global average, there is significant room for improvement. According to the report, ‘when comparing the unit water use per capita, South Africa appears to have a relatively high per capita water use, which suggests consumers waste water, and there is significant scope to reduce the unit consumption’.³⁷

An additional reason for concern is the fact that only 45% of municipalities could provide sufficient information to assess their level of non-revenue water. This means that 55% of municipalities are not even aware of whether or not they have a problem.

Nine of the large-scale reconciliation strategies outline WCWDM interventions, which amount to a 0.571 km³ reduction in demand by 2035. Much of this reduction (0.22 km³) is expected to come from WCWDM in the Vaal River catchment, which includes the cities of Tshwane and Johannesburg. The 2007 WCWDM potential assessment for the Vaal River system aimed for a reduction in demand by 15% by 2025, reducing the per capita per day consumption of water from 330 to 290 litres per capita per day (l/c/d).³⁸ Nevertheless, this consumption is still well above the international average of 173 l/c/d.³⁹

Achieving aggressive targets for reducing water demand will require collective action and a change in the mindset of water consumers. There is, however, huge potential to reconcile the water system through WCWDM interventions.⁴⁰

Only 45% of municipalities could provide enough information to assess their non-revenue water level, meaning 55% are not even aware if they have a problem

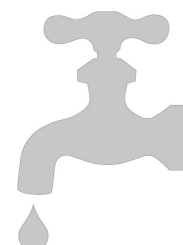
Conclusion

From the most recently available national data, it is evident that national water withdrawals in South Africa exceed national reliable supply. This does not mean that water is being overexploited everywhere – some areas of the country are in balance. But it is impossible to have a national water deficit without some areas overexploiting their resources.

Using the IFs forecasting system, this paper has forecast water withdrawals for three key sectors: municipal, industrial and agricultural. According to the assumptions in the model, withdrawals will increase in each of these sectors over the next 20 years.

To create a plausible water-supply forecast, the research for this paper has turned to the latest available large-scale reconciliation strategies conducted by the DWS. The AFP has gone through every one of these reconciliation strategies to identify and quantify every planned increase in water supply and every intervention designed to reduce water withdrawals.

This paper then presented the Current Path scenario. In this scenario, water withdrawals increase in all three sectors, municipal, industrial and agricultural. In an attempt to reconcile water supply and demand, South Africa increases its available water supply by nearly 2.5 km³ and reduces withdrawals by 0.57 km³ by 2035. This is in line with all of the planned interventions from all of the large-scale water reconciliation strategies from the DWS. Even with all of these interventions, however, withdrawals exceed supply every year through to 2035.



THE DEPARTMENT OF WATER AND SANITATION HAS INSTITUTED A ‘WAR ON LEAKS’ CAMPAIGN TO REDUCE WATER LOSS

This paper then presents the Closing the Gap scenario. This scenario is identical to the Current Path, except that additional measures are taken to reconcile national water withdrawals with available supply. In the Closing the Gap scenario, water withdrawals increase in all three sectors and all of the planned interventions from the large-scale water-reconciliation strategies are implemented on time. Additional measures are required to close the gap, however. Since most of the planned supply increases come from an increase in surface-water supply, these additional measures must come from use of groundwater, wastewater treatment and WCWDM. With these additional interventions, withdrawals decrease and supply increases enough to close the gap by 2035.

There is a thriving water-research community in South Africa and an abundance of data

Recommendations

The large-scale water-reconciliation strategies analysed for this research plan to increase national water supply by nearly 2.5 km³ by 2035. Much of this increase in supply will come from the construction and raising of dams to increase reliable surface-water yield. These interventions are necessary, as water demand is growing rapidly. Even with the successful implementation of these interventions, however, the demand forecasts explained in this paper indicate that withdrawals will exceed reliable supply every year through to 2035. This means that additional interventions on top of the large-scale reconciliation strategies will be required to bring withdrawals and supply into balance. This paper makes the following recommendations:

- All of the planned interventions outlined in all of the large-scale reconciliation strategies must be completed on time.
- Groundwater is an under-used resource in South Africa. Research indicates that the main constraint on groundwater use is not the availability of the resource but problems related to operation and maintenance.
- Only 54% of municipal wastewater is treated in South Africa and nearly a quarter of wastewater treatment facilities are in a critical state. Growing municipal water demand will translate into growing municipal wastewater, and facilities must be put in place to treat this wastewater. This will increase the overall supply of water in South Africa along with water quality.

- There is significant room for improvement in terms of WCWDM. This can be achieved by reducing non-revenue water and by reducing per capita water use.
- Setting and achieving the necessary targets to close the gap between withdrawals and supply require strategic foresight based on plausible forecasts. Strategic foresight is an iterative process, and the forecasts in this paper must be analysed and improved as more data becomes available and assumptions change.
- Plausible forecasts require timely data. There is a thriving water-research community in South Africa and an abundance of data, but this data is often not in a standardised format that can be easily analysed. Studies done at the municipal, provincial and catchment levels are not directly comparable because of differences in geographic scope. Furthermore, it is difficult to aggregate this data to create a national water balance. More research is required to create a coherent national water balance using all available research at all geographic levels of analysis. This paper is a first step in that direction.

Appendix: Model documentation⁴¹

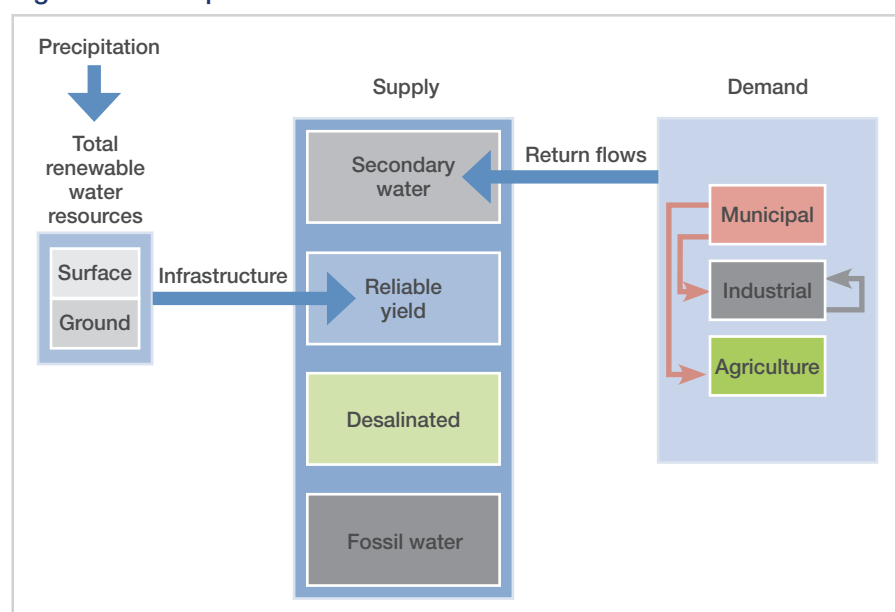
The International Futures (IFs) forecasting model is a long-term, global forecasting system. IFs uses over 3 000 datasets to forecast over 500 variables for 186 countries up to 2100. IFs is highly integrated, with each module interacting with every other module. The main modules in IFs are population, economics, health, education, infrastructure, governance, agriculture, energy, international-political and the environment. The water sub-module is a component of the environment module. Since the water sub-module of the IFs model is in a nascent stage, it is not as integrated with the other modules. This is a potential area of future research and one of the aims of future collaboration with the WRC. IFs is housed at the Frederick S. Pardee Center for International Futures at the University of Denver.

The water sub-module disaggregates demand into three sectors: municipal, industrial and agriculture. Supply is disaggregated into five components: surface water, groundwater, fossil (non-renewable) groundwater, direct reuse of treated wastewater and desalination. The main driver of municipal water demand is the size of the urban population. The main drivers of industrial water demand are thermo-electric power generation and the size of the manufacturing sector. The main driver of agricultural water demand is the area of land equipped for irrigation.

The model defines surface water and groundwater as exploitable renewable resources, which accounts for technical-economic, environmental and geopolitical criteria. This data is calculated at a 98% assurance of supply. Surface-water and groundwater data comes from the Aquastat database.

Fossil groundwater data comes from Aquastat, as well as from other peer-reviewed articles.⁴² Fossil water is not considered in South Africa however. This portion of supply follows a simple stock–flow dynamic, with total estimated fossil water being the stock and annual withdrawals being the flow.

Figure 7: Conceptualisation of the water sub-module within IFs



Source: Steve Hedden and Jakkie Cilliers, Parched prospects: The emerging water crisis in South Africa, September 2014.

Direct use of treated municipal wastewater is a portion of total treated municipal wastewater, which is itself a portion of total produced municipal wastewater. Total municipal water demand is used to estimate produced municipal wastewater. The proportion of this produced wastewater that is treated is a function of GDP per capita.

Desalinated water is driven using a growth rate that diminishes over time as the gap between demand and supply (if there is one) decreases.

Since the publication of the original 'Parched prospects' paper, improvements have been made to the water-demand forecasts in the IFs model. These model updates used feedback from a two-day water-expert workshop held at the ISS in conjunction with the WRC in October 2015.

Municipal water demand update

Previously, IFs used the size of a country's urban population to forecast municipal water demand. This relied on a linear regression between municipal water demand and urban population. This implicitly assumed that per capita municipal water demand remains constant. Research, however, has shown that the most important factor in increasing municipal water demand is income, which drives per capita water use.⁴³

To forecast changes in municipal water demand per capita over time this paper has used a new equation. The dependent variable in this equation is municipal water demand per capita. The independent variables are GDP per capita (at purchasing power parity); size of the urban population; and the percentage of the population served with piped water.

Industrial water demand

Industrial water demand is calculated as the sum of water demand for thermo-electric power generation (cooling) and water demand for the manufacturing sector.

Thermo-electric power generation

To forecast water consumption for thermo-electric power generation, we multiply total non-renewable electricity generation (in kWh) by a calculated value of water consumption per kWh. Water use per kWh is calculated as a function of both water scarcity within a country and the GDP per capita of the country. The more water-scarce a country is, the lower the desired water use per kWh. The actual water use per kWh is determined by this desired value together with the GDP per capita (PPP) of the country. Industrial water demand for electricity is thus a function of non-renewable electricity generation, water scarcity and GDP per capita (PPP).

Manufacturing

Although we do not have data on water demand for the manufacturing sector, using the calculations above for industrial water demand for electricity generation, we can estimate the portion of industrial water demand that is required for the manufacturing sector.

We use the size of a country's manufacturing sector to drive industrial water demand for manufacturing. There is a correlation between this calculated industrial water demand for manufacturing and the size of the country's manufacturing sector.

Industrial water demand for manufacturing is calculated by using the annual growth rate in the size of the manufacturing sector, adjusted by an elasticity of 0,45. This elasticity figure (0,45) was calculated using country-specific elasticities between manufacturing value-added growth rates and manufacturing water demand growth rates weighted by GDP.

This new formulation means that industrial water use per unit of value added from the manufacturing sector decreases for all income groups.

Notes

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- 5 Ibid., 1237. In response to the risk of compounded stress on water resources from overexploitation, degradation and increased drought stress, the IPCC suggests reducing non-climate stressors on water resources, strengthening institutional capacities for demand management, groundwater assessment, integrated water-wastewater planning, integrated land and water governance, and sustainable urban development (see Part B: Regional Aspects, Chapter 22: Africa, 1237).
- 6 For a full description of the water sub-module of IFs see the model documentation at <http://pardee.du.edu/ifs-environment-model-documentation>.
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- 8 Department of Water Affairs, National Water Resource Strategy, 2004, Chapter 2, 29, <https://www.dwa.gov.za/nwrs/NWRS2004.aspx>, accessed 29 November 2015.
- 9 FAO, Aquastat main database, <http://www.fao.org/nr/water/aquastat/main/index.stm>, accessed 13 November 2015. See the Aquastat glossary, www.fao.org/nr/water/aquastat/data/glossary/search.html, accessed 10 November 2015. By this definition, industries that are connected to the municipal network are included in municipal water demand rather than industrial water demand.
- 10 FAO, Aquastat main database, <http://www.fao.org/nr/water/aquastat/main/index.stm>, accessed 13 November 2015. This datapoint is modelled in the Aquastat model.
- 11 Ibid.
- 12 Department of Water Affairs, National Water Resource Strategy, 2004, Chapter 2, 29, <https://www.dwa.gov.za/nwrs/NWRS2004.aspx>, accessed 29 November 2015. The sum of these two categories is greater than industrial water withdrawal data in Aquastat for the same year (2000) because some of this is actually part of the public distribution network and therefore included in the municipal water withdrawal category rather than industrial.
- 13 Aquastat uses a 90% assurance of supply to assess exploitable regular renewable surface water.
- 14 This is roughly in line with StatsSA data and therefore with the figures used in the National Water Resource Strategy.
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- 25 Department of Water Affairs, National Water Resource Strategy (NWRS), 2013, <https://www.dwa.gov.za/nwrs/NWRS2013.aspx>, accessed 29 November 2015, page 10.
- 26 Ibid. page 11.
- 27 See Department of Water Affairs, National Water Resource Strategy (NWRS), 2013, <https://www.dwa.gov.za/nwrs/NWRS2013.aspx>, accessed 29 November 2015. 'For future scenarios, the DWA assumes that the amount of water allocated for agriculture remain the same; all land reform projects and revitalisation of smallholder irrigation schemes will use the same amount of water as before. An increase in irrigation will be effected through water use efficiency, and selected new development, such as in the Mzimvubu.'
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- 39 R McKenzie, ZN Siquabala and WA Wegelin, The state of non-revenue water in South Africa, Water Research Commission, 12 August 2012, WRC report no. TT 522/12.
- 40 It is important to note that water supply and demand do not yet equilibrate within the IFs model. WCWDM interventions may have unintended consequences that the model is not yet able to forecast. For example, increasing the efficiency of the system through the ‘war on leaks’ could lead to a reduction in the cost of water supply and an increase in overall water demand. Likewise, water scarcity may lead to more incentives for WCWDM than the model currently forecasts. The 2015/16 drought, for example, may lead to more water efficiency than is currently planned. These interactions will be incorporated into the model in the future.
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About the African Futures Project

The African Futures Project is a collaboration between the Institute for Security Studies (ISS) and the Frederick S. Pardee Center for International Futures at the Josef Korbel School of International Studies, University of Denver. The African Futures Project uses the International Futures (IFs) model to produce forward-looking, policy-relevant analysis based on exploration of possible trajectories for human development, economic growth and socio-political change in Africa under varying policy environments over the next four decades.

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