IS WATER SHEDDING NEXT?

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Abstract

South Africa is in the grip of an electricity crisis marked by a euphemism known as load shedding. The demand for electricity has grown to the point that the supply reserve margin is often under threat, necessitating the electricity supplier to cut supply to some areas, or to shed load. This is a condition unknown to South Africa since the country enjoyed electricity security from the mid-1950s. Are we, however, heading in the same direction when considering water? Is water shedding inevitable?

We ask these questions since South Africa is a country classified has having chronic water shortages, a condition exacerbated by climate change and the rapidly increasing demand for water. Can we avert a load-shedding crisis by being pro-active? In this paper we address this issue by applying a Computable General Equilibrium (CGE) model using an integrated database comprising South Africa's Social Accounting Matrix (SAM) and sectoral water use balances. We refer to ASGISA, the governments' Accelerated and Shared Growth Initiative in South Africa, and conclude that business as usual will indeed lead to a situation where water shedding will be inevitable.

Unlike electricity, however, water security is much more serious from a livelihoods and health perspective since there are no substitutes for it, yet it is not directly and immediately visible. This delayed effect can create a degree of comfort and ill-founded complacency leading to non-action whereas there is an urgent need for pro-active measures.

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1 INTRODUCTION

South Africa is currently in the grip of an electricity crisis euphemistically known as load shedding. The demand for electricity has grown to the point that the supply reserve margin is often under threat, necessitating the electricity supplier to cut supply to some areas, or to shed load. This is a condition unknown to South Africa since the country enjoyed electricity security from the mid-1950s, but the last power plant was built 25 years ago and since then neither supply augmentation nor any meaningful form of demand-side management was applied. The current electricity crisis is being dealt with at the highest possible level through a president announced task team to investigate and initiate an electricity security plan, yet commendable, this initiative is by nature reactive. Are we heading the same way when considering water? Is water shedding inevitable? Can we avert such a crisis by being pro-active? We address these questions by first providing a background to the water sector, then highlighting the six water-intensive ASGISA projects, followed by a discussion of the data and the model and the results.

2 BACKGROUND

How much surplus water does South Africa have; who is using it; and could the declining trend in water supply be changed? DWAF (2004) estimates that in 2000 South Africa had a total reliable surface water supply of 13,226 million m^3. In the same year, the nation used 13,041 million m^3, leaving a surplus of only 186 million m^3, or 1.4% of the supply (at 98% assurance of supply) for that year. Additionally, 12 of the country's 19 water catchments have recorded water deficits, which have only been offset by an intricate system of engineered inter-basin water transfer schemes. These worrisome statistics are supported by the Water Resource Accounts produced by Statistics South Africa (SSA 2006). In theory, as the remaining annual supply of a vital natural resource approaches zero - crossing clearly identifiable thresholds of scarcity - the marginal value of the resource approaches infinity (Farley and Gaddis 2007). This implies that the economic value of the last 1.4% of unutilised water resource becomes very high, far exceeding that of the prevailing bulk water tariff.

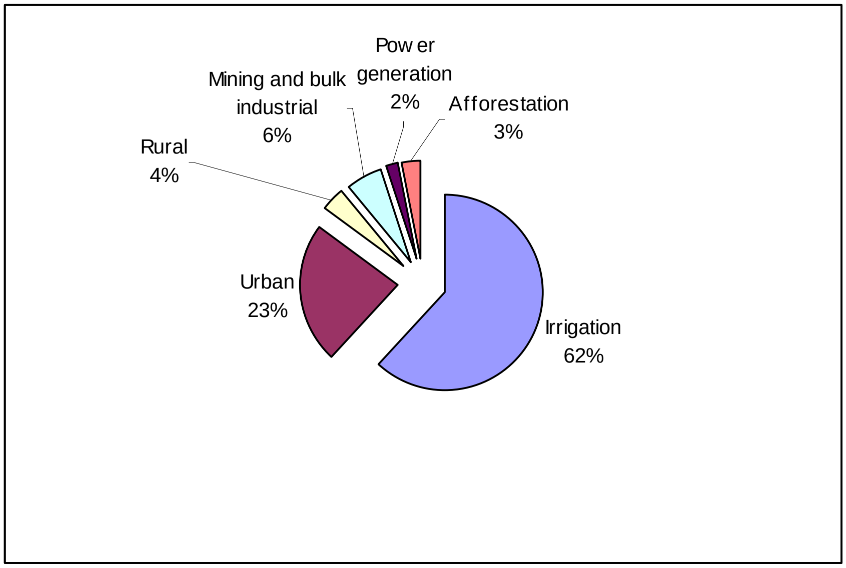
Moreover, the meagre water reserve mentioned above actually includes the water imported from neighbouring Lesotho through large-scale engineering projects involving large dams and tunnels, among other things. Unutilised domestic sources of water are limited to two river catchments in the ecologically sensitive and relatively undeveloped Eastern Cape Province. Water supply constraints are therefore an issue with unparalleled economic development implications. Further supply options are limited, but include further water importation from Lesotho, and, additionally from the distant Congo River, and/or desalination of seawater. All three options would be costly and capital intensive and their implementation would have a significant effect on water tariffs with the result of making drinking water less accessible to those who are most in need. In other words, only 1.4% of South Africa's water yield is currently available to address the demands of the poor, most of whom who do not have any access to potable piped water currently. But what are the likely impact of ASGISA and the introduction of the ASGISA projects on this surplus, or meagre unallocated, water? We return to this question shortly.

Surface water use

Irrigation agriculture – consuming 60% – is by far the largest single surface water user, with agriculture and forestry consuming 65% of the total available water resource, see Figure 1 (SSA 2006). Large-scale farmers use 95 per cent of agriculture's share, predominantly for irrigation (Schreiner and Van Koppen 2002). Much of the irrigation is provided by way of central pivot systems, supported by intricate channels and water reservoirs (dams) developed more than 50 years ago. In a country where about 90% of annual precipitation is used in the form of evapotranspiration and deep seepage due to climatic and geological conditions (CSIR 2001), central pivot systems are an extremely inefficient means of irrigation. Additionally, central pivot systems could lead to excessive irrigation causing the salination of the soil, something South Africa is very susceptible to. Irrigation's surface water use has also increased steadily from 7,630 million m^3 in 1995 to 7,921 million m^3 in 2000, an increase of 291 million m^3, or 4%. This represents 160% of the total water surplus remaining at the end of 2000. The official water use for 2005 has not yet been released, but if the volume of water used for irrigation increased by the same margin, without any compensatory reduction in water use by other sectors having taken place, then there must have been a deficit for the country as a whole. Furthermore, the total increase in water consumption for all sectors from

1995 to 2000 was 348 million m^3, which implies that irrigation's portion of the increase was 84%! Based on these figures, surface water use is increasing rapidly, and there are no signs of a decline in use in any other sector.

Figure 1: Water requirements by sector in South Africa in 2000



Source: SSA 2006.

Ground water use

In addition to the increased use of surface water, the use of groundwater is increasing rapidly as well (Vegter 2001, Botha 2005). Vegter (2001) estimates that by 1999 there were approximately 1.1 million water boreholes in the country, compared to only 225,000 recorded on the National Groundwater Database. From drilling data and agricultural records Vegter (2001) calculates that the groundwater use in 1999 was about 3,360 million m^3 per year and increasing at 3.4% per year. The estimated use at the end of 2001 was approximately 3,850 million m^3, which is 49% of the surface water usage. The exploitable ground water usage for 2000 is estimated at 9,500 million m^3 (SSA 2006), which implies that ground water usage at that stage was about 41% of the potential. This allows room for some further development, but clearly the surplus is dwindling fast. In fact, if water abstraction of both surface and groundwater has increased so quickly in recent years, it is primarily to drive the development of agriculture, mainly in the horticulture and animal production sectors, as will be seen below.

Water: The limiting factor

Clearly the growth in demand for water compared to the supply constraints is leading to an untenable situation and implies that not only would water conservation have to be applied, but also that profound efforts at redistribution of water would have to take place as well. This is a fact recognised by DWAF (2004) who states that given demographic trends South Africa as a whole is likely to have a water deficit of approximately 1.7% by 2025. The amount of surplus water available for utilisation of any kind is therefore declining fast, which implies that water is becoming a very scare resource – even the limiting factor to development – as eloquently articulated by Scholes (2001), (see also Daly and Farley 2004; Aronson *et al*. 2006; Farley and Daly 2006), in the following words:

> *The availability of water of acceptable quality is predicted to be the single greatest and most urgent development constraint facing South Africa. Virtually all the surface waters are already committed for use, and water is imported from neighbouring countries. Groundwater resources are quite limited; maintaining their quality and using them sustainably is a key issue.*

Water use cannot continue to grow at current rates indefinitely given the supply constraints, and the likely decline in the water availability due to changes in climatic conditions, and the socio-economic and demographic pressure to increase the use of potable water for domestic use and to allocate water to higher value added industries (Blignaut *et al.* in press). Something has to change, and fast.

For the time being the effect on agriculture of the changes in climatic conditions that did take place over the past four decades - notably the 6% decline in mean annual rainfall - has been mitigated by the aggressive increase in irrigation from both surface and groundwater resources. The conventional methods of irrigation will have to change, as they can no longer hedge agricultural production from the impacts of changes in climate, and they may well lead to degradation and salinisation of soils, judging from long experience in other hot and dry regions. Come what may, water is going to become increasingly less available for agriculture. This will have obvious implications for food security, future irrigation methods, the type, and structure of agriculture production, the way in which land reform is being conducted, and the rural economy in general. These are all major and complex issues that cannot be addressed fully within the scope of this paper. Instead, we focus in the next section on the effects that ASGISA could have on water demand.

ASGISA

ASGISA's stated objective is to accelerate economic growth and seek to distribute the benefits therefore so that all people might share in the growing prosperity of the country. ASGISA' therefore states (The Presidency, undated):

> *Government's investigations, supported by some independent research, indicate that the growth rate needed for us to achieve our social objectives is around 5% on average between 2004 and 2014. Realistically assessing the capabilities of the economy and the international environment, we have set a two-phase target. In the first phase, between 2005 and 2009, we seek an annual growth rate that averages 4,5% or higher. In the second phase, between 2010 and 2014, we seek an average growth rate of at least 6% of gross domestic product (GDP).*

To achieve these stated targets ASGISA listed 12 flagship projects in the ASGISA Summary document, projects that should contribute significantly towards achieving these above-mentioned growth targets. These projects are (The Presidency, undated):

1. A biofuels initiative that will cover at least Northern Cape, Free State, KwaZulu-Natal, Eastern Cape and Mpumalanga;
2. The Makhathini Cassava and Sugar Project in KwaZulu-Natal;
3. A national livestock project that would particularly focus on the Northern Cape and North West;
4. The Umzimvubu Catchment and Timber Industries Development Initiative in the Eastern Cape;
5. The Dilokong Platinum Corridor to integrate development located around the planned De Hoop Dam in Limpopo;
6. A water reticulation project for Mokopane-Vaalwater-Marken in Limpopo;
7. The proposed Square Kilometre Array and linked projects in Northern Cape;
8. The Cape Flats Infrastructure Project in the Western Cape;
9. A diamond and gemstone jewellery project in the Northern Cape;
10. A Moloto Corridor Rail Project, mostly in Mpumalanga;
11. Gauteng-Durban Corridor including Johannesburg City Deep, Harrismith Hub and Durban Dube Trade Port; and
12. The Johannesburg International Airport Logistics Hub and Industrial Development Zone in Gauteng.

While it is hardly possible to criticise the ASGISA objective and ideals stated, disconcertingly, however, the first six projects listed above are all water intensive. It is as if these projects were identified in complete isolation from the fact that South Africa is a water scarce country and the profile of water availability provided above. The question is: what would be the likely impact of the first six projects on water availability? .

MATERIALS AND METHOD

The Model

The model used called UPGEM, the University of Pretoria CGE Model of South Africa. It is similar to the ORANI-G model of the Australian economy, which is fully presented and explained by Horridge (2002), with a theoretical structure that is typical of most static CGE models, and consists of equations describing producers' demands for produced inputs and primary factors; producers' supplies of commodities; demands for inputs for capital formation; household demands; export demands; government demands; the relationship of basic values to production costs and to purchasers' prices; market-clearing conditions for commodities and primary factors; and numerous other macro-economic variables and price indices[2]. Conventional neoclassical assumptions drive all private agents' behaviour in the model. Producers minimise cost while consumers maximise utility, resulting in the corresponding demand and supply equations of the model. The agents are assumed to be price takers, with producers operating in competitive markets, which prevent the earning of pure profits. In general, the static model with its overall Leontief production structure allows for limited substitution on the production side, and more substitution possibilities in consumption. It has constant elasticity of substitution (CES) sub-structures for (i) the choice between labour, capital and land, (ii) the choice between the different labour types in the model, and (iii) the choice between imported and domestic inputs into the production process Household demand is modelled as a linear expenditure system that differentiates between necessities and luxury goods, while households' choices between imported and domestic goods are modelled using the CES structure.

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[2] This description was taken from our 2008 paper in *Ecological Economics*, where exactly the same model was used.

Data

The CGE model is based on the 1998 Social Accounting Matrix of South Africa. It shows the linkages between all players in the economy, such as industries, households, the government and the foreign sector. To model the effects of policy scenarios on water demand, some additional data was required (Table 1). In principle, for each industry we added:

- the quantity of "taxable water" used. This roughly corresponds to raw water abstracted from rivers, but also includes rain falling on tree plantations; and
- a semi-elasticity showing how water intensity (water per output) might change in response to a change in volumetric water charges.

[insert Table 1 near here]

Column 1 of Table 1 indicates three main types of sector. Those marked A are agricultural – large users of water who pay various volumetric charges. Those marked B are bulk users of non-potable water. Unmarked sectors are mostly consumers of potable water delivered by water utilities. We have distributed the raw water used by the (municipal) water industry among remaining industrial and household users of treated water. For forestry we have incorporated an estimate of the streamflow loss caused by exotic species (as compared to native species). Column 2 of Table 1 shows quantities of water used. Column 3 shows a range water tariffs (for 2002) following a survey done among large water utilities and column 4 shows elasticities derived from various sources. We estimated semi-elasticities (column 5) that should be interpreted as the percentage change in water use per unit change in the marginal cost of water, adapted to allow for sector specific variations.

The Scenarios

The modelling task at hand was to determine the economy-wide impacts on GDP, employment, and water consumption for the following three scenarios:

1. A R1 billion injection into the economy in each of the six sectors linked to the six water-intensive projects listed above. These sectors are:
    - Dryfield agriculture (project 1)
    - Irrigation horticulture (project 2)
    - Livestock (project 3)

- Timber (project 4)
- Other mining (project 5); and
- The water sector (project 6)

2. 1c/m^3 increase in water tariff, with the revenue not returned to the general economy; and
3. Balanced budget: 1c/m^3 increase in water tariff, but revenue returned to the six ASGISA water intensive project sectors with the understanding that this revenue be used to support demand-side management

RESULTS

The results of modelling the scenario's as described above are depicted in Table 2. Should government invest R1billion in each of the six sectors, GDP would increase by 0.36% with the largest contribution coming from the livestock and timber plantation sectors. Employment of unskilled labour would increase by 1%, mainly from the aforementioned two sectors as well, but water demand would increase by 2.2%, mainly from the irrigation, timber and water provisioning sectors. The fact of the matter is, however, that the increase in demand for water would outstrip its contribution to GDP by several orders of magnitude, and, what is more, this increase is 50% more than the current available surplus supply of water of 1.4%. This does not imply that these projects could not be implemented; it only states that once they are implemented there would be less water for other projects, such as delivering potable water to the thousands of households that do not have such luxury.

Should one increase water tariffs uniformly across these six sectors with 1c/m^3 without recycling the revenue, then the decline in GDP is 0.01%, yet the decrease in water demand is almost 2.8%. The decline in the GDP is much less than the reduction in water consumption. Should one, however, increase the water tariff by 1c/m^3, and recycle the revenue to the respective sectors, one mostly retains the reduction in water demand (-2.74%), while the net result on GDP is positive.

[insert Table 2 near here]

CONCLUSION

ASGISA implies targeting some economic industries or sectors to stimulate growth. In this paper we argue that the stimulation of any industry would increase the demand for water as input into the production process. To illustrate this we have shown that a hypothetical injection into the economy of R1b stimulation to each of six targeted industries would lead to a deficit in the available amount of water. It would therefore be physically impossible to stimulate the six industries as planned, unless the necessary water supplies were re-allocated from other sectors. We "found" enough water for the ASGISA initiative from a 1c surcharge on all water demanded in the economy. (We did not use the most efficient method to save water, but taxed all water equally to show our point). The water tax would decrease total water demand sufficiently to provide for the ASGISA initiative, and have some savings left over. Moreover, if we use the recycle the water tax revenues towards the six ASGISA industries, the damage of the water tax is diminished in terms of GDP and employment effects, while a large net saving of water remains.

This analysis shows that macro-economic planning and the design of economic development strategies cannot be done in isolation from considering natural resource constraints. Natural capital is increasingly the limiting factor to development and any investment in economic development should take serious cognisance of these limitations. Having said this does not imply that ASGISA should not proceed seeking sectors and projects to investment in, but that it should also consider resource constraints in an integrative manner. Opportunities should be explored that, through investing in natural capital, that will stimulate economic development, create jobs and augment the dwindling supply of natural resources. So, answering the question whether water shedding is next, the answer is that it is indeed plausible if macro-economic decision making is not conducted in such a way as to acknowledge and plan with implicit resource constraints. Water shedding's feedback loop, however, is likely to be much more delayed than that of electricity and will not be directly and immediate observed. This might lead to non-action and ill-founded complacency that while immediate action is required.

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Table 1 Taxable water, water tariffs (2002) and the semi-elasticity for water demand

	(1)	(2) Taxable water (million m³)	(3) Water tariff (R/m³)	(4) Elasticity	(5) Semi-elasticity
Irrigated field	A	7,152	0.10	-0.25	-44.20
Dry field	A	0	0.10	-0.15	0.00
Irrigated horticulture	A	3,400	0.10	-0.25	-44.20
Dry horticulture	A	0	0.10	-0.15	0.00
Livestock	A	191	0.10	-0.15	-37.73
Forestry		1,673	1.80	n.a.	0.00
Other Agric	A	25	0.10	-0.15	-26.54
Coal	B	40.3	2.12	-0.32	-47.654
Gold	B	284.8	2.12	-0.32	-47.654
Crude, petroleum & gas	B	0.74	2.12	-0.48	-88.02
Other mining	B	368.3	2.12	-0.32	-47.654
Food		376.4	4.00	-0.39	-49.050
Textiles		104.4	4.00	-0.33	-41.325
Footwear		0	4.00	-0.33	-41.325
Chemicals & rubber	B	59.4	2.12	-0.15	-22.576
Petroleum refineries	B	92	2.12	-0.48	-70.656
Other non-metal minerals	B	44	2.79	-0.32	-43.986
Iron & steel	B	56.21	2.79	-0.27	-37.017
Non-ferrous metal	B	14.04	2.79	-0.27	-37.017
Other metal products	B	60	2.79	-0.27	-37.017
Other machinery		37.27	4.00	-0.25	-47.500
Electricity machinery		6.23	4.00	-0.38	-47.713
Radio		0	4.00	-0.38	-47.713
Transport equip		20.42	4.00	-0.38	-47.713
Wood, paper & pulp	B	157.5	2.12	-0.59	-86.609
Other manufacturing		13	4.00	-0.38	-47.713
Electricity	B	208	2.12	-0.80	-328.17
Water	B	5,906.0	2.12	-0.60	-88.302
Construction		167.12	4.00	-0.38	-47.713
Trade		491.4	4.00	-0.19	-23.750
Hotels		319.8	6.11	-0.19	-22.110
Transport services		497.11	6.11	-0.19	-22.110
Community services		175.8	6.11	-0.19	-22.110
Financial Institutions		281.3	6.11	-0.19	-22.110
Real estate		662	6.11	-0.19	-22.110
Business activities		26.2	6.11	-0.19	-22.110
General government		524.76	6.11	-0.19	-22.110
Health services		331.3	6.11	-0.19	-22.110
Other service activities		198.74	6.11	-0.19	-22.110

Note: Sectors marked A are agricultural – large users of water who pay little in the form of volumetric charges. Those marked B are bulk users of non-potable water.

Source: Semi-elasticities derived from: DWAF's water tariff table and survey conducted among large water utilities, DBSA 2000, Renzetti 1992, Veck and Bill 2000 and Le Maitre *et al.* 2000.

Table 2: Results from modelling the implementation of the 6 water intensive ASGISA projects on, GDP, employment, water demand and CO_2

	% change in			
	GDP	Unskilled labour	Water use	CO_2-emssions
Scenario 1: Injection of R1bn in				
- Dryfield agriculture	0.03	0.11	0.02	0.03
- Irrigation horticulture	0.05	0.18	0.72	0.02
- Livestock	0.09	0.22	0.10	0.07
- Timber	0.08	0.25	0.67	0.04
- Other mining	0.04	0.10	0.02	0.09
- Water sector	0.07	0.16	0.64	0.10
Total	0.36	1.02	2.17	0.35
Scenario 2: Water tariff increase 1c/m^3, with the revenue not returned to the economy	-0.01	-0.03	-2.78	-0.01
Scenario 3: Water tariff increase 1c/m^3, and recycled to				
- Dryfield agriculture	0.00	-0.01	-2.78	-0.01
- Irrigation horticulture	0.00	0.00	-2.65	-0.01
- Livestock	0.01	0.01	-2.77	0.00
- Timber	0.01	0.02	-2.68	0.00
- Other mining	0.00	-0.01	-2.77	0.01
- Water sector	0.00	0.00	-2.68	0.01
Total	0.01	0.01	-2.74	0.00