Water resource management and climate change in South Africa: Visions, driving factors and sustainable development indicators

---

PREPARED BY
PIERRE MUKHEIBIR AND DEBBIE SPARKS

Report for Phase I of the
Sustainable Development and Climate Change project

April 2003
ENERGY & DEVELOPMENT RESEARCH CENTRE
University of Cape Town

Contents

1. Introduction

The Sustainable Development and Climate Change Project is an initiative of 12 institutes from developing and developed countries. It explores the idea that a less polarised way of meeting the challenges of sustainable development and climate change is to build environmental and climate policy upon development priorities that are vitally important to developing countries. South Africa is one of the six countries involved in exploring these linkages.

This document outlines possible water resource futures for South Africa. It should be read together with a companion report with describes different futures for the energy sector. This paper takes the first steps to identifying promising policy options for a transition to long-term sustainable development in South Africa. It sets the context for further analysis (in Phase 2) of water resource management policies and strategies that meet both the development priorities of South Africa and address climate change.

Water is an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilisation. Water is a limiting resource for development in Southern Africa and a change in water supply could have major implications in most sectors of the economy, especially in the agriculture sector. Factors that contribute to vulnerability in water systems in Southern Africa include seasonal and inter-annual variations in rainfall, which are amplified by high run-off production and evaporation rates.

Climate change is expected to alter the present hydrological resources in Southern Africa and add pressure on the adaptability of future water resources (Schulze & Perks 2000). During the past 20 years, most of Africa has experienced extensive droughts, the last two (1986-88, 1991-92) being attributed to El Nino(Chenje & Johnson 1996). Water scarcity is a problem in many parts of the Southern African Development Communicty (SADC) region. Poor distribution of water resources and pollution coupled with frequent droughts and floods has lead to direct hardship for many people, particularly the poor, since it has affected food security (SADC 2001a), specifically for subsistence farmers. If the occurrence of drought became more frequent, the impact on water resources, and consequently agriculture, would be significant.

In light of this, the available literature suggests that it would be prudent to account for climate change in water resource planning to meet the development objectives of South Africa. The Minister of Water Affairs, Mr Ronnie Kastrils, has also acknowledged that 'it is possible that the effects of global climate change will influence the availability of water and patterns of use during the next few decades' (Kasrils 2002).

This paper begins with an overview of the current water resource situation in South Africa and then locates water resources in the broader policy context. For water resource management policy more specifically, it recalls the major objectives of water policy. It then identifies driving forces for water resource futures, both general ones and those specific to the water sector. Section 5 outlines different visions of water futures in Southern and South Africa and looks specifically at the impact of climate change on these futures. These water futures could be analysed using the indicators for sustainable development outlined in the following section. The paper concludes identifying key water policy areas to be examined in Phase 2.

2. Overview of current South African water sector

2.1 Water is a scarce resource

South Africa is a water-stressed country with an average annual rainfall of 500mm (60% of the world average). Only a narrow region along the south-eastern coastline receives good rainfall, while the greater part of the interior and western part of the country is arid or semi-arid. 65% of the country receives less than 500m per year, which is usually regarded as the minimum for dryland farming; 21% of the country receives less than 200mm per year (DWAF 1994).

The natural availability of water across the country is variable, and rainfall displays strong seasonality. Stream flow in South African rivers is at a relatively low level for most of the year. This feature limits the proportion of stream flow that can be relied upon for use. Moreover, as a result of the excessive extraction of water by extensive forests and sugar cane plantations in the relatively wetter areas of the country, only 9% of the rainfall reaches the rivers, compared to a world average of 31% (DWAF 1996). Rainfall variability also has implications for water-related disasters such as floods and droughts. Many urban and industrial developments, as well as some dense rural settlements, have been established in remote locations at a distance from adequate reliable water sources. As a result, the requirements for water already far exceed the natural availability of water in several river basins, and therefore large-scale transfers of water across catchments have been implemented, like the Lesotho Highlands Water Scheme.

Groundwater also has an important role to play in rural water supplies, but few major groundwater aquifers exist that can be utilised on a large scale due to high salinity in most parts of the country. It is estimated that about 5 400 million cubic meters of water a year could be obtained from underground sources(DWAF 1994).

The total average annual available surface water in South Africa is 49 200x$10^6$$m^3$ (this includes the inflow from Lesotho and Swaziland). Of this, 13 911x$10^6$$m^3$ is can be economically harnessed as usable yield (this includes usable return flow).

Table 1: Available yield in year 2000
Source: DWAF (2002a)

Source	*Million m^3/a*
Surface water	10928
Groundwater	1042
Usable return flow	1941
TOTAL	**13911**

The total amount of water required for 2000 was 13 280x$10^6$$m^3$, a figure close to availability limits (DWAF 2002a). Agriculture is by far the largest user of water, as shown in Figure 1, while urban and rural requirements make up 25% and 4% respectively.

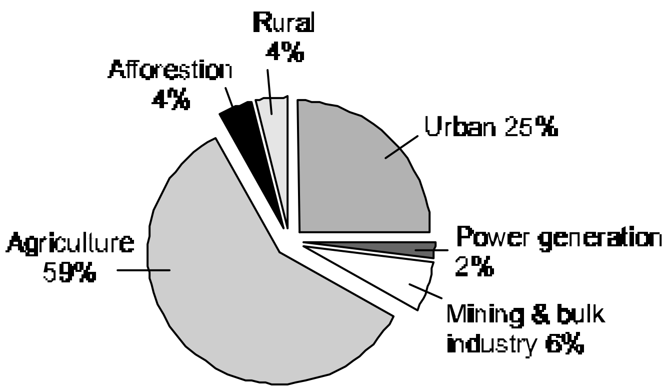

Figure 1: Water demand for 2000 per sector
Source: (DWAF 2002a)

2.2 Food production

As illustrated in Figure 1, agriculture and forestry together use two thirds of the available water resources. The projected impacts of climate change are predicted to affect the yield of various agricultural crops and the productivity of rangelands by 2050 (Midgley 2001). 16.7 million hectares (ha) (13.7%) of South Africa is potentially arable. 68.6% (83.9 million ha) is grazing land, 9.6% (11.8 million ha) protected by nature conservation, 1.2% (1.4 million ha) under forestry, and 6.9% is used for other purposes. Of the arable portion, 2.5 million hectares is in the former 'homelands' and is primarily used for subsistence farming, while 14.2 million is farmed by commercial agriculture.

Food production makes up approximately 92% of the agricultural yield by volume (NDA 2002). Agriculture is declining as a contributor to GDP. In 1998, agriculture and forestry contributed 4.0% of GDP, significantly lower than in 1965 at 9.1% (NDA 2000). It is interesting to note that, whilst irrigated agriculture uses 59% of the available national water resources, it provides less than 2% of the total country's employment. All agricultural practices, including dryland farming, forestry and livestock, provide approximately 10% of the country's employment (DWAF 2002a).

The production of agricultural products can be closely linked to the drought patterns of Southern Africa. Figure 3 illustrates the steady increase in agricultural production since 1965. The period from 1967 to 1973 was a dry one across the region (Chenje & Johnson 1996), and agricultural production shows little growth. Dips in production can be seen in the early 1970s, 1980s and mid 1990s, which correspond with the occurrence of significant droughts experienced in South Africa and serve to illustrate the vulnerability of agriculture to variations in climate, and potentially to long-term climate change.

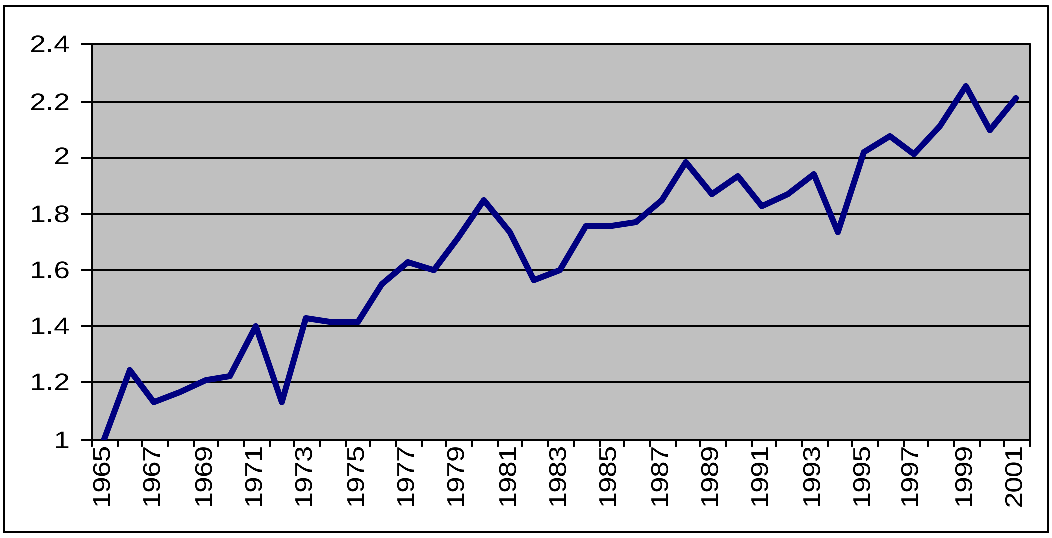

Figure 2. Indices of the volume of agricultural production measured against 1965
Source: Data from NDA (2002)

2.3 Equitable access to water

According to the 2001 census, 84% of South Africans have access to piped water, 32% directly into their homes (SSA 2003). A large percentage of those without access to clean water live in the historically disadvantaged rural areas, specifically in the previously demarcated homelands.

2.4 Water pricing

Apartheid policies distorted the provision of water supply services and generated a biased approach to water resource management. Until recently, users of bulk water in South Africa paid a subsidised price on water that was less than the economic value. Government water policy, and in particular the provision of subsidies (including those associated with the provision of irrigation water, where they only paid for the operating costs and were exempted from paying for the capital costs of water delivery (Hassan et al. 1996)), resulted in considerable advantages to large, mainly white commercial farmers at the expense of emerging black farmers and smallholders. The Raw Water Pricing Strategy of 1999 aims to achieve social equity by redressing the imbalances of the past, both with respect to equitable access to water supply services and with respect to direct access to raw water. The following objectives are stated as having equal importance in formulating the new pricing strategy (DWAF 1998): social equity; ecological sustainability; financial sustainability; and economic efficiency.

3. Existing water policy objectives

3.1 Water in the policy context of the New Partnership for Africa's Development (NEPAD)

NEPAD[1] states that the objectives for the continent with regards to water are as follows (NEPAD 2001: 27):

- To ensure sustainable access to safe and clean water supply, especially for the poor
- To plan and manage water resources to become a basis for national and regional cooperation and development
- To systematically address and sustain ecosystems, biodiversity and wildlife
- To cooperate on shared rivers among member states
- To effectively address the threat of Climate Change
- To ensure enhanced irrigation and rain-fed agriculture to improve agriculture production and food security

In response to the threat of climate change in Africa, NEPAD plans to establish a task team to make plans to mitigate the negative impacts.

3.2 Water in the SADC context

The recent progress by SADC[2] countries to improve cooperation among themselves provides a foundation for the management of the region's water resources. The key opportunities for improved regional water resources management include the following (SADC 2001b: 21):

- A political environment and level of awareness to promoting and implementing regional opportunities for integrated water resources management, and with priority to access to clear potable water especially in rural areas;
- Political stability in the region, a precondition for co-operation and development;
- Institutional, legislative and policy reforms in all countries towards integrated water management approaches that include environment management;
- Reforms in line with international consensus on integrated water resources management, already started in a number of countries;
- SADC Protocol which forms a basis for the management of shared watercourses systems and the establishment of the SADC Water Sector;
- Need for the international community to increase flow of financial resources.

A number of SADC co-operation frameworks exist, such as the Protocol on Shared Watercourses in SADC, which deals with water matters and is coordinated by the SADC Water Sector, led by Lesotho. The Water Sector has developed a Regional Strategic Action Plan for managing and developing the water resources of the region, and is reported to be in the process of initiating a number of projects (DWAF 2002a).

1 NEPAD is an African-driven programme to extricate Africans from the malaise of underdevelopment and exclusion in a globalising world.

2 The Southern African Development Community (SADC) is an intergovernmental legal entity grouping fourteen Southern African States (Angola, Botswana, the Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe) committed to equitable economic integration and sustainable development.

3.3 South African water policy and legislation

Significant transformation in the field of water resources management policy in South Africa have been driven by two aspects:

- the democratisation of South Africa, which has brought about the need to eliminate disparities between various sectors of South African society with respect to access to resources, among which water is primary; and
- awareness that the increased exploitation of water resources to meet rising water demands in South African catchments, as well as the intensification of associated impacts on water quality needs to be addressed.

The South African Constitution offers the primary legal framework for the government's water policy and as discussed below, is the basis for formal legislation. Amongst the socio-economic rights, the constitution confers on 'everyone the right to have access to water'. The White Paper on Water Supply and Sanitation published in 1994 by the Department of Water Affairs and Forestry (DWAF) (DWAF 1994) states that water and related policies are important issues for all South African. Not only is water central for development but it is an essential basic human need for physical survival.

The policy principles around which the policy was based are:

- demand-driven and community-based development;
- that basic services are a basic human right;
- the principle of 'some for all' rather than 'all for some';
- equitable regional allocation of development resources
- that water has an economic value;
- the 'user pays' principle;
- integrated development; and
- environmental integrity.

The National Water Act (DWAF 1998) replaced the 1956 Water Act with the following relevant core objectives:

- meeting the basic human needs of present and future generations;
- promoting equitable access to water;
- redressing the results of past racial and gender discrimination;
- promoting the efficient, sustainable and beneficial use of water in the public interest;
- facilitating social and economic development;
- providing for growing demand for water use;
- protecting aquatic and associated ecosystems and their biological diversity;
- reducing and preventing pollution and degradation of water resources;
- managing floods and droughts.

The National Water Policy White Paper (DWAF 1997b) and National Water Act (DWAF 1998) are based on the principles of equity, sustainability and efficiency. The country's new laws have instituted a macroeconomic and environmental reform process in the sector in which water rights have been separated from land rights and a water right is limited to a 'use-right'. Water is now deemed a common property source owned by the people of South Africa and managed by the Government. (Goldblatt et al. 2002)

Basic adequate water services are defined by DWAF as potable water supply of 25 litre/person/day within a walking distance of 200m (DWAF 1994). This is considered sufficient for cooking and drinking. To address the issue of affordability, Government has recently committed itself to providing 25 litres per day, free of charge (the life-line tariff), to be implemented by local authorities (Majola 2002).

DWAF has recently developed a draft National Water Resource Strategy (NWRS) (DWAF 2002a) to address the management of the water resources to meet the development goals of the country. It will be reviewed at least every five years (Kasrils 2002). One of the key objectives of the NWRS is to identify areas of the country where water resources are limited and constrain development as well as development opportunities where water resources are available. In an attempt to redress the past imbalances, the NWRS has identified some specific linkages with the Integrated Rural Development Programme and the Urban Renewal Strategy (DWAF 2002a: 36):

- Ensuring that rural development features strongly in water catchment management strategies.
- Identifying rural water needs and opportunities and making specific allowances for rural development and livelihoods in re-allocating water by compulsory licensing.
- Ensuring community representation on the management bodies of water management institutions.
- Contributing to the planning and development of urban river floodplains to ensure public safety, and the safety of infrastructure, during floods.

Whilst attention in the past was mainly focused on the development of new resources, the efficiency of water use has not been as well developed. With the current high degree of water resource utilisation in the country, the efficiency of water use needs to be substantially improved. With this in mind, the Department of Water Affairs is currently developing a programme for water conservation and water demand management.

4. Driving forces for water future

Three main driving forces affect South Africa's freshwater environment. Firstly, the natural conditions, low rainfall with high evaporation rates, which together create low availability of run-off. It is has been projected that climatic change will have notable impacts on the available run off. Second is population growth and the need for economic development leading to greater water demand and increased pollution of available resources. A third driving force is the policy pertaining to management of water resources, which determines the approach taken by relevant authorities at all levels of government to managing the resource and directly impacts other driving forces and pressures.

4.1 Climate scenarios and water resources

It is useful to examine future climate scenarios as they relate in particular to water resources. The indications for a future climate outlined below are based on the South African Country Studies report (Kiker 2000), which used the HadCM2 and CSM model results.

For summer, there is likely to be a greater number of days with a deep trough in the easterly wave over the interior, a southwards shift in the orientation of the South Atlantic high pressure and an increase in ridging of the high pressure. This, in conjunction with an expected increase in moisture in the atmosphere may result in the following: increased intensity of rainfall events in the north-east, an increase in orographically driven rainfall to the south, a general drying in the south-western Cape, as well as an increase in pollution potential associated with an increase in inversions through increased subsidence. For winter, an increase in the frequency of cold fronts from the south-west (this is only in the CSM model) and an increase in ridging highs are indicated.

Temperature indications are for a minimum temperature increase in summer and a summer extension into the shoulder seasons, a maximum temperature increase in summer and autumn, greatest warming over the western half of the country, continental warming of 1-3ºC, and greatest warming inland, reducing towards the coast.

Precipitation response is more uncertain, with the two models showing some differences in response. Changes in the CSM model are greater than in the HadCM2 modek. The latter shows a general decrease in summer rainfall, generally being 5-10% of present rainfall. The CSM model also shows a 5-10% change, but with more regional structure. There is also an indication of precipitation reductions from the north-west to the south-east, and shoulder seasons may have a decrease in summer rainfall length.

The models show an increase in Hadley circulation, an increase in moisture and an increase in winter fronts in the south-west. Along with precipitation and temperature changes, these may imply the following:

1. The summer season circulation implies greater continental subsidence leading to greater pollution potential through inversions, suppression of convective rainfall and greater evapotranspiration and increased stress on already marginalised zones, with the possibility of increased flooding.
2. The increase in atmospheric moisture content may be the result of general precipitation increases in early summer in the north-east. This is coupled with greater instability in the atmosphere and greater dry-spell lengths and intensity of convective rainfall.
3. The south-west region may have increased frontal and orographic rainfall in early winter.

Changes in the climate system will impact on hydrological systems and water resources. Sensitivity studies undertaken showed runoff to be very sensitive to precipitation changes. However, the winter rainfall regions of the south-western Cape were not as sensitive. Recharge into the vadose zone (the zone above the water table) appears to be more sensitive to precipitation changes than runoff is. The western half of South Africa could likely have a 10% reduction in runoff by 2015 (based on the HadCM2 model excluding sulphates), while the eastern half would have a similar reduction much later (2060).

There are still many uncertainties with regard to the magnitude, direction and regional direction of climate change. The climate change outputs from the models currently being used have produced significantly different simulations (Schulze & Perks 2000).

4.2 Domestic and economic development

Statistics South Africa gives the size of the South African population as 45 million in 2001 (SSA 2003). The Development Bank of Southern Africa (DBSA) uses population projection, differentiating on low and high impacts of HIV/AIDS, of 70 million and 47 million respectively by 2025 (Calitz 2000b; 2000a). The uncertainty in population growth due to the impact of HIV/AIDs makes it difficult to plan for water resource requirements. Changes in population have a relatively small *direct* impact on water demand however, but significant *indirect* consequences in the economic sectors.

Income inequality is high, with the Gini coefficient index for South Africa reported as the fourth worst of 105 countries in 1993, according to a World Bank survey (World Bank 2000). A poverty study in 1998 found that 40% of the population earned 11% of the country’s income, while 10% of the population earned 40% of the income (May 1998).

Whilst poverty cannot be reduced to income, it does gives a rough first impression. The lowest quintile of households had a monthly income of R291, while the highest earned an average R16 139 (UCT 2002). The two lowest quintiles are considered poor. Given the major emphasis in government policy on poverty reduction, understanding income inequalities is critical.

The provision of water is key to a coherent development strategy if it is to be successful. Access to clean water is the most significant resource for reducing poverty and disease, and improving the life of poor South Africans. Available water is also key in promoting rural development and increasing food security. The legacy of apartheid has left the country with the huge task of providing sustainable water delivery services to its population in order to meet these basic needs. The majority of the people without basic domestic water services live in rural areas. To address the needs of the rural poor, the Growth, Employment and Reconstruction (GEAR) strategy focuses on land reform and associated agricultural development and on the provision of infrastructure, notably water. (DWAF 1997b). The two main objectives of the Reconstruction and Development Programme (RDP) and GEAR are to attain both equity and economic growth. The combination of these objectives makes it clear that economic development progresses towards some set of social goals – notably more jobs and more equal income distribution. Without adequate supply of water for economic activities, these two objectives will be difficult to achieve.

The trends towards industrialisation of the economy and urbanisation of the population are expected to continue. It is therefore expected that future growth in water demand will be largely in the main metropolitan centres. Together with catchments already under stress, particular attention will therefore have to be given to ensure adequate future water supplies to these areas.

In addition to supporting urban, industrial and mining growth, the following opportunities for increased water use were identified in the NWRS (DWAF 2002a: 9):

- Expansion of irrigation in the Lower Orange and Fish to Tsitsikama water management areas with water from the Upper Orange water management area.
- Expansion of irrigation below Pongolapoort Dam in the Usutu Mhlathuze water management area.
- Refurbishment of irrigation schemes and additional development in the Mzimvubu to Keiskamma water management areas.
- Expanded forestry development in some catchments.
- Expansion of irrigation in the north-eastern part of Limpopo Province.

4.3 Water management drivers

4.3.1 Demand – access to basic water services

Access to piped clean water in 2001 was 84% (SSA 2003). DWAF has projected that the remainder will all have access to water infrastructure by 2008 (Kasrils 2003). To address the issue of affordability, the government has committed itself to providing a 25 litres per day free of charge (life-line tariff), implemented by local authorities, amounting to about 6 000 litres per household per month, based on eight people per household. Currently 57% of the population have access to free basic water services – 73% of those with access to water infrastructure (Kasrils 2003). The primary intention of the policy is to ensure that no one is denied access to water supply simply because they are unable to pay for the service. Underlying this is the recognition that supply of water at a basic level assists in alleviating poverty, improves community health and addresses the plight of women. The volume of free water will be regulated as part of the national strategy in terms of Sections 9 and 10 of the Water Services Act of 1997 (DWAF 1997a). This provision should result in an increase in the use of water and should be considered when projecting future water use requirements.

4.3.2 Supply – water security

In the short term there does not appear to be a major threat of water scarcity for manufacturing, mining or domestic consumption in South Africa. In the long term the total water demand will likely exceed the availability of water within the country's borders after 2025 (DWAF 2002a), and there will be a need to both reduce consumption and increase supply to maintain water security and allow for sustainable development. Specific drivers to reduce consumption would include demand-side management through pricing mechanisms and other non-economic mechanisms to achieve the goals of sustainable use, demand reduction, efficient allocation and equitable allocation.

There is still 5500 million m^3 of potential yield from current freshwater resources to meet the projected future demands over the next 25 years. Table 2 shows the planned schemes and the related costs to increase the supply to meet the projected development needs. By 2025 the local yield will be increased by 936 million m^3 at a cost of R6 029 million (approximately US$800 million).

Table 2: Reconciliation of water requirements and availability for year 2025 base scenario (million m^3/annum)

Source: DWAF (2002a)

	Water management area	*Local yield*	*Trans-fers In*	*Local needs*	*Transfers out*	*Balance*	*Potential for developt*	*Planned schemes by 2025*	*Indicative costs (Rm)*
1	Limpopo	281	18	347	0	-48	8		
2	Luvuvhu/Letaba	403	0	349	13	41	102	50	693
3	Crocodile West & Marico	805	901	1 594	10	102	0		
4	Olifants	630	210	1 075	8	-243	239	180	865
5	Inkomati	1 073	0	1 088	148	-163	114	114	1012
6	Usutu to Mhlathuze	1 011	32	700	114	229	110	10	101

	Water management area	Local yield	Trans-fers In	Local needs	Transfers out	Balance	Potential for developt	Planned schemes by 2025	Indicative costs (Rm)
7	Thukela	742	0	347	497	-102	598	88	140
8	Upper Vaal	1 818	1 743	1 440	2 042	79	50	50	350
9	Middle Vaal	205	775	400	580	0	0		
10	Lower Vaal	48	648	645	0	51	0		
11	Mvoti to Umzimkulu	555	34	1 012	0	-423	1 018	47	440
12	Mzimvubu to Keiskamma	872	0	413	0	459	1 500		
13	Upper Orange	4 799	2	1 022	3 496	283	900		
14	Lower Orange	(1 001)	1 931	883	54	-7	150	150	165
15	Fish to Tsitsikamma	452	595	979	0	68	85		
16	Gouritz	278	0	353	1	-76	110	5	31
17	Olifants/Doring	335	3	371	0	-33	185	141	819
18	Breede	869	1	639	203	28	197		
19	Berg	506	203	829	0	-120	210	111	1413
	Total for country	14 681	0	14 486	124	68	5 576	936	6029

4.4 Future water sector outlook

The National Water Resource Strategy document of DWAF states that overall water demand is expected to increase by approximately 9% over the period 2000-2025 (DWAF 2002a), the total demand for water rising to 14 486 x $10^6 m^3$.[3] The reliable local yield is set to increase to 14 681 x $10^6 m^3$ over this same period, mainly due to growing wastewater return flows (see Table 2).

Factors such as climate, nature of the economy and standards of living influence water requirements, with population and economic growth being are the primary factors with the respect to future water requirements. Urbanisation and the negative impacts of HIV/AIDS are also key considerations when making future projections on water requirements. In the NWRS document, DWAF states that this estimate of future requirements is based on a scenario of high population growth and high standard of services together with a strong increase in the economic requirements for water so as serve as a conservative indicator. International experience has shown that countries with renewable freshwater resources below 1000 m^3 per capita per year are prone to experience severe water scarcity that will impede development and be harmful to human health (WRI 1996). By 2010 the population is estimated to be approximately 53 million and the per capita water resources will dip below the 1000 m^3 benchmark, based on a growth rate of 2% per annum and an available average runoff is estimated at 53 500 million m^3 (DEAT 1999).

The NWRS (DWAF 2002a: 9) specifically draws attention to the following management areas that will need consideration:

- Crocodile West and Marico water management area – Large additional transfers of water to the Pretoria-Johannesburg area, in the upper reaches of the Crocodile catchment, will be required in future. Specific attention will need to be given to the balance between the transfer of water and re-use of return flows.

---

3 The reasoning behind the water use projections is not well documented in the NWRS. A much higher projection is made by Basson et al (1997), who stated that the water requirement in the domestic, urban and industrial sectors would grow at 3% per annum. This would result in an increase in water demand of 30 415 x $10^6 m^3$ – 51% from 1996 to 2035. Goldblatt et al rather predict a dynamic water future in which a combination of factors suppress water demand growth or increase available supplies. It suggests that conservative water management policies coupled with appropriate price incentives could easily avoid the conclusion of Basson et al that all water resources would be exhausted by 2030.

- Olifants water management area – Addressing deficits which will result from implementation of the Reserve and future water supplies for power generation and mining. Possible impacts on Mozambique to be considered.
- Inkomati water management area – Current deficits, and impacts associated with implementation of the Reserve need to be addressed, with joint management of the Komati River being of specific importance.
- Upper Vaal water management area – This water management area should be adequately supplied until 2025, given the projections in the base scenario. The existing surplus transfer capacity is to be reserved for urban, industrial and mining developments, and not used for irrigation.
- Mvoti to Umzimkulu water management area – Ensuring adequate future water supplies for the Durban-Pietermaritzburg metropolitan area.
- Berg water management area – Provision of water to meet future requirements in the greater Cape Town area.

4.4.1 Cost of new infrastructure development

It has been estimated that approximately R6 029 million may be required for the development of major new government waterworks during the next 25 years (see Table 2). This new infrastructure would yield a further 936 million m^3 of water per year at an average cost of R6.50 per m^3 per year (ranging from R2-R15 per m^3). The NWRS states that future funding arrangements for infrastructure development may be the responsibility of the appropriate water utility. However, it goes on to say that the government may be required to continue funding schemes from the exchequer funding for irrigation, social, disaster mitigation or environmental purposes (DWAF 2002a) .

In recognising that climate change impacts are a potential threat to the water related development goals of the country, substantial investments are required for water infrastructure and other water management strategies to be put in place.

5. Strategies for future sustainable water supplies

5.1 Policy vision

The challenge for the future is to balance the demand for water with the available supply. Since it is not possible to increase the amount of water, except to extract more from the available resources, the opportunity exists to satisfy both urban and rural needs using appropriate management mechanisms.

Currently, climate change does not feature prominently as a real threat to the reduction of the existing available water resources, so that strategies have not been developed to adapt to the projected impacts. Current water management mechanisms and policies have been developed to ensure that the existing supply of water meets the growing demand. Some of the mechanisms may be appropriate to deal with the future shortage that will be brought about by climate variation, but robust long-term strategies are required to ensure the demand for water matches supply, even in times of reduced availability. In addressing future projected climate change impacts, some of the measures may need to be introduced sooner than originally planned.

5.2 Potential for integrated sustainable development and climate change adaptation strategies

As stated previously global temperatures are rising, with some climatic models suggesting that this could cause a decrease in runoff in South Africa, spreading progressively from west to east during the next few decades. In order to address this, three basic areas of adaptation for water resources have been suggested (Benioff et al (1996) in Schulze & Perks (2000: 107)):

- *Increased water supply:* eg modified catchment vegetation, construction of reservoirs and dams, reduction of evaporation, development of groundwater resources and utilisation of inter-basin transfers
- *Reduced water demand:* eg demand side management, reuse and recycle water

- *Deferent management of supply and demand:* eg crop substitution, conjunctive use of ground and surface water, apply climate forecasts to manage water resource operations, provide more versatile inter-basin transfer schemes and more flexible operating rules for water systems.

The following examples have been adapted from Schulze & Perks (2000) to illustrate examples of existing and possible adaptation measures which could be considered in the water resources sector as a response to changes in climate.

5.2.1 Resource management – planned and co-ordinated use of river basin

Comprehensive planning across a river basin may allow coordinated solutions to problems of water quality and water supply as well as address the effects of population, economic growth and changes in the demand of water (Schulze & Perks 2000). Industrial users will be required by December 2005 to develop and submit a water management plan if they draw their water directly from a water source (DWAF 2002a).

Regulation of streamflow through storage dams and the control of abstraction and release to provide appropriate quantities of water at specific times and locations to meet users' requirements would need appropriate and frugal management of water resources.

Groundwater is likely to be most severely affected, with the groundwater table dropping due to reduced recharge. Strict groundwater management systems should be put in place with early warning mechanisms to report depleted groundwater reserves.

5.2.2 Conservation of water / demand management

A key challenge for sustainable development in South Africa will be a reconciliation of water demand and supply both for the medium and long term. While there is planning for future sources of water supply, it appears as if the demand-side of the equation has been neglected. Reducing demand can increase excess in supply thereby creating a greater margin of safety for future droughts. This could be through a range of measures that 'encourage efficient water use including education, voluntary compliance, pricing policies, legal restrictions on water use, rationing of water or the imposition of water conservation standards on technologies' (Schulze & Perks 2000: 108).

5.2.3 Reduction in water services losses

The domestic sector accounts for 15% of total national use and has the highest expected growth in demand. The level of unaccounted for water in urban distribution systems is between 15 and 20%, which is viewed as high by international standards (Goldblatt et al 2002). Efficient use of water will reduce treatment and distribution costs.

5.2.4 Reduction of losses due to agriculture

As stated before, irrigation accounts for almost 60% of water used in South Africa. There are significant losses in many distribution and irrigation systems as well significant evaporation losses. Alternative irrigation methods and practices should be investigated.

5.2.5 Re-use and recycling of water

Water not used in a consumptive manner should be re-used or recycled. This could be either by returning the water back to the river in a fit state for further use downstream or for reuse within the system from which it was first abstracted, specifically for industrial and domestic users. Coastal towns specifically could look to recycling as a potential source of additional water, before discharging waste water to the sea.

5.2.6 Control of water pollution / water quality

Polluted water that is unfit for drinking or other uses can have a similar effect as reduced water supply. Reducing water pollution effectively increases the supply of water, which in turn increases the safety margin for maintaining water supplies during droughts (Schulze & Perks 2000). The protection of water quality presents a major challenge to water policy in South Africa.

5.2.7 Allocation of water supplies by market-based systems

Most policy papers dealing with natural resource management in South Africa recognise the need for economic instruments and market mechanisms for efficient utilisation and allocation of natural resources and environmental resources. The provision of water at prices below the true economic value is considered the main reason for inefficient use of water and allocation in South Africa. Further, in the context of water scarcity, an argument can be made for the introduction of economic incentives in water-stressed catchments to encourage the conservation of water and its shift from low to higher value use. This can be done administratively or by using market-related mechanisms. Issues to be considered when reviewing the pricing of water are (Hassan et al 1996):

- Marginal cost pricing is more appropriate than average cost pricing since it sends the right signal to efficient water users.
- Variable tariff rates, as apposed to flat rates, to provide for periods of scarcity and peak demands.
- Opportunity cost of water, especially when water is scarce.
- Pricing undelivered water i.e rainfall runoff that is absorbed by crops vs natural vegetation.
- Property rights and tradable permit systems in water.
- Lifeline tariffs and equity.
- Rewarding quality return flows from waste streams.

Market-based allocations are able to respond more rapidly to changing conditions of supply and also tend to lower the water demand, conserve water and consequently increase both the robustness and resilience of the water supply system (Schulze & Perks 2000).

5.2.8 Modification of catchment vegetation

DWAF have initiated the 'Working for water' programme to remove invasive alien tree species (wattles, pine etc) from catchments in South Africa. Through the modification of the vegetation in various catchments, where water-thirsty vegetation with high transpiration rates has reduced the stream flow, the available water supply can be increased. Invading alien plants have covered some 10 million hectares, about 8%, of South Africa. They cause the loss of some 7% of the annual flow in South Africa's rivers each year – about 33 million m^3 of water. (This excludes their severe impact upon groundwater reserves.) Through the Working for Water Programme it is estimated that approximately 750 000 hectares will need to be cleared each year over a 20-year period (Kasrils 2000).

5.2.9 Contingency planning for drought

Much research has been conducted into the adaptation to climate variability (droughts and floods) and specifically measures that could be taken to prevent or minimise the disruption and damage caused by such occurrences. In the past, most of this research has been conducted in agricultural sector; more recentlym research has been focused on the impacts of drought and floods on people and their livelihoods. The lessons from this research, and resilience strategies of vulnerable communities, need to be taken into consideration when developing strategies to deal with the impacts of future long-term climate change. If the development goals of the country are to be achieved despite the impacts of climate change, then the appropriate lessons need to be incorporated into national and local water management policy. The cost of developing contingency plans to adapt to water shortages and mitigate droughts is relatively small compared with the potential benefits (Schulze & Perks 2000).

5.2.10 Improved monitoring and forecasting systems for floods and drought

It is possible that climate change will affect the frequency of floods and droughts. Monitoring systems will help in coping with these changes, even without the impact of climate change (Schulze & Perks 2000).

5.2.11 Inter-basin transfers

Transfers of water between basins may result in more efficient water use under the current and future changed climate. Inter-basin transfers are considered an effective short-term measure for addressing drought and water supply on a regional scale. This, however, is an expensive option (Schulze & Perks 2000).

5.2.12 Marginal changes in construction of infrastructure

Marginal increases in the size of dams or marginal changes in the construction of canals, pipelines, pumping plants and storm drainage should be considered (Schulze & Perks 2000).

5.2.13 Maintain options for new sites

Potential sites for new dams should be kept open till they are required, since there are a limited number of sites that can be used efficiently as reservoirs and removing structures once an area has been developed may be very costly or politically difficult (Schulze & Perks 2000).

5.2.14 Crop substitution

It has been observed that some farmers are substituting their crops with ones which require less water and perform better in high temperature. This is an expensive option, but the economics of this longer-term planning may justify the expenditure (Midgley 2003).

5.3 Strategies for implementing adaptation

In the South African context, sustainable development should be designed with climate change in mind, to ensure that the development objectives are resilient to climate variability and ultimately adaptable to climate change. The development of such strategies should be viewed as part of the process outlined below (Warrick 2000):

- **Awareness raising** of climate change within government, NGOs, private sector and public sector to garner political support.
- **Capacity building** for technical assessments, planning and policy development.
- **Adaptation assessment** at national and community level.
- **Policy, planning and project development** incorporating climate change and adaptation into development policies and projects.
- **Project implementation** that incorporate adaptation measures.
- **Evaluation and monitoring** the outcomes of the interventions so as to modify the strategies if necessary. By definition, 'development' implies adapting to change and so strategies should include climate change into the debate.

6. Sustainable development indicators

In order to measure the impact of various interventions, sustainable development indicators are necessary for adequate comparisons. Indicators should be both clear and measurable. The following are potential indicators for measuring the impact of climate change on development.

Some specific DWAF development indicators:

- Access to clean drinking water:
  - short-term 20-30 litres per person per day (percentage of people with access);
  - medium to long-term 50-60 litres per person per day (percentage of people with access).
- Subsidy of 25 litres per person per day free of charge (percentage of people receiving subsidy);

Water-related sustainable development indicators:

- Share of people without improved water access/population not using improved water resources (as percentage of total population).
- Volume of available freshwater per capita per annum (percentage of people receiving less than 1000 kl).
- Urban households with access to onsite water (percentage of households with onsite water)
- Water quantities used by different sectors (in percentages).
- Water costs as a share of income (percentage of income).
- Water costs as share of production costs (percentage of production costs).

Other development goals:

- Population below US$ 1 a day (percentage of population).
- GDP per capita.
- Human development index.
- Life expectancy.

7. Potential water adaptation initiatives for investigation in phase 2

This report concludes with examples of possible key questions for analysis in a detailed SA country study in Phase 2 of this project. The first step in the second phase should be the elaboration of these questions and detailed planning of further analysis.

1. What role does climate change play in catchment basin management planning strategies?

As stated in section 3.3, significant transformations in the field of water resource management have taken place. More recently a number of catchment basin studies have been commissioned to investigate the climate change impacts on water availability and the adaptive capacity of the users (viz Berg river, Thukela Basin and the Breede River Valley). An investigation into these strategies should be conducted to establish which have resilience to the likely impacts from both short-term climate variability and long-term climate change while conforming with the long-term development goals of South Africa. Furthermore, the impact of climate change should be compared with other water demand/supply impacts to establish the priority that climate change should be given in this context. More specifically the future study could:

- investigate strategies for dealing with the impacts of climate variability and change on water resources;
- identify existing development goals and policy questions;
- identify options to address policy issues and will be compared with others;
- make recommendations based on the above made to relevant policy makers.
- deliver input to a global dialogue in the 'Development and climate project' on how international collaboration can enhance national implementation

2. What coping strategies have been adopted by vulnerable communities in times of climate variability, specifically drought?

An investigation into these strategies should be conducted to establish which strategies enable long-term resilience to climate change impacts by testing them against various future development scenarios. During the past 20 years, most of Africa has experienced extensive droughts, the last two (1986-88, 1991-92) being attributed to El Nino (Chenje & Johnson 1996). If the occurrence of drought became more frequent, the impact on water resources and, consequently, agriculture would be significant. Based on these projections, the most severe impacts are likely to occur along the western part of South Africa, where small towns and subsistence formers are most vulnerable. The available literature suggests that it would be prudent to account for climate change in water resource planning to meet the development objectives of South Africa.

With this in mind, an investigation of the adaptive capacity of small towns and communities in the Western and Northern Provinces to climate variability, specifically drought, would be of interest. By extrapolation of these strategies, planning policies for national and water resource planning and management would be developed to ensure water security against the impacts of climate change. Specifically the investigation would:

- show the relationship between the change in temperature and rainfall and available water resources in small towns in the Northern and Western Cape for the past 30-50 years;
- document existing coping strategies in times of climate variability (drought) in small towns in the Northern and Western Cape;
- propose long-term strategies for dealing with the impacts of predicted climate change in small towns in the Northern and Western Cape.

3. What role does the modification of the catchment vegetation play in climate change adaptation?

The Working for Water Programme was established in 1995 to address the invading aliens causing the loss of some 7% of the annual flow in South Africa's rivers each year. The programme has invested R1.6 billion into operations over the past seven years, aimed at gaining control of invasive plants, while at the same time providing employment for over 20 000 South Africans (DWAF 2003). According to DWAF (2002b), the programme aims to:

- Enhance water security.

- Improve the ecological integrity of natural systems.
- Restore the productive potential of the land.
- Invest in the most marginalized sectors in South Africa and enhance their quality of life through job creation.
- Develop economic benefits from wood, land, water and trained people.

It is estimated that the increase in runoff will be up to 3 500 kl per hectare per year (DWAF 1996). This study should investigate the climate change benefits and losses due to this initiative in terms of adaptation to reduction in water resources and carbon sequestration issues.

References

Basson, M, Van Niekerk, P & Van Rooyen, J 1997. Overview of Water Resources Availability and Utilisation in South Africa. Pretoria, Department of Water Affairs and Forestry.

Benioff, R, Guill, S & Lee, J 1996. Vulnerability and Adaptation Assessments. *An International Handbook*. Dordrecht, Kluwer Academic Publishers. Version 1.1.

Calitz, J M 2000a. Provincial population projections, 1996-2001: High HIV/AIDS impact. September. Johannesburg, Development Bank of Southern Africa.

Calitz, J M 2000b. Provincial population projections, 1996-2001: Low HIV/AIDS impact. August. Johannesburg, Development Bank of Southern Africa.

Chenje, M & Johnson, P (Eds) 1996. *Water in Southern Africa*. Harare, SADC Environment and Land Sector Coordination Unit.

DEAT 1999. National State of the Environment Report – South Africa, DEAT.

DWAF 1994. Water Supply and Sanitation Policy – White Paper. *Water – an indivisible national asset*. Cape Town.

DWAF 1996. The working for water programme annual report 1995/96. Pretoria, DWAF.

DWAF 1997a. Water Services Act.

DWAF 1997b. White paper on a National Water Policy for South Africa, DWAF.

DWAF 1998. The National Water Act.

DWAF 2002a. National Water Resource Strategy – Summary. *Proposed first edition*.

DWAF 2002b. The Working for Water Program. *Annual report 2001/02*. Cape Town, DWAF.

DWAF 2003. The Working for Water programme – Biennial Research Report 2001/02-2002/03, DWAF.

Goldblatt, M, Gelb, S & Davies, G 2002. Macroeconomics and sustainable development in Southern Africa. Development Bank of Southern Africa.

Hassan, R, Breen, C & Mirrilees, R 1996. Management of Water Resources and Emerging Water Policy Challenges in South Africa. The Economics, Policy & Natural Resource Management Southern Africa Workshop, Pretoria, 1996. IUCN.

Kasrils, R 2000. A water perspective on invasive species. The best management practices symposium, Kirstenbosch.

Kasrils, R 2002. Parliamentary Media Briefing, DWAF.

Kasrils, R 2003. Parliamentary Media Briefing, DWAF.

Kiker, G A 2000. Synthesis report for the vulnerability and adaptation assessment section: South African Country Study on Climate Change. Pretoria, Department of Environmental Affairs and Tourism.

Majola, B 2002. Highs and lows of state's delivery. *Mail & Guardian*. February 8-14**:** 10.

May, J (Ed) 1998. *Poverty and Inequality in South Africa*. Durban, Praxis.

Midgley, G F 2001. Biophysical impacts of climate change in South Africa. Cape Town, National Botanical Institute.

Midgley, G F 2003. Personal communication. National Botanical Institute. 13 May 2003.

NDA (National Department of Agriculture) 2000. Abstract of agricultural statistics. Pretoria. http://www.nda.agric.za/ see publications – statistics.

NDA 2002. Abstract of agricultural statistics. Pretoria.

NEPAD 2001. New Partnership for Africa's Development. October. www.gov.za/issues/nepad.htm.

SADC 2001a. Key Priorities for SADC. SADC Sub Regional consultations in preparation for the WSSD, Mauritius.

SADC 2001b. SADC Progress report on the implementation of agenda 21 and sustainable development. *A report submitted to the 2002 world Summit on sustainable development*. Maseru.

Schulze, R & Perks, L 2000. Assessment of the Impact of Climate Change on Hydrology and Water Resources in South Africa. ACRUcons report 33. Pietermaritzburg, School of Bioresources Engineering and Environmental Hydrology, University of Natal. January 2000.

SSA (Statistics South Africa) 2003. Key results: Census 2001. Pretoria. www.statssa.gov.za/SpecialProjects/Census2001/KeyResults/Key%20results.htm.

UCT (University of Cape Town) 2002. Options for a basic electricity support tariff: Analysis, issues and recommendations for the Department of Minerals & Energy and Eskom. Cape Town.

Warrick, R 2000. Strategies for vulnerability and adaptation assessment in the context of national communications. The 2nd AOSIS Workshop on Climate Change Negotiations, Samoa.

World Bank 2000. *World Development Report 2000/2001*. Oxford, Oxford University Press.

WRI (World Resources Institute) 1996. World Resources 1996-97. Washington D C, World Resources Institute.