Parched prospects: THE EMERGING WATER CRISIS in South Africa

South Africa is over-exploiting its freshwater resources and water could be a large constraint on the implementation of the National Development Plan. Using the International Futures forecasting system, Steve Hedden and Jakkie Cilliers of the Institute for Security Studies modelled and forecast water demand and supply until 2035. Their research found that the gap between demand and supply increases, and that the solutions proposed by the Department of Water and Sanitation (DWS) will not close the gap without additional, aggressive measures.

The first National Water Resource Strategy (NWRS1) was released in 2004 as a blueprint for water resource management and as one of the requirements of the 1998 National Water Act. The NWRS1 provided quantitative information about the present and future availability of and requirements for water in each of the 19 water management areas until 2025.

The NWRS2 is the second edition of the report. It seeks to 'ensure that national water resources are managed towards achieving South Africa's growth, development and socio-economic priorities in an equitable and sustainable manner over the next five to ten years'. The NWRS2 provides hard targets for increasing water supply for each of the recently promulgated nine water management areas.

Among its many goals, the National Development Plan sets the following interrelated targets: all South Africans should have access to clean running water in their homes by 2030, South Africa should achieve a food trade surplus; and the country should produce sufficient energy. The National Development Plan proposes a 33% increase in the area of land currently under irrigation. It states that efforts should be made to make mineral extraction less water-intensive, advocates investments in infrastructure for water, and proposes achieving an average reduction in water demand of 15% below baseline levels in urban areas by 2030.

CURRENT WATER DEMAND AND SUPPLY IN SOUTH AFRICA

The NWRS2 does not provide explicit data on the current water demand by sector, and is somewhat reliant on the studies carried out for the 2004 report. That report put total water withdrawal at 12.87 km^3, and exploitable yield at 13.25 km^3. While this implies a surplus of water still existed in South Africa in 2004, more than half of the water management areas were already being over-exploited.

More recent studies have shown that the NWRS1 may have overestimated water supply. Demand has increased since 2004 and rather than the small positive balance reported in 2004, South Africa is currently over-exploiting its renewable water resources on a national level.

Using the most recent data available for water demand in each sector, as well as the driving variables for water demand, the authors estimate that South Africa is currently withdrawing 15.6 km^3 of water per annum. The agricultural sector is the largest user of water, accounting for 57% of total water usage. Municipal demand accounts for 35% of water usage and the industrial sector accounts for the remaining 8% (Figure 1).

The NWRS2 estimates that the exploitable surface-water yield available on a 98% assurance of supply is 10.24 km³. Even if one includes the 2.1 km³ of treated wastewater produced each year, surface water is being heavily over-exploited at the national level. South Africa's capacity to build more dams is limited by the availability of streamflow, and under conditions of climate change this is likely to decrease as evaporative losses of open water increase. Current water supply is depicted in Figure 2.

More than two-thirds of South Africa's mean annual runoff is already stored in dams, limiting streamflow to a bare minimum. In the case of the Orange River, for every 100 units of rain that fall across the entire basin, only 5.1 units end up in the river (as opposed to in dams). If one calls these 5.1 units 100% of runoff, then South Africa has dams capable of storing almost double this flow.

The NWRS2 estimates that current groundwater withdrawal in South Africa is at 2 km³ out of exploitable groundwater resources estimated at 5.5 km³. Allowing for an underestimation of exploitable groundwater resources, the NWRS2 estimates a total potential of about 3,5 km³ of groundwater available for exploitation.

South Africa has over 1 000 water treatment facilities currently in operation discharging 2.1 km³ of treated water back into the river systems – although the quality of treated water is often suspect. Direct reuse of this water is minimal, but since the treated water is discharged into the river systems it is available as a secondary water source.

Desalination is being implemented on a small scale in South Africa. The industrial and mining sectors desalinate used water for reuse. Brackish groundwater desalination by reverse osmosis provides drinking water to small towns and communities along the West Coast. Desalination of acid mine drainage has been pioneered in eMalahleni, and is now under consideration for the Witwatersrand goldfields.

Seawater desalination is being used to supplement municipal water supplies in towns along the southern and Eastern Cape coastlines. In 2000, however, this accounted for just 0.018 km³ of the country's freshwater supply. The authors estimate that South Africa currently desalinates about 0.025 km³ of water.

MODELLING WATER SUPPLY AND DEMAND

To forecast South Africa's water sector, this authors used the IFs (information on this system can be found in the original paper for which the link is provided below).

To model water supply, the authors used the sum of assured surface water yield, renewable groundwater withdrawal, non-renewable (fossil) groundwater withdrawal, treated and reused wastewater, and desalinated water. Treated wastewater that is not directly reused is added to surface-water yield. Separate equations are used to forecast water demand for the main sectors of water usage, namely municipal, industrial and agricultural.

FORECASTING WATER DEMAND

Demand for water in South Africa can be reasonably expected to increase in all sectors. The authors' base case forecast of water usage (Figure 3) is that the largest increase in water demand by 2035 will come from the municipal sector, followed by industrial (which includes energy and mining) and agriculture.

Municipal water demand is forecast to increase from 5.5 km³ in 2014 to 7.2 km³ by 2035. Industrial water demand increases from 1.2 km³ to over

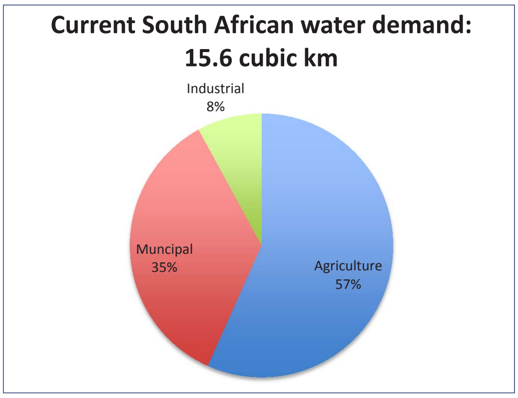

Figure 1

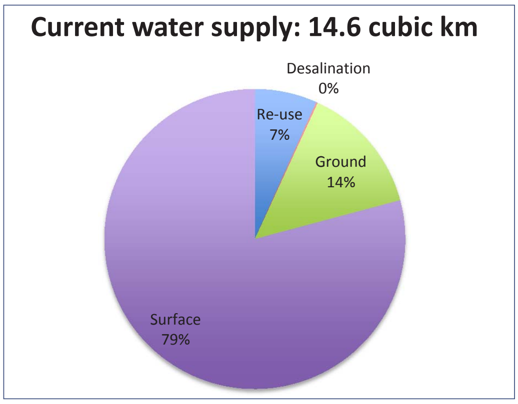

Figure 2

More than two-thirds of South Africa's mean annual runoff is already stored in dams, limiting streamflow to a bare minimum.

3 km³ in 2030 and then decreases to 2.8 km³ by 2035. This decline is due to the onset of renewable energy production, which does not require water for cooling. Agricultural water demand increases from 8.9 km³ to 9.7 km³ in line with objectives of the National Development Plan.

Even though the NWRS2 does not anticipate an increase in agricultural water demand, government's intention to increase the area of land under irrigation will increase water demand for the agricultural sector unless sufficient advances are made in water efficiency or water-withdrawal licences are transferred to other sectors.

FUTURE WATER SUPPLY IN SOUTH AFRICA

This section reviews water supply from surface water, groundwater, water reuse and desalination (See Figure 4).

To increase water supply, the NWRS2 plans for increased investment in surface water infrastructure, mainly from dams – although all significant rivers are at maximum yield, with few remaining dam sites and little remaining streamflow. The strategy plans to increase surface-water yield by about 1 km³ by 2035. Much of this will come from Phase 2 of the Lesotho Highlands Water Project, which supplies water to Gauteng through transfer from the Katse and Mohale dams in Lesotho to the Upper Vaal management area, to be completed in 2020.

With respect to groundwater, the NWRS2 plans to increase usage by 0.117 km³ by 2035. Although more water can be reliably extracted from underground aquifers, it is unlikely that South Africa will be able to increase groundwater withdrawals to the 3.5 km³ limit by 2035.

The NWRS2 sets hard targets for the reuse of water for several water management areas. Altogether, the strategy proposes the reuse of over a quarter of a cubic kilometre of wastewater by 2035.

Finally, the NWRS2 lays out plans to increase the use of desalinated water in several water management areas. The plan calls for at least 0.15 km³/annum by 2035 in at least three water management areas.

One way to reduce water demand is to decrease the volume of water that is lost through physical leakage or commercial losses, referred to as non-revenue water. A study, published in 2012 by the Water Research Commission (WRC) found that 36.8% of municipal water withdrawal was non-revenue water – most of which was a result of direct physical losses. This is on par with the global average of 37% but much higher than other water-scarce countries like Australia, whose non-revenue water is less than 10% of municipal demand.

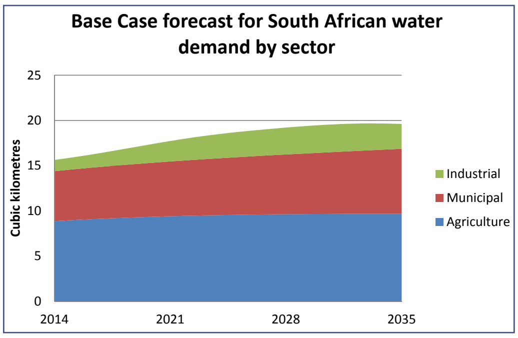

Figure 3

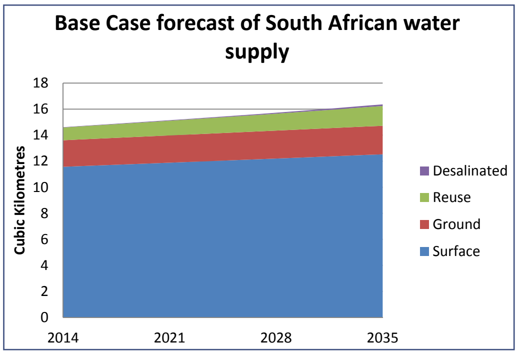

Figure 4

FORECASTING THE DEMAND-SUPPLY GAP

To model the NWRS2's ability to close the gap between demand and supply, the authors built a supply forecast that simulates the NWRS2 plans to increase supply using the IFS model. This includes all of the explicit supply increases outlined in the strategy. As seen in Figure 5, increasing supply

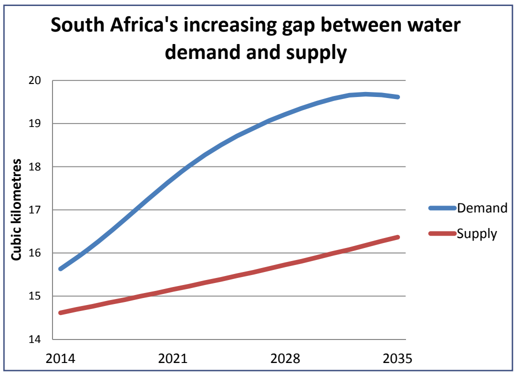

Figure 5

as proposed in the NWRS2 will not be sufficient to meet the growing demand for water.

The gap between demand and supply increases to over 3.5 km³ by 2030, and is only reduced to 3.2 km³ by 2035. This reduction in gap, which is predicted to take effect from 2030, is largely because of the expected drop in coal production together with continued growth in renewable energy.

WATER AS A CONSTRAINT ON GROWTH

If demand for water continues to exceed supply, then water resources in South Africa will be continuously over-exploited. This has serious consequences for the environmental resilience of aquatic ecosystems and the reliability of water supply for human consumption. Over-exploitation of water will also constrain growth, employment and general human development, since hydrology is a defining variable of the potential performance of water-constrained countries' economies.

Due to its naturally variable climate drought recurs regularly in South Africa. Over-exploitation of freshwater resources increases the changes that a drought will exacerbate water shortages. If there is not a reliable supply of water, whatever the source, then communities and industries that rely on rainwater will experience water shortages.

To illustrate the extent of water as a constraint on growth, we turn to the 'Mandela Magic' (high road) scenario from the South African futures 2030 paper. In this scenario, South Africa grows at an average rate of 5.1% from 2014 to 2030 (compared to an average growth rate of 3.8% forecast for an amended baseline called 'Bafana Bafana' in the same paper) and has, by 2030, an economy that is 23% larger than the base-case forecast.

Economic development increasingly drives water demand. Most of this increased demand comes from the industrial sector – total water requirements are 0.7 km³ higher in 2035 in the 'Mandela magic' scenario than in the base case, depicted in Figure 6.

Economic growth is also expected to drive investment in wastewater treatment facilities, thereby increasing overall water supply. Although more wastewater is treated in this high road scenario, more untreated wastewater is also produced, resulting in more contamination of water catchments.

Furthermore, the increase in supply is outweighed by the increase in overall demand, resulting in an even larger gap between demand and supply than in the base case. The gap increases from 3.23 km³ in the base case in 2035 to 3.77 km³ in the Mandela Magic scenario.

Water is therefore a significant constraint on South Africa's development potential and the next section looks at how this gap can be closed.

REDUCING DEMAND

This section discusses methods of reducing water demand and increasing supply and includes a summary of the associated scenario called 'close the gap'.

The average per capita water consumption in South Africa is higher than in most other countries, so behavioural changes in municipal consumption are particularly important. Central to this required change in attitude is the emerging global notion of stewardship, which is based on an ethos of sustainable custodianship rather than on consumption.

Reducing the volume of non-revenue water will greatly curtail the rise in municipal water demand. Better monitoring of municipal and industrial water supply might also help reduce lost water. New technology, such as advanced metering infrastructure, could also help to reduce these losses.

If per capita municipal consumption were lowered to the world average by 2035 (a significant challenge in itself), the demand-supply gap would be reduced by almost half. In the 'close the gap' scenario, municipal water demand falls from 7.18 km³ in 2035 in the base case to 5.74 km³. This is some 20% lower than in the base case – though still above the expected value given the size of South Africa's urban population when compared to urban water use globally.

While the National Development Plan acknowledges that investment in agricultural irrigation may have many social and economic benefits, and aims to increase the area of land under cultivation, the NWRS2 does not allow for any increase in water allocation for the agricultural sector.

The authors' analysis shows that South Africa uses less water for agriculture than one would expect

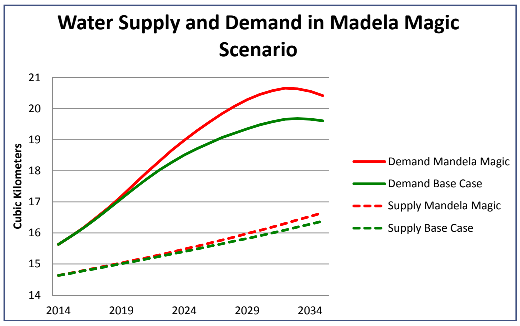

Figure 6

Better monitoring of municipal and industrial water supply might also help reduce lost water. New technology, such as advanced metering infrastructure, could also help to reduce these losses.

given the area of land equipped for irrigation. This does not necessarily mean, however, that water is being used efficiently in irrigation schemes.

However, the economic benefits of irrigation should not be underestimated. While the NWRS2 claims that agriculture contributes only 3% to the national economy, it is estimated to contribute as much as 18% in secondary processing. In the 'close the gap' scenario, the demand for agricultural-use water decreases by only 2% compared to the base case by 2035. This assumes gains in water-use efficiency as well as increases in the area of land equipped for irrigation.

Thermoelectric power generation, the manufacturing sector and the mining sector will primarily drive industrial water demand. Although these area economically important industries, their water needs must be balanced with the needs of other sectors. Industrial water demand decreases by 10% compared to the base case.

Even with all these improvements in efficiency, water demand still increases in each sector over the time horizon – implying that the reduction in demand levels is insufficient. Supply also has to increase as discussed in the next section.

Finally, South Africa faces a legacy of a skewed allocation of water rights. Efforts to balance water rights will be constrained by the supply and demand challenges outlined in this article.

Groundwater is currently not over-exploited on a national level and there is room to increase groundwater extraction significantly, especially in rural areas and on small farms.

INCREASING SUPPLY

In addition to the 1.87 km^3 reduction in overall water demand in 2035, the IFs model forecasts an increase in exploitable water supply by 1.43 km^3 in comparison to the base case. Bear in mind that the base case already includes the hard targets set out in the NWRS and these supply increases are in addition to the plans of the NWRS. Surface water is over-exploited on a national level and while infrastructure is being built to increase the reliable yield, there is a limit on the ability of dams and redistribution networks to satisfy global demand.

Almost without exception, municipal wastewater is not being utilised in South Africa – another opportunity to increase water supply. In addition, reducing non-revenue water represents an opportunity to decrease municipal water demand.

Groundwater offers another potential way of meeting some of the supply increases. Groundwater is currently not over-exploited on a national level and there is room to increase groundwater extraction significantly, especially in rural areas and on small farms. The forecast increases exploitable groundwater from 2.19 km^3 in 2035 in the base case to 2.93 km^3 in the 'close the gap' scenario.

There is some room for developing surface water, but the base case already includes planned infrastructure development, like Phase 2 of the Lesotho Highlands Water Project. Exploitable surface water yield can be increased, however, through the treatment of wastewater. In the 'close the gap' scenario, 80% of municipal wastewater is treated. Two-thirds of this is then directly reused and the remainder is available as exploitable surface water.

In the 'close the gap' scenario, desalination is increased by 70% against the base case, yet it still contributes very little to overall water supply on a national level. Starting from such a small base, it is difficult for desalination to play a significant role in the South African water sector for the next 20 years. An option that this research did not consider is for South Africa to import more water than it already does from Lesotho.

SUMMARY RESULTS

The policies set out in the NWRS2 are clearly not enough to address the water constraints facing South Africa. Even if policies that would close the demand-supply gap by 2035 are put in place now, South Africa will still be over-exploiting water for the next 20 years – even on South Africa's current growth path, which is significantly lower than that presented in the 'Mandela Magic' scenario.

This over-exploitation increases the vulnerability of the water system to shocks such as droughts and will be aggravated by the impact of climate change. Clearly, an attempt to reconcile this gap must include policies to reduce demand, increase supply, improve efficiency and create the necessary incentives for the transition to a recycling economy, in which water of different quality and price is used for different purposes.

Achieving the 'close the gap' scenario requires significant investment in water supply – more than is explicitly called for in the NWRS2 – as well as much more efficient uses of water to reduce demand. The results are presented in Figure 7.

The base case forecasts a gap between supply and demand of 3.23 km^3 in 2035. To close this gap, we set aggressive targets for each sector of demand and each source of water supply. Most of the gains come from demand management – primarily in the municipal sector. This would necessitate significant behavioural changes in urban water consumption, as well as reductions that come about from improvements in the management of non-revenue water.

Generally, the forecasts show that the overall increase in both land under irrigation and thermoelectric generation counteract improvements in efficiency, which means that water demand increases in every sector even with improvements in efficiency.

Figure 8 and 9 respectively present increases in water supply from each source and reductions in water demand from each usage sector that are needed to close the gap between demand and supply. this reflects the huge contribution made from greater efficiencies in the use of municipal water and exploitation of groundwater.

CONCLUSION

South Africa is facing a potential water crisis and the current policies of the DWS are not sufficient to address this problem. Although not impossible to achieve, the reductions in demand and increases in supply necessary to close the gap outlined in this article, are very optimistic.

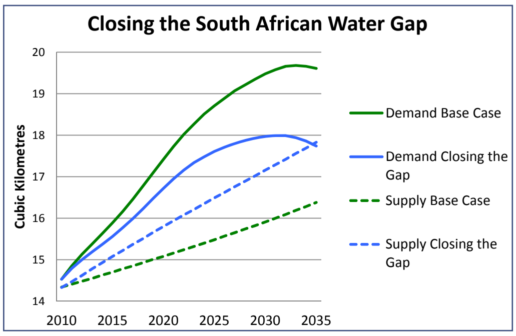

Figure 7

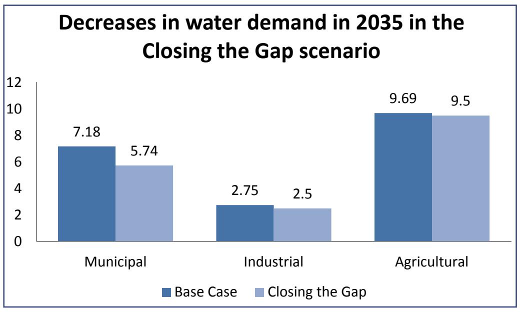

Figure 8

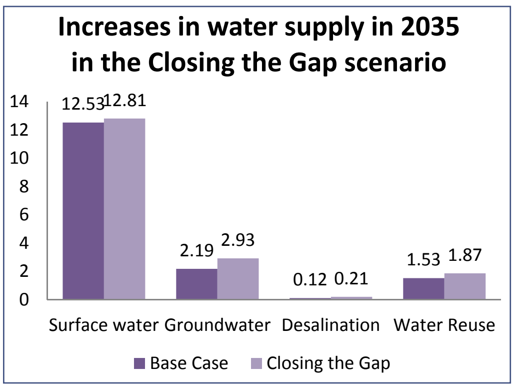

Figure 9

Increases in water supply cannot match the expected increase in demand without additional and far-reaching interventions. The water crisis cannot be solved through engineering alone – demand management in terms of both efficiency and allocation will have to play a large part in the efforts to close the water demand-supply gap in South Africa.

In line with some of the key messages from the reconciliation strategies laid out in the NWRS2, it is evident that South Africa cannot afford to waste any water, anywhere, any more. More specifically:

- Groundwater is important, and currently undervalued and under-used, especially in small-scale rural farming. It may emerge as the most important way in which any expansion in the agricultural sector is possible.
- There is huge potential to increase the reuse of municipal and industrial water at the coast and in inland systems.
- There is limited opportunity for more dams or transfer schemes, but they are inevitable in certain areas.
- Due to the high levels of evaporation and transpiration loss in South Africa, the storage of water in aquifers has to be considered as part of future policy or alternative ways need to be found to reduce evaporation.
- Expensive desalination projects would have to be considered as an option to increase supply of water, especially on coastal areas with limited alternative sources of supply.
- The necessary incentives should be put in place for the transition to a recycling economy, in which water of different quality and price is used for different purposes.
- Monitoring and evaluation of the water sector is necessary to set and achieve the goals outlined in this article.

Over-exploiting water threatens the health and prosperity of South Africa. While there is great uncertainty regarding the future of water demand and supply, it is clear from the forecasts presented here that a business-as-usual future scenario for water in South Africa will result in an unsustainable gap between supply and demand for many years. This gap represents a large risk – a risk that water may become a finite constraint to economic development and a crisis could ensue.

South Africa has a diverse and active community engaged in water issues. Despite the sterling efforts by the WRC, the lack of publicly available and easily accessible data is a major problem in researching water supply and demand in South Africa. The excessive use of consultants and inability to capture and integrate the associated research results presents a serious constraint on planning and accountability. ❑

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