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Natural resource accounts

Updated Water Accounts for South Africa: 2000

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Preface

This document[1] contains updated Water Accounts for South Africa for 2000 constructed according to the recommendations of the United Nations. The first water accounts for South Africa (in physical terms), Report No. 04-05-01 (2000), were published in 2004. The accounts are presented as a Satellite Account to the 1993 System of National Accounts. Satellite accounts provide a framework linked to the central accounts and enable attention to be focused on a certain field or aspect of economic and social life in the context of national accounts: examples are satellite accounts for the environment, tourism, or unpaid household work.

This document forms part of the work Statistics South Africa is currently doing on natural resource accounting (environmental economic accounting). Through initiatives such as this one, Statistics South Africa is collaborating with stakeholders to contribute to the principles of sustainable development.

[1] This document was developed in collaboration with the Centre for Environmental Economics and Policy in Africa and CIC International.

Contents

Abbreviations

A&S	atmosphere and sea
AR	annual recharge
AW	available water
CMA	catchment management agency
DWAF	Department of Water Affairs and Forestry
EAS	Economic Activity Survey
GDP	Gross Domestic Product
HP	harvest potential
IB	irrigation board
I-O	input-output
ISIC	International Standard Industrial Classification
ISP	Internal Strategic Perspective
IWRM	Integrated water resources management
MAR	mean annual runoff
NRA	natural resource accounting
NWA	National Water Act
NWP	National Water Policy
NWRS	National Water Resource Strategy
ROW	rest of the world
RSA	Republic of South Africa
SA	South Africa
SAM	Social Accounting Matrix
SAU	Standard Accounting Unit
SEEA	System of Integrated Environmental and Economic Accounts
SEEAW	Integrated Environmental and Economic Accounting for Water resources
SFRA	stream flow reduction activity
SIC	Standard Industrial Classification of all Economic Activities
SNA	System of National Accounts
Stats SA	Statistics South Africa
SUT	supply and use tables
SWY	surface water yield
TCTA	Trans Caledon Tunnel Authority
UN	United Nations
WB	water board
WCDM	water conservation and demand management

WDM	water demand management
WFA	water flow account
WfW	Working for Water
WMA	water management area
WRA	Water Resource Account
WRC	Water Research Commission
WRMC	water resource management charge
WRSA	Water Resources Situation Assessment
WSAM	Water Situation Assessment Model
WST	water supply table
WTA	Water Trading Account
WUA	water user association
WUT	water use table

1. Executive summary

The water sector in South Africa has been witnessing radical changes following from the National Water Act (NWA), (Act. No. 36 of 1998) introduced in 1998. The required reforms span almost all aspects of water management and allocation, including revolutionary changes in defining and granting rights to water, reorienting investment and allocation priorities and strategies to strongly pro-poor and environmentally sustainable approaches.

The changes are in line with global trends of natural resource management, as is demonstrated by the outputs of the Millennium Ecosystem Assessment. Humans, who are so reliant on natural resources, have made unprecedented changes to ecosystems in recent decades to meet growing demands for food, fresh water, fibre, and energy. These changes have helped improve the lives of billions, but at the same time have weakened nature's ability to deliver other key services such as purification of air and water, protection from disasters, and the provision of medicines. The loss of services derived from ecosystems is a significant barrier to economic development and the reduction of global poverty, hunger, and disease. Although modern technology and knowledge can reduce the human impact on ecosystems considerably, they are unlikely to be deployed fully until natural resources cease to be perceived as free and limitless, and their full value is taken into account. Better protection of natural assets will require coordinated efforts across all sections of governments, businesses, and international institutions. The productivity of ecosystems depends on policy choices on investment, trade, subsidy, taxation, and regulation, among others (World Resource Institute, 2005).

Water Resource Accounts provide an accounting framework that enables the integration of specialised physical resource sector data with other information on the economics of water supply and use in a structure that is consistent with the way data on economic activities are organised in the System of National Accounts. In addition to facilitating integration and sharing of a more comprehensive knowledge base, the natural resource accounting framework provides the basis for evaluating the consistency between the objectives and priorities of water resource management and broader goals of economic development planning and policy at national and local scales. This in turn improves the communication between various agencies generating and using information about water for various purposes and contributes to better coordination, packaging and analyses of such information that are more relevant to the needs of water managers and policy-makers in the country (Hassan and Crafford, 2006).

Water resource accounting in South Africa is of particular value to water authorities as it provides an initiative for improved water data collection, representation and interpretation; can assist with the National Water Act requirement of the establishment of a national water information system; and will provide valuable policy and other management information to South Africa's water allocation reform process.

The System of National Accounts constitutes the primary source of information about the South African economy. Updated Water Resource Accounts have now been developed to improve the measurement of the value of water for economic well-being and to monitor the interactions between the environment and economic activity. The System of National Accounts is an internationally agreed framework to measure the economic performance for a country. It therefore provides internationally comparable indicators, and it is the major source of information for national economic analysis and modelling. Thus, the integration of environmental information into this framework facilitates consideration of environmental issues into mainstream economic decision-making and the evaluation of the impacts of economic activity on the environment and of environmental policies on the economy.

However, the System of National Accounts has a number of shortcomings regarding the treatment of the environment. One of the shortcomings is the limited asset boundary which is assessed by the System of National Accounts and that fails to internalise natural assets such as natural forests, biodiversity and water resources. Another shortcoming is the failure of the System of National Accounts to evaluate the depletion (sustainable use) of natural resources. The United Nations and its counterparts (European Commission, International Monetary Fund, Organization for Economic Co-operation and Development, and the World Bank) have responded to this situation by developing an updated accounting framework. This discussion document reports on a WRA for South Africa, developed according to the principles of this accounting framework, the *Integrated Environmental and Economic Accounting for Water resources,* which is commonly referred to as the SEEAW.

In line with the Integrated Environmental and Economic Accounting for Water Resources, Flow and Asset Water Resource Accounts were developed for South Africa. Within these accounts, **physical accounts** present the physical flow of water resources (measured by volume), and **monetary accounts** convert the volumetric flow of water to economic values.

Although a Water Resource Account is compiled for evaluating macroeconomic policy, it is important to reflect spatial differences in water use and supply, and pressure on water resources. The distribution of rainfall over time has both seasonal and long-term temporal variations. Therefore accounts were developed as far as data allowed for individual water administration areas (in South Africa's case 19 water management areas) and for two years of analyses (1995 and 2000).

The United Nations framework for water resource accounting provided the basic structure for organising the South African water accounts. Key features of the physical and monetary components of water flow and asset accounts of the Integrated Environmental and Economic Accounting for Water Resources have been adapted for consistency with the principles of water management and policy mandate of the principal water management institutions in South Africa. At the same time physical and monetary data on water resources sourced from the Department of Water Affairs and Forestry and other water management agencies are reconciled with economic data available from the System of National Accounts to produce comprehensive integrated water resource accounts for the country. The adjustments made to the United Nations system were necessary for facilitating more effective integration of sources of key physical and monetary data on water resources in the country and better communication between those involved in water management and macroeconomic policy-making and development planning.

The **physical accounts** provide information on the volumetric supply and use of water. South Africa receives approximately 500 mm of rainfall per year. Calculated over the total surface area of South Africa, this equates to 611 billion m^3 of rainfall falling annually in South Africa. The bulk of this water is evaporated or used by the natural environment (transpiration) leaving 49 billion m^3 available to mean annual runoff. The usable yield of mean annual runoff is 13,2 billion m^3, comprising approximately 10,2 billion m^3 of surface water yield, 1,1 billion m^3 of groundwater yield and approximately 1,9 billion m^3 of return flows. These water yields are supplied through a complex distribution network of dams and transfer schemes. The following institutions constitute the water distribution system in South Africa: the Department of Water Affairs and Forestry, catchment management agencies, water boards, irrigation boards, water user associations, and municipalities. The water yield is used mainly by the agriculture sector (67%), most of which is used in irrigation (62%). Second to agriculture is domestic use (15%) followed by services (7%), manufacturing (5%) and mining (3%). Dryland agriculture and cultivated forests rely on soil water, and also impact on yield.

The **monetary accounts** provide a basket of measures that describe the economic and welfare impacts of water supply and use. It is important to clarify that water valuation was not attempted in this document. The valuation of water resources and their depletion remain controversial because of the fundamental importance of the resource for basic human needs and the lack of a real market for water.

This document was developed as a discussion document and is principally aimed at South African water management authorities: the Department of Water Affairs and Forestry, water boards and water user associations. The primary purpose of the document is to provide these authorities with a basis for discussion for the further functional development of Water Resource Accounts as a satellite account in the System of National Accounts. The document furthermore intends to provide all other interested parties, both nationally and internationally, with deeper insight into the availability and use of water resources in South Africa.

The target audience is of a diverse nature ranging from specialists in hydrology and economics to lay people with an interest in the South African water situation. It is therefore a secondary purpose of this document to clarify various hydrological and economic concepts, in order to facilitate discourse.

In South Africa in 2000, water contributed the highest share of intermediate input costs in the mining sector (more than 3%) followed by other trade and services sectors with the construction and manufacturing sectors showing the lowest share (less than 0,5%). On average, the share of water in total intermediate costs was slightly more than 1% for the national economy. Trade and services sectors paid the highest cost per unit water (R12/m^3) followed by the mining (R3,76/m^3), manufacturing (R1,58/m^3) and domestic use sectors (R1,19/m^3). On the other hand, agriculture paid the least (2,3 cents per m^3 of water used), while water used in power generation cost 50 cents per m^3 in 2000. While agriculture used the highest share of total water use it contributed only 3% of the national income. Conversely, trade and services used only 8% of the water to contribute about 70% of the total national income while manufacturing produced close to 20% of the total income and used only about 6% of the water. Consequently, trade and services had the highest GDP/m^3 indicator (R654) among all activities followed by manufacturing, mining and lastly agriculture (R3/m^3). The average national Gross Domestic Product indicator was R77/m^3 of water in 2000 (see Table 10).

Historically, the water pricing system for South Africa has hardly reflected any cost recovery. Under the 1998 National Water Act, water tariffs were to be increased to reflect the full financial cost of providing water services and the benefit of water to society. This new system is premised on equity and efficiency considerations and ecological and financial sustainability. Tariffs have therefore generally increased significantly since the late 1990s, reflecting the cost recovery pricing policy that was adopted through the 1998 National Water Act. Municipal authorities enjoyed a subsidy of 9,31 cents per m^3 of water distributed to domestic, commercial and industrial clients in 2002. The subsidy to municipalities averaged about 5% of the total expenditure and slightly over 6% of revenue collected from water sales between 2002 and 2004. The water sector as a whole received a subsidy of R93 million, equivalent to less than one cent per m^3 of water distributed during that year. Subsidies on bulk water supply decreased from 57% in 1998 to 35% of the total expenditure by bulk water supply programmes in the year 2000. Nevertheless, the financial subsidy on water services in South Africa amounted to about US$121 million in 2000. The water sector furthermore receives indirect financial subsidy through the Working for Water programme.

2. Introduction

Since the latter part of the 20th century, there has been a growing international realisation of the importance of environmental services to human welfare. These services include:

- The provision of raw materials and energy for the production of goods and services;
- The absorption of waste from human activities; and
- The provision of life support and other amenities (landscape).

The question therefore arises whether national endowments of natural resources are used sustainably. The United Nations (UN) have led the development of Integrated Environmental and Economic Accounting, which aims to develop natural resource-specific accounts as part of the System of National Accounts (SNA). A Water Resource Account (WRA) is therefore a satellite account of the national accounts (UN, 2005).

Data required for the development of WRAs are of a physical and monetary nature. The water authorities (and the Department of Water Affairs and Forestry (DWAF) in particular) responsible for the sustainable allocation, supply and management of water, generate and maintain various datasets of a physical nature, relevant to water management. Statistics South Africa (Stats SA) is the national custodian of economic data, and generates and maintains various datasets of a monetary nature which are relevant to water management. This document integrates available relevant water databases into the Integrated Environmental and Economic Accounting for Water resources (SEEAW) framework, conducts limited analyses of the resulting WRA and explores ways in which the WRA may be expanded as a satellite account useful to water authorities.

2.1 The water economy

Although relatively large quantities of water flow through the South African economy on an annual basis, only a limited amount of this water is available for human use and consumption.

Within this context, South Africa (SA) has challenging economic development goals which rely on water-intensive economic sectors such as agriculture, forestry, mining, energy production, manufacturing and many types of small, medium and micro-sized enterprises. Within these sectors, increased competition places pressure on water users to continue supplying their markets with competitively priced goods, while the rising cost of new water supplies puts pressure on water users to allocate sufficient water to their production processes. These market forces, and the relative scarcity of water as an economic production factor, affect financial viability and imply that the economic efficiency of water use becomes increasingly important.

A country's water economy can be described as either **expansionary** or **mature** (Gillit, 2004). An expansionary water economy is characterised by a relatively low social cost of water and an emphasis on water supply engineering projects. South Africa's water economy shows the typical characteristics of a mature water economy, which is characterised by:

- A high and growing demand for water;
- Intense competition for water between different sectors;
- Environmental externality problems;
- A price inelastic, long-run supply of impounded water; and
- Increasingly expensive water supply projects (Gillit, 2004).

Within the South African water economy therefore, water valuation is becoming ever more crucial for making informed water management decisions, and in particular for those related to the allocation of water to different uses. DWAF, CMAs, water boards (WBs) and water user associations (WUAs) are principally responsible for water management in SA. These authorities typically face many questions, for example: How much water should be allocated to agriculture for food and fibre production? How much should go to cities for final consumers and to industries? How much is needed for hydropower generation and instream uses? How much groundwater should be extracted versus how much surface water? How should the allocation process work? How much should the beneficiaries of water pay for water supply? (IEEA, 2003). WRAs can contribute valuable information to answering some of these questions.

2.2 The importance of Water Resource Accounts

Water resource accounting in SA is of particular value to water authorities for a number of reasons, these include:

- It provides an initiative for improved water data collection, representation and interpretation. The water data are of a physical (volumetric and quality parameters) and monetary nature, and may be sourced from databases at DWAF, Stats SA, WBs, and WUAs (irrigation boards and/or local government municipalities).
- The National Water Act (NWA) of 1998 requires the establishment of a national water information system, to which DWAF has responded by initiating an Information System Development Process (DWAF, 2004). A WRA provides an opportunity for formalising both physical and monetary water information systems.
- WRAs may provide valuable policy and other management information to SA's water allocation reform process, initiated through the NWA and increasing water scarcity in a number of priority areas. This information relates to the analysis and re-planning of administered water tariff structures and comparative analyses of economic costs and benefits related to water use.

3. Water policy and natural resource accounting in South Africa

3.1 Background to water policy and water resource accounting in South Africa

WRAs have to be aligned to water policy definitions and objectives in order to ensure its relevance.

Since the start of economic development in SA during the latter part of the 19th century, the country has faced water scarcity. Severe water scarcity in the fledgling mining town of Johannesburg for instance, forced pioneer Barney Barnato in 1887 to establish the Johannesburg Waterworks Company (Jackson, 1990). The development of the water sector and the supporting water policies have therefore always implicitly been linked with the solution of water scarcity problems. This has resulted in a water supply industry that is structurally well designed and well managed. However, water supply projects have become increasingly expensive and less feasible. The water sector in SA is also witnessing radical changes following from the new principles of the NWA to correct the biases and injustices of the past (pre-1994) and move toward more socially just, economically efficient and environmentally sound water management and allocation regimes and policies in the country. The required reforms, many of which are under way, span almost all aspects of water management and allocation, including revolutionary changes in defining and granting rights to water, reorienting investment and allocation priorities and strategies to strongly pro-poor and environmentally friendly approaches (Hassan, 2005).

The National Water Policy (NWP) adopted by Cabinet in 1997 established three fundamental objectives for managing water resources in SA: to achieve (a) equitable access to water, (b) sustainable use of water and (c) efficient and effective water use. Following directly from these objectives the NWA was drafted to be the principal legal instrument for implementing the objectives of the NWP (NWA, 1998). The key provisions and fundamental changes introduced by the NWA and their specific implications for water management are outlined below (following from Hassan, 2005).

3.1.1 Transforming legal access and rights to water

Prior to 1994, access to water for productive purposes was linked to ownership of land, which was determined on racial basis according to the 1913 Land Act. Under the old Water Act of 1956, private rights were given to land owners to use water from ground and surface sources on or next to their land. Consequently, the racial biases of the previous apartheid system of land ownership have automatically transmitted serious inequities in access to water, where private rights to water use concentrated in the hands of a minority group of the population who owned land. The state had limited control over these private riparian rights. Under the new NWA (the NWA of 1998) ownership of water resources has been nationalised (water considered a national asset) and consequently all private rights to water were repealed.

3.1.2 Ensuring provision of water for basic human needs and protection of aquatic ecosystems

The only water right guaranteed under the 1998 NWA is the right to water required to meet basic human needs[2] and sustain aquatic ecosystems (the reserve). Water use for all other purposes is then authorised and licensed according to the various rules ensuring protection, conservation, development and management of water for the highest social and economic benefit to all people and the environment with special pro-poor provisions. The NWA ensures that the amount of water required for basic human needs and ecosystem health is 'reserved' or set aside before water resources can be allocated to other water users.

3.1.3 Decentralising water management through more enabling institutions

The NWA aims to move away from the previous centralised system of water management to a more democratic system of participatory governance which decentralises responsibility for and authority over managing water resources. Therefore DWAF aims to play an enabling water management role as opposed to an implementation role.

3.1.4 Adopting integrated water resources management

Integrated water resources management (IWRM) requires that the complex interactions among the various elements of the hydrological cycle (rivers, groundwater, wetlands, and estuaries) and between freshwater systems and the surrounding biophysical and socio-economic environments be carefully taken into account in managing and use of water resources in the country. This has important implications for policies and rules governing the use and allocation of the various sources of water for all purposes.

3.1.5 Pricing for financial and environmental sustainability, economic efficiency and social equity

Following the directives of the NWA, a national water pricing strategy has been established (DWAF, 1999) to set various water use charges to:

- Fund costs associated with managing the quality and quantity of water resources.
- Fund costs associated with development and operating of water supply schemes.

[2] Basic human needs are referred to in the NWRS to include water for drinking, food preparation and personal hygiene (DWAF, 2004a).

The purpose of establishing the above water charges is to:

- Ensure the financial sustainability of water supply utilities and management institutions through full cost recovery;
- Minimise harmful impacts on water resources (managing pollution and discharging of wastewater for ecological sustainability);
- Promote efficient and beneficial use and prevent wastage of water; and
- Achieve the objectives of social equity in water use through differential charging schemes for different user categories subsidising the poor and previously disadvantaged.

3.1.6 Refocus on water conservation and demand management

Water conservation and demand management (WCDM) aims at improving the efficiency with which water is currently used and minimising loss and wastage of water. SA had in the past relied on supply-side strategies to balance water availability and requirements through the development of additional physical infrastructures to augment sources of water supply.

3.1.7 The National Water Resource Strategy

In pursuit of the above objectives of the NWP and NWA, DWAF has developed a National Water Resource Strategy (NWRS), which sets out objectives, strategies and procedures for efficient, equitable and sustainable management of water resources in the country (DWAF, 2004). The NWRS provides comprehensive information about how to balance current and future availability of and requirements for water and how water resources are to be managed and what institutions need to be established to undertake the various management tasks. One important role of the NWRS is to establish priorities for water use and accordingly define the proportions of total water available in each of the water management areas (WMAs) that fall under the direct control of DWAF. Priority uses are currently specified to include (DWAF, 2004):

- The reserve, defining basic human needs and ecological water requirements;
- Water required for compliance with international rights and obligations;
- Water use for strategic importance, such as power generation;
- Inter-catchment water transfers from surplus to deficit WMAs; and
- Water for projected future needs.

After allocations are made for all the above in the NWRS (national responsibility), all other uses of water are to be authorised by the respective regional and local water management institutions (catchment management agencies (CMAs) and WUAs) in the various WMAs.

3.2 Natural resource accounting

Natural resource accounting provides the basis for evaluating the consistency between the objectives and priorities of water resource management and broader goals of economic development planning and policy at national and local scales. In addition, the natural resource accounting (NRA) framework enables the integration of specialised physical resource sector data with other information on the economics of water supply and use in a structure that is consistent with the way data on economic activities are organised in the System of National Accounts (SNA). This in turn improves the communication between various agencies generating and using information about water for various purposes and contributes to better coordination, packaging and analyses of such information that are more relevant to the needs of water managers and policy makers in the country.

The NWA further calls for the establishment of a national water information system to which DWAF has responded by initiating an Information System Development Process (DWAF, 2004). NRA has the potential to contribute to formalising such an information system that has direct correspondence to the SNA (Hassan, 2005).

4. Methodology and data

4.1 SNA and SEEAW guidelines

The UN and its counterparts (European Commission, International Monetary Fund, Organization for Economic Co-operation and Development, and the World Bank) have developed a guideline entitled *Integrated Environmental and Economic Accounting for Water Resources*, which is commonly referred to as the SEEAW. The guideline, which is currently in draft form, proposes a common framework for presenting and analysing economic and environmental information in order to assess environmental contribution to the economy (UN, 2005).

The SEEAW has been designed to link economic information contained in the SNA with hydrological information in order to provide for integrated analysis. The SNA only includes water transactions that describe the physical use of water by economic sector; and in exceptional cases, groundwater assets, which are of such scarcity, that use rights and/or market valuation are enforced. The SEEAW considerably broadens the asset boundary to include all water assets, their quality and the produced assets (dams, reservoirs, transfer schemes) used for mobilising water resources.

The guidelines define water resources to include both direct use (basic human needs and production) and non-use benefits (ecosystems functioning). This implies that the SEEAW asset category includes all the water resources, which can be extracted in the current accounting period (direct use benefits) or might be of use in the future (option benefits) (UN, 2005).

Exchanges of water between the environment and the economy include mostly direct abstraction and returns of water to ground and surface water. The passive uses of water by the economy which do not involve direct abstraction, such as recreation or transportation, are not considered.

The SNA makes use of the International Standard Industrial Classification (ISIC) to classify economic role players. Within the ISIC, a number of activities are defined to relate to water supply. These include: operation of irrigation systems (ISIC 0140); collection, purification and distribution of water (ISIC 4100); transport via pipelines (ISIC 6030); public administration of water (ISIC 7512); and sewerage and refuse disposal, sanitation and similar activities (ISIC 9000). In addition, virtually all economic activities are users of water. The SEEAW is designed to fit into this framework.

The SEEAW specifically proposes the development of flow and asset water resource accounts. Within these accounts, **physical accounts** present the physical flow of water resources (measured by volume), and **monetary accounts** convert the volumetric flow of water to economic values.

4.1.1 Flow accounts

The SNA is essentially based on supply and use tables (SUTs) which detail, in matrix format, the supply and use of goods and services in an economy for a particular accounting period. The SEEAW therefore uses SUTs as a point of departure. **Physical water SUTs** are constructed. These tables are of a physical nature as they express transactions in volumetric terms (cubic metre), and describe the flow of water both within and between the environmental asset sector (which is not part of the conventional SNA) and the economy.

Additional physical information may be added through the construction of **water emission accounts**. These tables indicate the amount and nature of water pollutants (emissions) released by industry, households and government with or without treatment.

The **monetary accounts** are the financial counterparts of the physical accounts. The monetary accounts report on the financial transactions associated with the physical accounts. For the most part, these do not represent the value of water exchanged, but rather the cost or value associated with the service provided by the supplying industry. Economic transactions such as water taxes, subsidies and costs associated with water rights form part of the monetary accounts. Furthermore, environmental protection expenditures to avoid environmental degradation associated with water, form part of the monetary accounts.

4.1.2 Asset accounts

Asset accounts measure stock levels at the beginning and end of an accounting period, and evaluate the changes in stock over the period. Three asset classes exist: produced assets (water supply and treatment infrastructure), volumetric water resource assets (the volume of water available in surface water and groundwater reservoirs and run-of-river availability), and water quality.

Although asset accounts can be compiled in both a physical and monetary format, it is more common to express them only in physical units. This is because water very rarely has a positive economic value as it is provided at administered prices which reflect the social nature of water rather than the actual cost of services.

4.1.3 Spatial considerations

Although WRAs are compiled for evaluating macroeconomic policy, it is important to reflect spatial differences in water use and supply; and pressure on water resources. National level WRAs can therefore be supported by the development of accounts for administrative regions or river basins within a country. In SA, WMAs are the key administrative regions.

4.1.4 Temporal considerations

The distribution of rainfall over time has both seasonal and long-term variations. As the accounting period for the SNA is 12 months, regular WRA reporting is required to reflect changes in hydrological patterns, and water supply and use.

4.2 Adapting the SEEAW principles to WRAs for South Africa

The UN framework for water resource accounting provided the basic structure for organising the water accounts for SA. This section describes how key features of the physical and monetary components of water flow and asset accounts of the SEEAW have been adapted for consistency with the principles of water management and policy mandate of the principal water management institutions in SA. The section also discusses how physical and monetary data on water resources sourced from DWAF and other water management agencies are reconciled with economic data available from the SNA to produce comprehensive integrated water resource accounts for the country. The adjustments made to the UN system were necessary for facilitating more effective integration of sources of key physical and monetary data on water resources in the country and better communication between those involved in water management and macroeconomic policy-making and development planning.

4.2.1 Water flow accounts for South Africa

These represent the core of the SEEAW, which is structured essentially as water SUTs that are consistent with the ISIC of the monetary SUTs of the SNA. The following key features of the SEEAW needed some modifications to be consistent with the way water resources are managed and data on water supply and allocation are organised and used by principal water management agencies in SA.

a. The economic focus

The water SUTs of the SEEAW focus on water flows between the economic system and the environment and flows within the economy (between economic units). Accordingly, the water use table (WUT) is divided into two parts, one tracing flows of water from the environment (source) to the economy (abstraction by industry and households) and the other recording flows of water within the economy (supplied by other economic units and the rest of the world). Similarly, the water supply table (WST) comprises two parts, one tracing flows leaving an economic unit supplied to other units within the economy (water distribution by economic units to other industries, households and the rest of the world) and the other describing flows leaving an economic unit back to the environment (return flows).

In this structure water flows occurring exclusively within the environment (i.e. between the atmosphere, surface and subsurface sources of natural water supply such as contribution of precipitation and seepage to surface and groundwater and direct losses-evaporation from water sources to the atmosphere) are not explicitly included as integral components of the SUTs. Moreover, since the primary focus of the SEEAW is on economic abstraction, storage and release of dam water is considered part of the hydrological cycle and not an economic activity due to the difficulty with separating discharge for direct economic use from releases to manage water flow and regulate runoff during floods and dry seasons.

DWAF bases its water supply and allocation decisions and strategic plans on effective management of the water system on *yield*. Total water *yield* is defined by DWAF to be the total volume of water that can be abstracted at a relatively constant rate (assured with no failure) over a specified period of time, i.e. years (usually 49 out of every 50 years). To ensure a reliable supply of water to meet the fairly constant demand throughout the year and at different locations by all sectors (with the exception of seasonal agricultural activities); DWAF regulates the highly fluctuating stream flows in SA. This is achieved through storage in dams (to manage temporal fluctuations in supply) and transfers from other locations within the country (WMAs) and from the rest of the world (ROW) (see Appendix 3 for a detailed description of the water *yield* concept as used by DWAF). This necessitated modifying the SEEAW to capture explicitly key water flows within the environment that is the target of strategic water management in SA and are consequently directly influenced by DWAF decisions and actions.

b. In-situ (passive) water requirements

While these are not explicitly included in the SEEAW as they do not involve removal of water from the environment, the NWRS gives human needs and protection of aquatic ecosystems a priority in water allocation. While water required to meet basic human needs must be abstracted and delivered, water reserved for ecological purposes is left in-situ to satisfy instream flow requirements for the protection of ecosystems. This however, has direct implications for water *yield* available for distribution to other uses, and forms a critical component of the water resources management mandate of DWAF.

Water use has further been redefined in the NWRS to distinguish between categories of uses depending on the nature of use and the magnitude of their impact on the quantity and quality of the water resource. An important member of this new family of water users is plantation forestry added as stream flow reduction activity[3] (SFRA).

While the adapted water accounting framework retained the same convention of partitioning SUTs by their two key components of *within the environment* and *between the environment*

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[3] Other types of use that were added include using water for recreation, using water to dispose of waste, storing water, changing the physical structure of rivers and streams and removing underground water (NWRS, 2004). While these uses did not require registration and licensing in the past they are now subject to all provisions and regulations of the NWRS as well defined water-using activities.

and economy, the tables describing water flows have been adapted to integrate the environment as a source and user of water resources in SA. Sectors included within the environmental sphere to represent important processes influenced by key elements of water management policies and strategies in SA are:

- *The atmosphere and sea (A&S)*, which are the source of all inland fresh water resources and the ultimate repository to which all used and non-used water return;
- *The natural mean annual runoff (MAR)*, receiving water from A&S and storage augmentation and redistributes to surface water and return flows back to A&S;
- *Surface water yield,* collecting from MAR and redistributing to available *yield*, ecological reserve and SFRA, i.e. plantation forestry;
- *Groundwater,* sources replenished by A&S and contributing to available *yield;*
- *Soil water,* collecting precipitation from A&S to support evapotranspiration activities through natural and cultivated agriculture;
- *The ecological reserve*, which refers to water kept instream for maintenance of freshwater ecosystems.

Considering the environment as an integral component of the water system led to two distinct definitions of water consumption. As all water originating from within the entire system (including the environment component) is returned back to the system, water can only be lost from the system boundaries (spatial accounting territory) through exports to the ROW, and consequently consumption of the whole system is measured as net imports (water imported from other countries minus water exported outside the country). On the other hand, *economic consumption* is defined to represent water removed and made unavailable for distribution during the current accounting period due to economic activity (including managing water flows within the environment such as storage and transfers).

4.2.2 Water asset accounts for South Africa

Produced assets (dams, reservoirs and transfer schemes) may be valued either based on its book/depreciated value or its replacement value. **Volumetric water resource stocks** are not managed according to opening stock/closing stock principles in SA. DWAF rather manages water supply from its system of dams, reservoirs and transfer schemes according to the amount of water that can be yielded from the supply system over a long hydrological period. **Water quality** accounts reflect the change in water quality over the accounting period. Since it is complex to link changes in water quality to the causes that affect it, and environmental assets such as the impact of wetlands on water quality, it is a complex account to construct.

Therefore, given the nature of water assets intrinsic in their high spatial and temporal mobility and the typical difficulty with obtaining detailed information on components of the UN SEEAW, this study used a simplified version of asset accounting, following the Australian practice of *pathways analyses* adopted in earlier water resource accounting exercises in South Africa (CSIR, 2001).

4.2.3 Spatial considerations for South Africa

Spatial variance in water supply and use was evaluated by constructing flow accounts per WMA, which are water administration areas constituted under the NWA.

4.2.4 Temporal considerations for South Africa

A WRA was developed for 2000. Additionally a WRA was constructed for 1995 to analyse temporal variances.

4.2.5 Adopted approach for compiling flow and asset accounts for South Africa

The WRA was developed according to the following procedure:

- An input-output (I-O) matrix was developed as the first step of the accounting procedure. The I-O matrix describes the supply and use water transactions in one table, and therefore provides the non-economic audience with easier interpretation of water flows within an economic framework. Furthermore, the I-O matrix prevented double accounting during the interpretation and application of complex hydrological numbers within the WRA.
- Using the SEEAW as guideline, the I-O framework was developed to be consistent with the definitions of the NWA and NWRS. These documents report on water supply and use within sectors that are not consistently defined with the ISIC (see section 4.3). Stats SA uses the Standard Industrial Classification of all Economic Activities (SIC) which is based upon the ISIC with suitable adaptations for local conditions.
- An I-O WRA was developed for each of the 19 WMAs for the accounting years 1995 and 2000. These datasets therefore provided spatial information on water supply and use.
- The individual WMA I-O WRAs were aggregated to produce national WRA I-O matrixes for 1995 and 2000. Some macroeconomic adjustments were made to the national I-O table to ensure consistency with SEEAW guidelines.
- The national I-O WRAs were converted to the adjusted UN SUT format described in the paragraph above (see section 4.3 for a detailed description).

4.3 Reconciling DWAF physical data with national accounts economic data

Water use and supply sectors are classified differently from the ISIC by water management authorities. This is due principally to the policy and management goals that are unique to water management in SA, and the definitions inherent to the discipline of hydrology. This in turn leads to important differences between the way information on water supply and use is organised for DWAF planning purposes and how information on economic activity is structured in the SNA. To establish a direct link between databases utilised by DWAF and the SNA, the following differences have been reconciled in constructing the water resource accounts for the country:

The NWRS definition of water *yiel*d excludes all activities directly abstracting rainfall water if they do not result in stream flow reduction, i.e. if they have no effect on *yield* over natural vegetation (see Appendix 3 for the definition of water *yield* in the NWRS). This type of water use includes all dryland farming activities except cultivated forest plantations, which have been formally recognised in the water policy as a SFRA. Water use by dryland agriculture however, generates economic benefits (income and employment) recorded in the SNA. Dryland agriculture has therefore been added to water use sectors to reconcile the NWRS with the SNA.

Water users are aggregated in the NWRS to correspond to particular categories according to how water is supplied to these users. The following classification of water users is therefore adopted by NWRS:

- Irrigation agriculture to which water is delivered by irrigation boards (IBs);
- Mining and other industries directly abstracting or receiving bulk water supply from WBs;
- Power generation also using bulk water as ‘use of strategic importance’;
- Municipal water users, which include all urban-based industries, services and domestic users;

- Afforestation (cultivated plantations) as SFRA;
- Rural users, which mainly include estimates of water requirements for basic human needs and stock watering in rural areas; and
- Transfers of water outside the accounting boundary area.

While this classification of users was maintained for construction of the physical supply and use and input-output tables for DWAF purposes, they have been further disaggregated by key economic activities following the ISIC adopted by the SNA, especially in constructing the monetary flow accounts. Currently, the NWRS also does not provide information on abstraction for own use by self-providers. Again, because of the implications of this factor for important monetary aspects of water supply and use in key economic sectors such as mining and irrigation agriculture, this study made an attempt to augment the NWRS to include such information particularly in the monetary accounts.

4.4 Data

Based on physical and monetary data availability, a WRA for the year 2000 was developed for SA. An additional physical account was also developed for 1995, to enable comparative analysis with the 2000 physical account.

The following data sources were used to construct the SA physical water accounts:

4.4.1 Physical data

- The Water Resources Situation Assessment (WRSA) that was conducted by DWAF for 1995 (DWAF, 2003). The data were compiled by various consultants to define in great detail water supply and demand situations in the 19 WMAs and published as 19 WRSA reports. These reports provided the key source of information used to construct physical water flow accounts for the 19 WMAs, based on which national physical water accounts were developed for 1995.
- The NWRS, which provided water supply and demand data for every WMA for the year 2000. The data were based on outputs of the Water Situation Assessment Model (WSAM), developed by DWAF since the late 1990s (DWAF, 2004a). The NWRS data used to construct the 2000 water accounts provided less detail than the 1995 dataset. DWAF also published a set of Internal Strategic Perspective (ISP) reports for each of the 19 WMAs. These reports updated the NWRS figures, based on specialist studies, and provided data for the year 2003. These data were not used as they were post-2000 data (DWAF, 2004b).

Data from the above sources come from DWAF efforts in studying water supply and use over many years, leading to the development of comprehensive databases essentially generated from complex hydrological models which used inputs from metered time-series data from weather stations, dams and weirs. These data are presented with statistical probabilities of supply and allocation of water, based on a 1:50 year assurance. This basically means that bulk water is allocated by DWAF based on the principle that its availability can be guaranteed for 49 out of every 50 years (Stoffberg, 2005).

Data on the environment sphere (natural sources of supply) of the accounts (*MAR, Surface Yield, Groundwater, Ecological Use and Water Balance*) were sourced from DWAF 2000 NWRS. Total **precipitation** (water received from the atmosphere) was calculated using a simple formula, which multiplied average annual precipitation (500mm/a) with the total surface area in SA. **Soil water use**, as defined in the SEEAW, is not a DWAF standard accounting unit (SAU) category and was therefore calculated. Soil water use refers to the use of water stored within the root zone of plants. Dryland agriculture, irrigated agriculture and plantation forestry are examples of commercial activities using soil water. A simple method was used to calculate soil water use. Planted area data obtained from the 2000

Agricultural Census for all the major agricultural crops in South Africa (NDA, 2001) were combined with average transpiration data for these crops from earlier work (CSIR, 2001) to calculate soil water use (see Appendix 2). A similar calculation was carried for water use by plantation forestry, based on earlier work done for the Water Research Commission (WRC) (Crafford et al, 2004). The resultant numbers however, will not reflect the 1:50 assurance, and must therefore be treated as demonstrative values only and need further refinement.

4.4.2 Monetary data

Data used for compiling monetary flow accounts for SA were mainly sourced from Stats SA national accounts (mainly Stats SA 2000 SUTs) and accounts were therefore only constructed at national level due to a lack of similar economic data at WMA level. The geographical boundaries of the 19 WMAs do not correspond to geographical accounting units of Stats SA (provinces or municipalities) and therefore no economic datasets were available to construct monetary accounts per WMA.

Other sources including data on tariffs from DWAF and unpublished surveys (Hassan, 2005) have also been used to complement the Stats SA information on economic activity.

5. Physical water flow accounts for South Africa

Water SUTs for SA were constructed for the years 1995 and 2000 using an adapted structure of the UN SEEAW as discussed earlier. I-O tables were constructed at WMA level and aggregated into a national I-O table for water supply and use in 1995 and 2000. These tables were then converted to national SUTs for 1995 and 2000.

In addition to the data availability discussed above, the choice of the 1995 to 2000 interval coincides with the current practice within DWAF to update strategic water management plans and databases at 5-year intervals starting from the NWRS for 2000. Due to a number of important changes in the water policy recently introduced, many aspects of water management in SA have changed between 1995 and 2000. This included new definitions and treatment of key elements of water supply and use, such as the concept of ecological reserve among others. This has led to notable variations between the numbers reported for the two calendar years and to a large extent made the two sets of accounts not directly comparable. As a result, the current analysis focuses on presenting detailed discussions of the 2000 accounts.

5.1 Natural sources of water supply

Natural sources of water supply are the sectors included in the environmental sphere of the WRAs. Table 1 gives a summary of water flows from (supply) and to (use by) natural sources (the environment). The table shows six natural sources (and sinks) of water. Table 7 shows that, of the 611 600 million m^3 of rainfall falling annually in SA, the *atmosphere* constitutes a total of 105 528 million m^3 (17%) available for runoff, groundwater and soil water. The rest of falling precipitation (506 072 million m^3) is directly evaporated or used by natural vegetation (evapotranspiration) and never reaches the rivers. The natural system supplies 49 040 million m^3 to *MAR*, about 60% (see Tables 1 (Use table) and 7), of which 29 683 million m^3 is retained within the environmental sphere supporting the base flow[4] and other leakages and losses. The remaining 40% (19 357 million m^3) is delivered to *surface water* yield (see Tables 1 and 7). About 51% of the *surface water* is directly abstracted by cultivated forest plantation (428 million m^3) and retained instream as the *ecological reserve* (9 545 million m^3) (see Table 1 (Supply table)). The remaining 49% (9 384 million m^3) of *surface water flows* constitutes the total *water yield* available for DWAF to distribute as bulk water supply to the economic system (see Table 7). *Available water yield* is then augmented from *groundwater*

4 The base flow is the groundwater component of river flow (see later section on groundwater resource accounts).

sources, which supply 1 088 million m^3. Water received from the *atmosphere* by *soil water* (55 400 million m^3) is made available for direct use by dryland agriculture (45 000 million m^3 or 81%) and forest plantations (10 400 million m^3 or 19%) (see Table 1 (Supply table)). The *ecological reserve* water is supplied back to the original *atmosphere and sea* source.

Table 1 (Use table) shows that water in *atmosphere and sea sources* is replenished by return flows from within the environment (evaporation of MAR and retained ecological reserve), the *balance* (surpluses) of *available water yield* not distributed by DWAF (186 million m^3) and residuals from production sectors (65 944 million m^3).

Table 1: Natural sources of water in South Africa, 2000 (million m^3)

			Supply table	**Environment: Atmosphere and sea**	**Environment: Natural MAR**	**Environment: Surface water yield**	**Environment: Groundwater**	**Environment: Soil water**	**Environment: Ecological reserve**
To the environment	S1		**Total water returned (D1 + D2)**	**105 528**	**49 040**	**9 545**	**0**	**0**	**9 545**
		D1	***To water sources***	***105 528***	***49 040***	***9 545***	***0***	***0***	***9 545***
			Atmosphere and sea (evaporation and losses)		29 683				9 545
			Evapotranspiration						
			MAR (including storage)	49 040					
			Groundwater	1 088					
			Surface water (including reserve)		19 357				
			Soil water	55 400					
			Ecological reserve			9 545			
		D2	***To other sources***	***0***	***0***	***0***	***0***	***0***	***0***
			Balance (to atmosphere or lower reserve)	0	0	0	0	0	0
To economic activities	S2		**Supply of water to other economic units**	**0**	**0**	**10 240**	**1 088**	**55 400**	**0**
			Of which:						
			Desalinated						
			Reused						
			Waste water to sewerage						
			To distribution (bulk yield available):			***9 812***	***1 088***	***0***	
			DWAF (available total yield)			9 812	1 088		
			Irrigation boards						
			Water boards						
			Municipalities						
			ROW and other WMAs						
			To direct use by:	***0***	***0***	***428***	***0***	***55 400***	***0***
			Agriculture – irrigation						
			Agriculture – dryland crops (excl forestry)					45 000	
			Agriculture – livestock and game						
			Agriculture – plantation forestry			428		10 400	
			Mining						
			Hydroelectric power						
			Other bulk: industrial						
			Other commercial and industrial						
			Domestic – urban						
			Domestic – rural						
		C1	Hydroelectric power						
		C2	Mine water						
		C3	Urban runoff						
		C4	Losses in distribution (leakages, etc.)						
Total supply of water (S1 + S2)				**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**

Table 1: Natural sources of water in South Africa, 2000 (million m^3) (concluded)

			Use table	Environment					
				Atmosphere and sea	**Natural MAR**	**Surface water yield**	**Groundwater**	**Soil water**	**Ecological reserve**
From the environment	U1		**Total abstraction**	**39 398**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**
		B1	***Abstraction for own use***						
			Hydroelectric power						
			Mine water						
			Urban runoff						
			Other						
		A1 B2	***Abstraction for distribution***						
			From water resources	***39 398***	***49 040***	***19 785***	***1 088***	***55 400***	***9 545***
			Atmosphere and sea (evaporation – losses)		49 040		1 088	55 400	
			MAR (including storage)	29 683		19 785			
			Groundwater						
			Surface water (including reserve)						9 545
			Soil water						
			Ecological reserve	9 545					
			Transfers in (ROW)	170					
		A2	***From other sources***	***0***	***0***	***0***	***0***	***0***	***0***
			Direct rain harvesting						
			Abstraction from sea						
From economic activities	U2		**Use of water supplied by other industries**	**66 130**	**0**	**0**	**0**	**0**	**0**
			Supplied by distribution sectors	***186***	***0***	***0***	***0***	***0***	***0***
			DWAF	186					
			Irrigation boards						
			Water boards						
			Municipalities						
			Supplied by other sectors	***65 944***	***0***	***0***	***0***	***0***	***0***
			Evapotranspiration	55 400					
			Losses – evaporation	10 544					
			Return flows						
			Effluent						
Total water use (U1 + U2)				**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**

5.2 Institutional sources of supply (water distribution sectors)

The water distribution network in SA is quite complex and is presently undergoing major changes emanating from the process of implementing the NWA. The following institutions constituted the water distribution system in South Africa in the past and are currently being transformed under the NWA:

- ***DWAF***, which regulates and manages supply and allocation of bulk raw water from surface and groundwater *yield* (including large water supply projects such as dams and inter-basin water transfer schemes). DWAF continues to assume this role with plans to transfer its responsibilities for water yield management to CMAs over the next decade as the decentralisation of water management proceeds under the NWA. While no CMAs are currently operational, they are being established to eventually manage water resources within each of the 19 WMAs.
- ***WBs***, which facilitate bulk water supply and management in specific areas within the country. WBs distribute water to municipalities and bulk water users such as mines, power generation and heavy industry (Other Bulk Use).
- ***IBs***, which receive bulk water from DWAF for distribution to irrigators.

- Irrigation and water boards and other communities of water users will, over the next decade, be constituted into ***WUAs***, which are currently being established under the NWA.
- ***Municipalities*** (local authorities and district councils) purchase water from DWAF or respective water boards and supplement that with their own sources such as municipal storage dams and groundwater supplies for distribution to end users (households, industries and commercial establishments) in towns and municipal areas under their jurisdiction.

SA has 50 IBs, 12 WBs and 283 municipalities. In addition to the above institutions, the water resource accounts for South Africa added one more water distribution activity transferring water in and out the boundaries of the specific WMA and the country. This activity is referred to as the ROW, which means other countries and/or other WMAs. While water transfers are managed by DWAF, this activity was added as a separate distribution sector to the Trans Caledon Tunnel Authority (TCTA), WBs and some municipalities.

Due to the complex nature of water distribution transactions between various water distribution sectors, economic activities and disposal of residual or unused water into the environment, and inadequacy of available data, a number of assumptions were made in compiling the WRA for the year 2000.

Because no CMA is currently operational, it is assumed that water is allocated by DWAF in its bulk raw form within the 19 WMAs. Similarly because WUAs have not yet been established, DWAF is considered to supply water to IBs, WBs, municipalities, and in some instances directly to users, through a large number of water supply schemes. However, in many instances IBs, WBs and municipalities extract water directly from rivers outside of DWAF water supply schemes. Nevertheless, in such instances it is assumed that the water is still allocated by DWAF. In other words, that irrigation and water boards receive all their water from DWAF. It is also assumed that IBs supply all irrigation water and those municipalities receive all their water from WBs and DWAF, and supply this to domestic, commercial and industrial users. Another important assumption is that effluent and other return flows from production sectors are supplied to municipalities that treat and process these and supply the treated effluent water to *available water yield* managed by DWAF.

It is clear from Table 2 (Use table) that SA is highly dependent on surface water (supplying 77% (9 812 million m^3)) of the total *water yield* managed by DWAF), followed by treated effluent processed and supplied to DWAF by groundwater and municipal authorities, each contributing 9% (1 088 million m^3) and 10% (1 233 million m^3). Return flows from irrigation agriculture contributed another 5% (676 million m^3) share of *available yield* in 2000. As mentioned earlier, irrigation and water boards receive all their water from DWAF, whereas the bulk (69% or 3 042 million m^3) of municipal water is received from water boards.

Table 2: Institutional sources of water in South Africa, 2000 (million m³)

			Supply table	Distribution: DWAF (total yield)	Distribution: ROW and other WMAs	Distribution: Irrigation boards	Distribution: Water boards	Distribution: Municipalities
To the environment	S1		**Total water returned**	**186**	**0**	**0**	**0**	**0**
		D1	***To water sources***	***0***	***0***	***0***	***0***	***0***
			Atmosphere and sea (evaporation – losses)					
			Evapotranspiration					
			MAR (including storage)					
			Groundwater					
			Surface water (including reserve)					
			Soil water					
			Ecological reserve					
		D2	***To other sources***	***186***	***0***	***0***	***0***	***0***
			Balance (to atmosphere or lower reserve)	186				
To economic activities	S2		**Supply of water to other economic units**	**12 613**	**0**	**7 920**	**4 094**	**4 381**
			Of which:					
			Desalinated					
			Reused					
			Waste water to sewage					
			To distribution (bulk yield available)	***12 300***	***0***	***0***	***3 042***	***1 223***
			DWAF (available total yield)		0			1 223
			Irrigation boards	7 920				
			Water boards	4 094				
			Municipalities	116			3 042	
			ROW and other WMAs	170				
			To direct use by	***313***	***0***	***7 920***	***1 052***	***3 158***
			Agriculture – irrigation			7 920		
			Agriculture – dryland crops (excl forestry)					
			Agriculture – livestock and game	313				
			Agriculture – plantation forestry					
			Mining				388	
			Hydroelectric power				297	
			Other bulk: industrial				367	
			Other commercial and industrial					1 199
			Domestic – urban					1 698
			Domestic – rural					261
		C1	Hydroelectric power					
		C2	Mine water					
		C3	Urban runoff					
		C4	Losses in distribution (leakages, etc.)					
Total supply of water (S1 + S2)				**12 799**	**0**	**7 920**	**4 094**	**4 381**

Table 2: Institutional sources of water in South Africa, 2000 (million m^3) (concluded)

			Use table	Distribution				
				DWAF (total yield)	**ROW and other WMAs**	**Irrigation boards**	**Water boards**	**Municipalities**
From the environment	U1		**Total abstraction**	**10 900**	**0**	**0**	**0**	**0**
		B1	***Abstraction for own use***					
			Hydroelectric power					
			Mine water					
			Urban runoff					
			Other					
			Abstraction for distribution					
		A1 B2	***From water resources***	***10 900***	***0***	***0***	***0***	***0***
			Atmosphere and sea (evaporation – losses)					
			MAR (including storage)					
			Groundwater	1 088				
			Surface water (including reserve)	9 812				
			Soil water					
			Ecological reserve					
			Transfers in (ROW)	0				
		A2	***From other sources***	***0***	***0***	***0***	***0***	***0***
			Direct rain harvesting					
			Abstraction from sea					
From economic activities	U2		**Use of water supplied by other industries**	**1 899**	**170**	**7 920**	**4 094**	**4 381**
			Supplied by distribution sectors	***1 223***	***170***	***7 920***	***4 094***	***3 158***
			DWAF		170	7 920	4 094	116
			Irrigation boards					
			Water boards					3 042
			Municipalities	1 223				
			Supplied by other sectors	***676***	***0***	***0***	***0***	***1 223***
			Evapotranspiration					
			Losses – evaporation					
			Return flows	676				
			Effluent					1 223
			Balance (surplus/deficit over current use)					
Total water use (U1 + U2)				**12 799**	**170**	**7 920**	**4 094**	**4 381**

On the other hand, most of the yield is supplied as bulk raw water by DWAF to irrigation agriculture through IBs (62% or 7 920 million m^3) and to other production activities through WBs (32% or 4 094 million m^3) (see Table 2 (Supply table)). In 2000 part of the yield (2% or 186 million m^3) was returned to the atmosphere as surplus water, this is also referred to as the Water Balance for 2000. Most of the water (74% or 3 042 million m^3) received by WBs was redistributed to municipal authorities, which in turn allocated 56% (1 698 million m^3) of that to domestic urban users and recycled 28% (1 223 million m^3) to augment water yield. The third biggest users of municipal water were commercial and industrial firms while domestic rural users received only a 8% (261 million m^3) share of municipal water supplies in 2000. It is important to note that a number of users self-supply water for own use independent of distribution sectors. Most important among self-providers are mining and irrigation agriculture. It is assumed that the NWRS estimates produced by DWAF include self-supplied water. Nevertheless, the monetary accounts section presents some information on self-providers.

5.3 Use of water as input and sink by economic production activities

The 2000 DWAF NWRS data were only available in broad categories of supply and use, and therefore the more detailed 1995 data of DWAF sets were used in some instances to further categorise some of the water use sectors. Water use categories defined in the 2000 NWRS dataset, such as urban, rural and mining and bulk industrial use, were further categorised into urban-domestic and urban commercial and industrial; rural-domestic and rural-agriculture; and mining and other bulk use respectively, based on ratios calculated from the 1995 dataset. Table 3 gives a summary of how water was supplied to and how it was used by production activities in 2000.

Table 3 shows that irrigation farming received all its water from IBs. It is true however, that many irrigators self-supply their own water directly. As mentioned earlier, while the NWRS figures include self-provision from surface and groundwater yield, no data were available to determine what share was provided by IBs. Dryland agriculture and cultivated forests relied mainly on soil water. Forest plantations also abstracted water directly from surface water, contributing a reduction of 428 million m^3 of available water yield (see Use table of Table 3). Livestock and game were supplied with water by DWAF. On the other hand, mining[5], power generation and other industrial establishments using bulk water received all their water from WBs, while the rest of the manufacturing and services sectors and rural- and urban-domestic users were supplied with water by municipal authorities. The bulk of the water received by production sectors was returned to the environment with some contribution to available yield through usable return flows, effluent discharge (processed by municipalities) and losses in distribution (see Supply table of Table 3).

5 The same situation regarding lack of data to decompose the NWRS total estimate of water use into self-supplied and WB provided shares, applies to mining, which has a significant share of self-provision.

Table 3: Water use and discharge by production sectors in South Africa, 2000 (million m^3)

			Supply table	Production								
				Agriculture								
				Dryland and irrigation	Livestock and game	Forestry	Mining	Electricity	Other bulk: industrial	Other commercial, industrial, institutional, municipal	Domestic – urban	Domestic – rural
To the environment	S1		**Total water returned**	**52 244**	**313**	**10 828**	**326**	**234**	**238**	**784**	**1 144**	**261**
		D1	***To water sources***	***52 244***	***313***	***10 828***	***326***	***234***	***238***	***784***	***1 144***	**261**
			Atmosphere and sea (evaporation – losses)	7 244	313		326	234	238	784	1 144	**261**
			Evapotranspiration	45 000		10 400						
			MAR (including storage)									
			Groundwater									
			Surface water (including reserve)			428						
			Soil water									
			Ecological reserve									
		D2	***To other sources***	0	0	0	0	0	0	0	0	0
			Balance (to atmosphere or lower reserve)									
To economic activities	S2		**Supply of water to other economic units**	**676**	**0**	**0**	**62**	**63**	**129**	**415**	**554**	**0**
			Of which:									
			Desalinated									
			Reused									
			Waste water to sewage				62	63	129	415	554	
			To distribution (bulk yield available)	***676***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
			DWAF (available total yield)	676								
			Irrigation boards									
			Water boards									
			Municipalities									
			ROW and other WMAs									
			To direct use by	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
			Agriculture – irrigation									
			Agriculture – dryland crops (excl forestry)									
			Agriculture – livestock and game									
			Agriculture – plantation forestry									
			Mining									
			Hydroelectric power									
			Other bulk: industrial									
			Other commercial and industrial									
			Domestic – urban									
			Domestic – rural									
		C1	Hydroelectric power					215				
		C2	Mine water				291					
		C3	Urban runoff								787	
		C4	Losses in distribution (leakages, etc.)	764	61		35	19	33	248	356	45
Total supply of water (S1 + S2)				**52 920**	**313**	**10 828**	**388**	**297**	**367**	**1 199**	**1 698**	**261**

Table 3: Water use and discharge by production sectors in South Africa, 2000 (million m^3) (concluded)

			Use table	Production – Agriculture: Dryland and irrigation	Production – Agriculture: Livestock and game	Production – Agriculture: Forestry	Mining	Electricity	Other bulk: industrial	Other commercial, industrial, institutional, municipal	Domestic – urban	Domestic – rural
From the environment	U1		**Total abstraction**	**45 000**	**0**	**10 828**	**0**	**0**	**0**	**0**	**0**	**0**
		B1	***Abstraction for own use***									
			Hydroelectric power									
			Mine water									
			Urban runoff									
			Other									
		A1 B2	***Abstraction for distribution from water resources***	***45 000***	***0***	***10 828***	***0***	***0***	***0***	***0***	***0***	***0***
			Atmosphere and sea (evaporation – losses)									
			MAR (including storage)									
			Groundwater									
			Surface water (including reserve)			428						
			Soil water	45 000		10 400						
			Ecological reserve									
			Transfers in (ROW)									
		A2	***From other sources***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
			Direct rain harvesting									
			Abstraction from sea									
From economic activities	U2		**Use of water supplied by other industries**	**7 920**	**313**	**0**	**388**	**297**	**367**	**1 199**	**1 698**	**261**
			Supplied by distribution sectors	***7 920***	***313***	***0***	***388***	***297***	***367***	***1 199***	***1 698***	***261***
			DWAF		313							
			Irrigation boards	7 920								
			Water boards				388	297	367			
			Municipalities							1 199	1 698	261
			Supplied by other sectors	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
			Evapotranspiration									
			Losses – evaporation									
			Return flows									
			Effluent									
			Balance (surplus/deficit over current use)									
Total water use (U1 + U2)				**52 920**	**313**	**10 828**	**388**	**297**	**367**	**1 199**	**1 698**	**261**

Production activities were further categorised using data from the official 2000 SUT for SA (Stats SA, 2003). These tables classify water use according to the SIC, and report the value of water purchase transactions. Water tariffs calculated by the CSIR (CSIR, 2001) were applied to these values to determine volumes of water used by various industries. Table 4 presents further analyses of water flows between production and distribution sectors and the environment using more disaggregation of production activities.

According to Table 4, if direct abstraction of soil water by dryland agriculture (this is agriculture without irrigation and includes cultivated forests) is considered water use, then agriculture would have used 94% of the total water in SA in 2000 (64 065 million m^3), mainly for dryland crops (66% or 45 000 million m$^{3)}$ and the dryland component of forestry (15% or 10 400 million m^3), while irrigation consumed only 12% of that water (7 920 million m^3). The rest of the economy was left with 6% of that total to share, most of which went to domestic use (3%) with mining, manufacturing and services each using only 1%. However, if abstraction of soil water is excluded from water yield available for bulk supply (as DWAF does), agriculture (excluding forestry) remained with the biggest share in total water use

(64% or 8 233 million m^3), most of which was used in irrigation (62% or 7 920 million m^3). Second to agriculture was domestic use (16% or 1 959 million m^3) followed by trade and services (7% or 865 million $m^{3)}$, manufacturing (5% or 700 million m^3) and mining (3% or 388 million m^3).

Table 4 also defines alternative water consumption measures. Again, when abstraction of soil water is considered, agriculture used 94% of total consumption, mainly for dryland crops (66%) and forestry (16%). However, excluding soil water use by dryland agriculture makes irrigation farming the major consumer of water (62 %) followed by urban domestic use (14%). It is important to note however, that evapotranspiration from cultivation of dryland crops was less than that from natural vegetation. Therefore, unlike cultivated forests, dryland crop farming could be considered to contribute positively to *water yield*. Also, while water returned to the system as effluent adds to yield, it required treatment and processing before it was made usable, a process that involves economic costs. This indicates the important implications of proper definition of water use, especially when efficiency of use and the economic contributions of competing users are to be evaluated, as will become clear later in the monetary accounts section.

Table 4: Water use by production activities in South Africa, 2000

	Industries	Water received										Water consumed				
		Surface	Soil	DWAF	Irrigation boards	Water boards	Munici-pality	Total water received		Total excluding soil water		Return flows	Consumption 1[6]	Consumption 2[6]	Losses in distribution	Consumption 3[6]
	Units	million m^3							% of total	million m^3	% of total	million m^3				
Agriculture	Irrigation				7 920			**7 920**	**12**	**7 920**	**62**	676	7 244	7 244	764	6 480
	Dryland crops		45 000					**45 000**	**66**	**0**	**0**		45 000	0	0	0
	Livestock and game			313				**313**	**0**	**313**	**2**		313	313	61	252
	Forestry	428	10 400					**10 828**	**16**	**428**	**3**		10 828	428	-	428
	Total	**428**	**55 400**	**313**	**7 920**	**0**	**0**	**64 065**	**94**	**8 661**	**67**	**676**	**63 385**	**7 985**	**825**	**7 160**
Power	**Power generation**					**297**		**297**	**0**	**297**	**2**	**63**	**234**	**234**	**19**	**215**
Mining	Gold					127		**127**	**0**	**127**	**1**	20	107	107	11	96
	Other					261		**261**	**0**	**261**	**2**	42	219	219	24	195
	Total	**0**	**0**	**0**	**0**	**388**	**0**	**388**	**1**	**388**	**3**	**62**	**326**	**326**	**35**	**291**
Manufac-turing	Food processing						123	**123**	**0**	**123**	**1**	43	80	80	22	58
	Other					367	211	**578**	**1**	**577**	**4**	202	375	375	104	271
	Total	**0**	**0**	**0**	**0**	**367**	**334**	**701**	**1**	**700**	**5**	**245**	**455**	**455**	**126**	**329**
Trade and services	Construction						110	**110**	**0**	**110**	**1**	38	72	72	20	52
	Transport						120	**120**	**0**	**120**	**1**	42	78	78	22	56
	Government						152	**152**	**0**	**152**	**1**	52	100	100	26	74
	Other						483	**483**	**1**	**483**	**4**	167	316	316	87	229
	Total	**0**	**0**	**0**	**0**	**0**	**865**	**865**	**1**	**865**	**7**	**299**	**566**	**566**	**155**	**411**
Domestic	Urban						1 698	**1 698**	**2**	**1 698**	**14**	554	1 143	1 143	356	787
	Rural						261	**261**	**0**	**261**	**2**		261	261	45	216
	Total	**0**	**0**	**0**	**0**	**0**	**1 959**	**1 959**	**3**	**1 959**	**16**	**554**	**1 404**	**1 404**	**401**	**1 003**
	Total	**428**	**55 400**	**313**	**7 920**	**1 052**	**3 158**	**68 274**	**100**	**12 867**	**100**	**1 899**	**66 370**	**10 970**	**1 564**	**9 409**

[6] Consumption 1 includes soil water (dryland agriculture); Consumption 2 excludes soil water (dryland agriculture); Consumption 3 excludes soil water & losses

5.4 WRA input-output tables

The WRA I-O tables are reported in Appendix 1.

5.5 WRA supply and use tables

The WRA SUTs are reported In Appendix 2.

5.6 Spatial patterns of water supply and use in South Africa: Comparing WMA accounts

The above analyses (sections 5.1; 5.2 and 5.3) conceal important regional variations in patterns of water supply and use within SA, as can be seen from the selected data for the 19 WMAs reported in Table 5. Significant differences in MAR exist between WMAs due to differences in annual rainfall and differences in surface area. Two of the most water-abundant WMAs (Mvoti to Umzimkulu and Mzimvubu to Keiskamma) are relatively large in surface area, but more importantly, located on the wetter eastern seaboard of SA. The Upper Orange WMA borders on Lesotho, and receives a large amount of water from its water-abundant neighbour. The driest two WMAs are the Lower Orange and Lower Vaal as both are located in the semi-desert, far western side of the country.

The ecological reserve for each WMA has been determined through scientific studies in an ongoing process continuously updating current knowledge. The ecological reserve is defined to be the minimum amount of water in rivers required to maintain the ecological integrity of the river system. It varies between about 10% and 30% of MAR across the various WMAs.

The concept of yield is discussed in some detail in Appendix 3. Yield is the amount of water that can reliably be withdrawn from a water source at a constant rate. Due to the erratic and unreliable nature of river flow in South Africa, only a small portion of the MAR is available as yield in its natural unregulated state. However, by storing water during periods of high flow for abstraction when natural stream runs are lower, the yield is increased. Negative yields from surface water in some WMAs (Middle and Lower Vaal and Lower Orange) may result from the fact that river losses (evaporation and seepage) can in some WMAs be greater than the additional yield contributed by local runoff within these areas. Water received from up-stream WMAs is regarded as transfers into the WMA, and therefore provides the water available for use (available yield).

Groundwater yield makes a small contribution to yield across the country (approximately 8% of the total (1 088 million m^3/13 227 million m^3 in Table 6)). However, some WMAs rely on substantial shares of groundwater yield, such as the Lower and Middle Vaal, where groundwater contributes more than the surface water yield (see Table 5). Other examples include the Limpopo and Crocodile West/Marico where groundwater contributes more than 50% of the total yield. Effluent and return flows from use activities make a larger yield contribution than groundwater (approximately 14% of the total yield). This is especially evident in the heavily industrialised and populated landlocked WMAs of the Upper Vaal and Crocodile West/Marico.

The total yield of the various WMAs (consisting of surface water, groundwater and effluent/return flows) is augmented by transfers into the WMA. These transfers are either from natural water courses,; or from man-made water transfer schemes, as in the case of the Upper Vaal, where water is transferred via canal from the Thukela

WMA. WMAs with zero value (*Transfers In),* have catchment boundary areas which correspond to the natural water boundaries. The NWRS reports a zero value for total water transfers into SA and hence does not reflect the fact that SA imports water from neighbouring countries, namely Lesotho. Water transfers from the Lesotho Highlands Scheme into the country are alternatively reflected as coming from the Upper Orange WMA (in the *Transfers Out*). On the other hand, SA exports 170 million m^3 (see Table 7) through transfers to neighbouring countries

As is clear from earlier sections, water use is dominated by irrigation, which falls within the *Production Use* classification of Table 5. The largest production water use areas are therefore also the WMAs with the largest irrigation requirements, such as the Lower and Upper Orange, the Crocodile, Olifants, Fish and Inkomati WMAs. Household water use reflects the population density in the various WMAs.

The *water balance* is calculated according to the formula *Total Yield* plus *Transfers In* minus *Use* minus *Transfers Out*. Negative *water balances* exist for 11 of the 19 WMAs, indicating serious situations of water scarcity. A negative *water balance* is an indication that the water that should have been reserved for ecological purposes is being abstracted for production and household use. The Inkomati and Mvoti to Umzimkulu are the WMAs with the largest *water balance* deficits. The total *water balance* for the country is 186 million m^3. This figure is calculated based on hydrological modelling and does not represent a simple summation of the water balances of the individual WMAs.

Table 5: Water supply and use in South Africa by Water Management Areas, 2000 (million m^3)

Water management area	Supply			Use			Theoretical ecological reserve	Water balance[7]
	MAR	Surface Water Yield	Groundwater	Production	Households	Ecological		
Limpopo	986	160	98	280	42	133	156	(23)
Luvuvu/Letaba	1 185	244	43	297	36	188	224	(36)
Crocodile-West/Marico	855	203	146	889	42	133	156	(23)
Olifants River	2 040	410	99	868	97	268	460	(192)
Inkomati	3 539	816	9	787	58	748	1 008	(260)
Usuthu to Mhlatuze	4 780	1 019	39	667	50	1 511	1 192	319
Thukela	3 799	666	15	288	46	756	859	(103)
Upper Vaal	2 423	598	32	669	376	318	299	19
Middle Vaal	888	(67)	54	310	60	115	109	6
Lower Vaal	181	(54)	126	599	44	79	49	30
Mvoti to Umzimkulu	4 798	433	6	510	287	920	1 160	(240)
Mzimvubu to Keiskamma	7 241	777	21	297	77	1 602	1 122	480
Upper Orange	6 981	4 311	65	881	87	1 682	1 349	333
Lower Orange	502	(1 083)	24	1 009	19	61	69	(8)
Fish to Tsitsikamma	2 154	260	36	852	46	338	243	95
Gouritz	1 679	191	64	301	37	261	325	(64)
Olifants/Doorn	1 108	266	45	365	8	121	156	(35)
Breede	2 472	687	109	600	32	421	384	37
Berg	1 429	403	57	444	260	189	217	(28)
Total	**49 040**	**10 240**	**1 088**	**10 913**	**1 704**	**9 844**	**9 537**	**186**

[7] Total yield *plus* transfers in *minus* use *minus* transfers out

5.7 Temporal patterns of water supply and use in South Africa

Table 6 summarises selected water supply and use data for 1995, 2000 and estimations for 2025. The 1995 data were generated during and immediately after the development of the NWA by different teams of consultants. Subsequently, DWAF has developed an integrated water model – the WSAM upon which the 2000 and 2025 data were based. This model is under constant revision to improve data and assumptions.

Comparison of the temporal aspects of water supply and use is therefore subject to data reliability. The 1995 data for instance, report MAR to be 44 333 million m^3 compared to 49 404 million m^3 for 2000. This change in value is a reflection of improved data accumulation and does not represent an increase in MAR. The same argument is valid for the yield values for surface water, groundwater and effluent/return flows. Water use by production sectors and households appears to have increased by 21% and 7%, respectively from 1995 to 2000. These increases however, may be defendable in the context of SA's opening economy and increasing domestic (especially rural) water supply schemes; but once again, the data source accuracy and consistency of the 1995 data compared to the WSAM data has to be questioned.

The 2025 data (which are also based on the WSAM) project an increase in *yield* of 7%, which will be the result of infrastructure under construction in 2000. Increased use of 11% will be mostly attributable to growth in urban areas. The combined effect of these two variables will be a net negative *water balance* of 234 million m^3. In response to this, potential new water developments have been earmarked for every WMA (DWAF, 2004).

Table 6: Temporal patterns of water supply and use in South Africa as (million m^3)

Heading	Heading	2000	2025
MAR		49 040	49 040
Yield	Total Reliable Local Yield	13 227	14 165
	Surface water Yield	10 240	10 961
	Groundwater Yield	1 088	1 167
	Return flows/effluent Yield	1 899	2 037
Transfers in		0	0
Use	Production	10 913	12 066
	Domestic Use (Urban + Rural)	1 959	2 164
Transfers out		170	170
Water balance		186	(234)

Source: Adapted from DWAF (2004)

Note that 1995 data are less accurate than 2000 data. The differences between 1995 and 2000 are rather a reflection of improvement in quality of the data and changes in definitions of key water management concepts used by DWAF after the new NWA. These differences therefore do not necessarily mean changes in supply and use patterns. Assumptions used to derive the 2025 forecasts include ratio of surface:ground:return flow water remains constant as in the period 1995–2000. The same assumption used for constancy of the production:household use ratio.

6. Physical water asset accounts for South Africa

Given the flowing nature of water assets intrinsic in their high spatial and temporal mobility and the typical difficulty with obtaining detailed information on components of the SEEAW, this study used a simplified version of asset accounting that reflects the approach DWAF follows in managing national water assets. The first physical water accounts for SA (CSIR, 2001) produced asset tables recording physical stocks of surface and groundwater for the period 1992–1999. Surface water stocks were measured as average annual runoff into rivers and storage of surface water in dams and transfer schemes (exports and imports). This document updates and augments the mentioned water asset accounts with better stock information that has become recently available for surface and groundwater resources. This study adopted an asset accounting approach that is consistent with the fact that DWAF manages water resources within the national boundaries for their total annual *yield* (with no distinction between ephemeral and perennial rivers), as described in more detail in Appendix 3. While the constructed accounts contain most of the key elements of the SEEAW classification of water assets, they reflect annual changes in water flow volumes and *water yield* of the whole system, but do not follow the opening and closing stocks convention common to asset accounting for other more stationary environmental stocks. Stats SA published the first official set of water accounts for the nineteen water management areas of South Africa for the 2000 reference year in January 2004 (Report No. 04-05-01 (2000), following the SEEAW guidelines available at the time.

The major source of fresh water supply in SA is surface runoff, which constitutes only a small share of total annual precipitation. Table 7 shows that approximately 83% of the annual precipitation is lost to evapotranspiration and deep seepage, and only 8% of rainfall formed a mean annual runoff of 49 billion m^3 in 2000, which flows into rivers and is managed through an elaborate system of water storage and inter-basin water transfer schemes developed between a number of rivers providing the current fresh water supply to the country.

After providing for river base flow (the underground component of river flow) and other natural leakages, MAR contributed about 20 billion m^3 (only 40% of its volume) to surface water yield, of which 9 545 million m^3 were reserved for ecological protection. The remaining surface flow was further reduced by plantation forestry and augmented by groundwater yield, usable return flows from economic activity and transfers from neighbouring countries to a total of 12 628 billion m^3 of total water yield (representing 26% of MAR) available for use within the national boundaries. Economic sectors used 12 015 billion m^3 leaving a positive *BALANCE* of 186 million m^3 in the year 2000.

Table 7: Annual changes in water flow volumes and yield of the water system in South Africa, 2000 (million m^3)

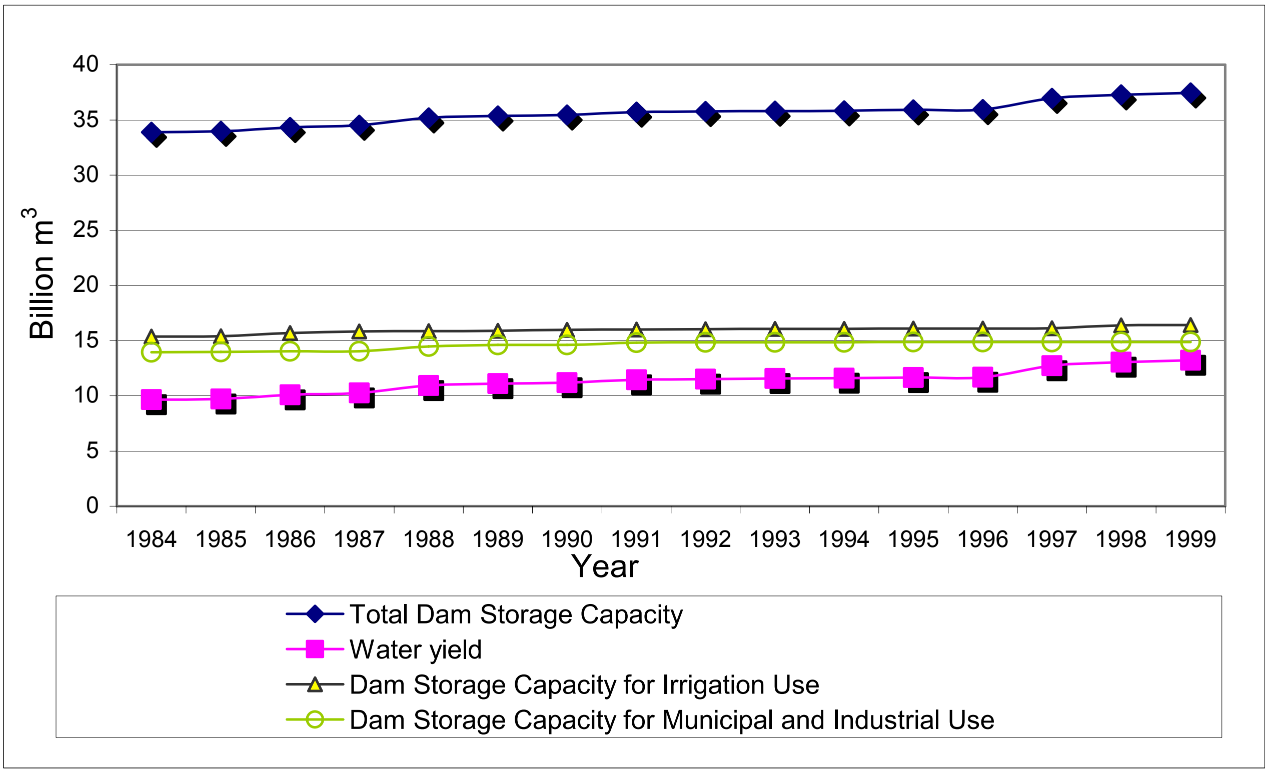
	Annual changes to stock	**2000**
A.	Changes due to natural processes	
A1.	Precipitation	611 600
A2.	Evapotranspiration and deep seepage	506 072
A3.	Gross annual runoff[a] (A1 – A2)	105 528
A4.	Transpiration from dryland agriculture (including plantations)	55 400
A5.	Replenishment of groundwater	1 088
A6.	***Natural MAR (A3 – A4 – A5)*** ***(% of total precipitation)***	***49 040*** ***8%***
A7.	Base flow [b]and other natural leakages from MAR	29 683
A.8	***Surface water yield (A6 – A7)*** ***(% of natural MAR)***	***19 357*** ***40%***
B.	**The ecological reserve (in-stream flow requirements-IFR)**	**9 545**
C.	**Changes due to human activity**	
C.1.	Cultivated forest incremental use	428
C.2	***Available surface water yield (A.8 – B – C.1)*** ***(% of natural MAR)***	*9 384* ***20%***
C.3	Available groundwater yield	1 088
C.4	Usable return flows	1 899
C.5	Transfers to ROW (water exports)	170
C.6	Total available yield (C.2 + C.3 + C.4 + C.5)	12 201
C.7	Total abstraction by production activities	*12 015*
D.	**Net annual change in flow water volumes (Balance) (C.6 - C.7)**	**186**

Sources: CSIR (2001), Vegter (1995); Baron et al (1998)

a. Gross annual runoff measures surface water flow volumes after losses through evaporation, seepage and use by natural vegetation (transpiration) are deducted from falling rains. This represents water available for dryland farming, cultivated forests, MAR and groundwater replenishment.
b. The base flow represents the groundwater component of river flow or MAR.

The total water storage capacity of the country has steadily grown over the past 15 years (see Figure 1) and stands at more than 37 billion m^3 holding about 76% of the MAR or water flow in 2000. Figure 1 also shows the high correlation between total water yield and growth in storage capacity, which is consistent with DWAF's approach to managing national water resource assets for annual *yield*. Figure 1 shows the expansion in storage capacity over the past 15 years by purpose of use. It is clear that use of water for irrigation and domestic and industrial purposes were the driving forces behind capacity expansions for more water yield. While these two uses basically shared the aggregate capacity expansion, they tend to alternate in priority in years when expansions are implemented.

Figure 1: Expansion in water storage capacity and yield in SA, 1984 to 1999 (Billion m^3)



6.2 Physical groundwater resource accounts

Abstraction of groundwater contributes only 9% (1 088 million m^3/12 201 million m^3) of total available annual water yield (see Table 7). One important feature of the hydrological linkages between surface and groundwater is the fact that groundwater supports a significant share (24% in 2000) of the annual surface runoff as base flow (see Table 8). The base flow holds the river up, and without groundwater the river would be absorbed into the riverbed. Due to the complex hydrological relationship between base flow and river flow however, it is not possible to determine whether the base flow comes from deeper groundwater sources or from the river itself.

Recent hydrological research assessing the groundwater resources of SA produced a comprehensive database on groundwater, including a set of national groundwater maps (Vegter, 1995 and 1995a; Baron et al, 1998; Seymor and Seward, 1998). These studies estimated the total groundwater stocks to be about 45% of the total net annual runoff (surface water resources), calculated as 17,76 billion m^3 for 2000 (see Table 8). Not all this volume however, can be abstracted and other measures of exploitable groundwater resources are therefore often used. Groundwater annual recharge (AR) estimated as the mean annual recharge to groundwater stocks is one measure of potential groundwater resources available for abstraction (Vegter, 1995). AR is calculated as the sum of base flow and annual extraction (see Table 8). However, the base flow provides a lower bound for groundwater AR as some groundwater is usually lost through evapotranspiration along river courses, even in areas where there is no groundwater abstraction through boreholes.

Another measure of potentially available groundwater resources is the harvest potential (HP)[8]. Baron et al (1998) derived an estimate of an average annual HP of 19 billion m^3/annum for South Africa. Although the two measures (AR and HP) may lead to different estimates of the groundwater potential, the Baron et al (1998) estimate of HP compares well with the estimate of AR in Table 8.

Note that both measures of groundwater total stocks and net annual runoff include the base flow of 11,85 billion m^3 in 2000. Groundwater storage can therefore be calculated by subtracting the base flow from groundwater stocks, giving an estimate of potential groundwater resources in storage of 5,94 billion m^3/annum in 2000. The share of groundwater resources in storage of the total annual water supply (net MAR) excluding the base flow, is accordingly lower and becomes only 15% compared to the 45% when base flow is included as part of groundwater storage. Net groundwater storage thus becomes gross storage minus annual extraction as calculated in Table 8.

Table 8: Groundwater physical accounts for South Africa, 1995 and 2000 (billion m^3)

Annual changes in stock		1995	2000
1.	Natural MAR	44,33	49,04
2.	Ecological reserve	4,58	9,55
3.	Net MAR (row 1 *minus* row 2)	39,75	39,49
4.	Base flow (billion m^3) [a]	11,93	11,85
	(% of MAR)	27%	24%
5.	Groundwater recharge	1,21	1,09
6.	Annual recharge of groundwater stocks (row 4 *plus* row 5)	13,14	12,94
7.	Total groundwater stocks [b]	17,28	17,76
	% of net MAR	44%	45%
8.	Groundwater storage (row 7 *minus* row 4)	5,35	5,94
	(% of net MAR)	18%	15%
9.	Net groundwater storage (row 8 *minus* row 5)	4,14	4,82
10.	Exploitable groundwater potential[b]	9,04	9,48
	% of net annual (river) runoff (Row 10 / Row 1)	23%	24%

Sources: CSIR (2001), Vegter (1995); Baron et al (1998)

a. The base flow represents the groundwater component of river flow.
b. Groundwater storage measures the theoretical available groundwater whereas exploitable groundwater potential measures utilisable groundwater that can actually be abstracted at reasonable costs.

One should also note that not all groundwater in storage could be abstracted depending on various determinants of abstractability such as transmissivity[9] and water quality. Low transmissivity requires a large number of low yielding boreholes, and low groundwater quality implies higher treatment costs. The abstractable amount of groundwater may be low in SA as the bulk of its groundwater resources are in

[8] The HP is defined by Baron et al (1998) to be the maximum volume of groundwater that may be abstracted per annum from an aquifer without depleting the aquifer. There are nevertheless, other alternative definitions for measuring HP depending on the scenario used to describe the interplay between groundwater in storage, recharge rates and time between recharge events (Baron et al, 1998). Hydrologists' definition of HP however, differs from the same term used by economists to mean exploitable potential rather than total potential.

[9] Transmissivity refers to the rate at which water is transmitted through rock body, usually expressed in m^3 per day.

secondary aquifers where water is contained mainly in fractures and pores in weathered rocks (Vegter, 1995). Accordingly, an exploitable groundwater potential of 9,48 billion m^3 was derived as the measure of the actual utilisable potential, which amounted to 24% of the net MAR in 2000 (see Table 8). Nevertheless, only about 11% (1,09 billion m^3) of the exploitable potential is currently abstracted.

7. Monetary water flow accounts for South Africa

Data used for compiling monetary flow accounts for SA were mainly sourced from Stats SA's national accounts and the monetary flow accounts were therefore only constructed at national level due to a lack of similar economic data at WMA level. Other sources including data on tariffs from DWAF and unpublished surveys (Hassan, 2005) have also been used to complement the Stats SA information on economic activity. Monetary accounts have been compiled only for flow water transactions but did not cover the environmental spheres of the flow accounts due to gaps in existing data and knowledge.

7.1 Expenditure on water by economic users

Dictated by data availability and the focus of this study, information on how much various economic users have spent on water compared to other components of production costs is analysed. Using the SUT for 2000, total and per unit expenditure on water used as input in production by economic activities are derived in Table 9. Water contributed the highest share of intermediate input costs in the mining sector followed by other trade and services with construction and manufacturing showing the lowest share in 2000. On average, the share of water in total intermediate costs was slightly more than 1% for the national economy. Trade and services sectors paid the highest cost per unit water (R7,56/m^3) followed by mining (R3,76), manufacturing (R1,58) and domestic use (R1,19). Agriculture paid the least (R0,023) per cubic metre of water used, while water used in power generation cost only R0,47 per m^3 in 2000.

Table 9: Expenditure on water use by production activities for South Africa, 2000

Industry		Water use supplied by other industries	Expenditure on intermediate inputs		Average water cost
		Million m^3	R million	% share of total	R/m^3
Agriculture	Irrigation	7 921			
	Dryland livestock	313			
	Forestry	431			
	Total	**8 665**	**203**	**0,7**	**0,023**
Power generation		**297**	**139**	**1,2**	**0,47**
Mining	Gold	127	479	3,8	3,77
	Other	261	981	2,8	3,76
	Total	**388**	**1 460**	**3,1**	**3,76**
Manufacturing	Food processing	123	296	0,4	2,41
	Other	577	812	0,3	1,41
	Total	**700**	**1 108**	**0,3**	**1,58**
Trade and services	Construction	110	83	0,2	0,75
	Transport	120	289	0,7	2,41
	Government	152	366	0,8	2,41
	Other[(a)]	483	5 802	2,6	12,01
	Total	**865**	6 540	1,8	7,56
Domestic	Urban	1 697			
	Rural	261			
	Total	**1 958**	**2 334**		**1,19**
Total		**12 873**	**11 784**	**1,2**	**0,92**

Source: Supply and use tables for 2000 (Stats SA, 2003)

(a) Represents trade and other services including the hotel and restaurant sectors

7.2 Indicators of income and employment supported by water use in production

Again, data from the national accounts for 1995 and 2000 were used to construct income and employment indicators (see Table 10). While agriculture used the highest share of total water use (about 67%) it contributed only 3% of the national income in 2000. Conversely, trade and services used only 8% of the water to contribute about 67% of total national income while manufacturing produced 19% of total income and used only 5% of the water in 2000. Consequently, trade and services had the highest GDP/m^3 indicator (R654/m^3) among all activities followed by manufacturing, mining and last agriculture (R3/m^3). The average national GDP indicator was R77/m^3 of water in 2000. The pattern was similar with respect to employment indicators with services, manufacturing and mining in the lead and an overall national average of about one full-time job per m^3 of water in 2000. While relative shares in GDP and water use were similar in 1995, the economy produced less economic output and generated fewer jobs per unit water in 1995. This was due to two effects, the reduction of water use per person and higher nominal GDP per capita in 2000.

Table 10: Value added and employment indicators of water use for South Africa, 2000

Industry		Water use		Value added (GDP) indicators								Employment indicators			
		Total in m³		GDP (R million)						GDP/m³ (R)		Employment (million)		Employment/ 000 m³	
		1995	2000	R million 1995	% of GDP	% of total water	R million 2000	% of GDP	% of total water	1995	2000	1995	2000	1995	2000
Agriculture	Irrigation	7 630	7 921	16 350	3,3	71,3	23 045	3	62						
	Dryland crops	0	0			0,0			0						
	Dryland livestock	385	313			3,6			2						
	Forestry	598	428	2 967		5,6	4 406		3						
	Total	**8 613**	**8 665**	**19 317**	**3,9**	**80,5**	**27 451**	**3**	**67**	**2**	**3**	**1,24**	**1,10**	**0,14**	**0,13**
Power generation		**280**	**297**	**15 503**	**3,1**	**2,6**	**19 431**	**2**	**2**	**55**	**65**	**0,09**	**0,08**	**0,31**	**0,26**
Mining	Gold	136	127	14 136	2,8	1,3	16 949	2	1	104	133				
	Other	281	261	20 694	4,1	2,6	46 442	6	2	74	178				
	Total	**417**	**388**	**34 830**	**7,0**	**3,9**	**63 391**	**8**	**3**	**84**	**163**	**0,45**	**0,48**	**1,08**	**1,23**
Manufacturing	Food processing	109	123	17 368	3,5	1,0	24 613	3	1	159	200				
	Other	511	577	90 717	18,1	4,8	137 852	16	4	178	239				
	Total	**620**	**700**	**108 085**	**21,6**	**5,8**	**162 465**	**19**	**5**	**174**	**232**	**1,45**	**1,50**	**2,34**	2,14
Trade and services	Construction	97	110	15 774	3,2	0,9	21 114	3	1	162	192				
	Transport	106	120	32 030	6,4	1,0	50 003	6	1	301	417				
	Government	135	152	80 831	16,2	1,3	133 158	16	1	600	876				
	Other	428	483	193 982	38,8	4,0	361 205	43	4	453	748				
	Total	**766**	**865**	**322 617**	**64,5**	**7,2**	**565 480**	**67**	**8**	**421**	**654**	**6,23**	**7,07**	**8,13**	8,17
Domestic	Urban	1 518	1 698												
	Rural	309	261												
	Total	**1 827**	**1 959**						**15**						
Total		**12 523**	**12 871**	**500 352**	**100,0**	**100,0**	**838 218**	**100,0**	**100,0**	**47**	**77**	**9,45**	**10,22**	**0,88**	**0,94**
Population		39 477	43 686												
Water use and GDP per capita		0,317	0,295	12 675			19 187								

Source: 2000 Supply and use table (Stats SA, 2003), National Accounts for 1995 (Stats SA, 1998), Census 1996 (Stats SA, 1998)

7.3 Tariffs on water use

Although historic data on delivery costs are not available, it can be discerned from available information that the pricing system hardly reflected any cost recovery. This was due to the preferential subsidy policy that prevailed in water pricing in the past. In the 1970s water provision services made in the interest of national development objectives were highly dependent on subsidies to help cover their operating expenses. Under the NWA of 1956, full cost recovery was not operational for irrigation and stock watering. Tariffs were made to recover operating costs of the scheme and were not to exceed a level that would recover the annual operating costs, redemption charges and interest charges. An exception to this was the households who were supplied from agricultural systems but were made to pay the full cost of water provision.

Schemes under the municipal and industrial sectors were subsidised only when the unit cost of water exceeded 22 cents per cubic metre. With regard to domestic and industrial use, water was supplied at a rate that recovered the full cost of the service. The tariff recovered the capital cost, interest charges, running cost of the supply schemes adjusted for inflation and deviations in water sales patterns. Subsidies for the care or construction of water works were applied at discretion and set at 33% of the cost. This subsidy policy was in operation until 1984. Subsidies applied after 1984 were intended to facilitate access to water for disadvantaged communities to improve living and health standards (CSIR, 2001).

Under the NWA of 1998, water tariffs were to be increased to reflect the full financial cost of providing water services and to reflect the benefit of water to society. This new system is premised on equity and efficiency considerations and ecological and financial sustainability. Subsidies are reviewed annually and are based on the cost of supplying water. This pricing strategy has three tiers:

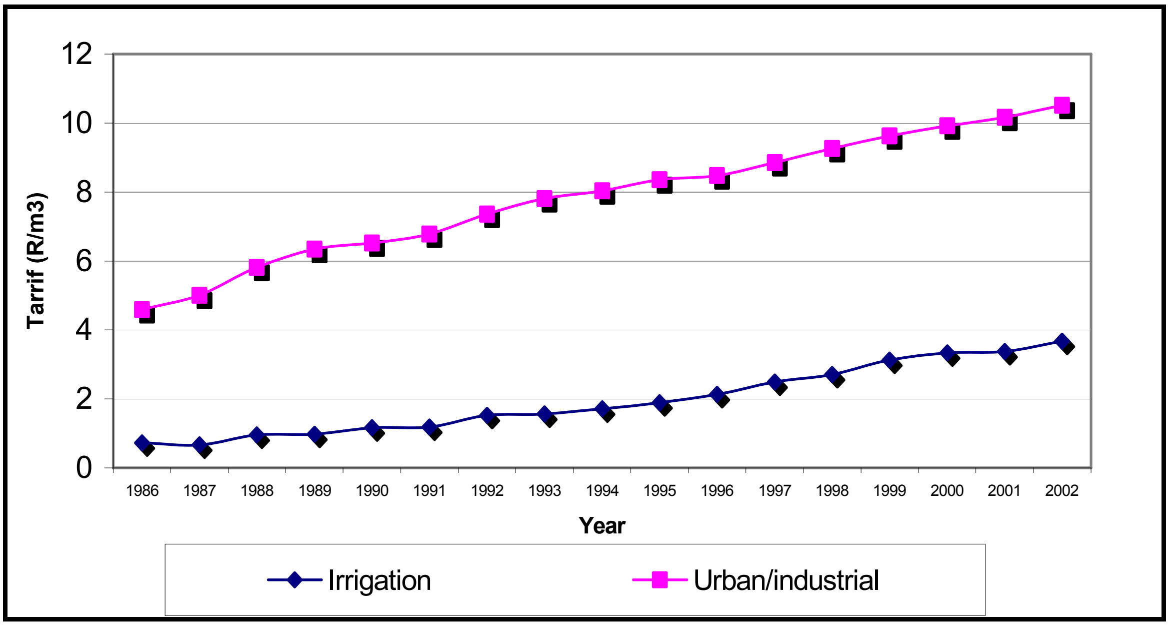
- First tier: raw-water tariffs set by DWAF on the basis of catchment management budgets and water use quantities.
- Second tier: WBs administer the wholesale price for water supplied to urban areas, which are mainly based on management costs.
- Third tier: local authorities set and administer prices of water services.

Under the new system, the cost associated with the management and protection of water resources at catchment level is paid by all users and covers the activities of abstraction of water from a water resource, storage of water, impeding or diverting water flow in a water course, or engaging in a stream flow reduction activity such as forestry and other activities. At present the water resource management charges (WRMC) are in operation only for activities that involve abstraction of water from a water resource and commercial afforestation. The charges do not apply to users who receive water under an arrangement with another service provider such as a municipality and users who use water for household activities. Because these charges are calculated from the actual costs of water resource management activities within the catchment, they tend to be relatively higher for WMAs that are relatively water scarce than for those in WMAs that do not experience shortages. These charges are calculated for three main sectors in each WMA, namely domestic/industrial, irrigation, and forestry and are reviewed annually.

The WRMC is paid over and above the WRC levy, consumptive charges and the TCTA where applicable. During the first year of implementation (2002/2003) the WRMC ranged between 0,2 cents and 3,37 cents per m^3 with irrigated agriculture paying less than one cent and forest plantations paying between 0,20 cents to one cent per cubic metre of water.

Figure 2 (data in Appendix 4) shows the trend in water tariffs on bulk water supply reflecting recent changes in the water pricing policy in SA. Urban and industrial users are clearly charged much higher tariffs than agricultural users. Tariffs have generally increased significantly since the late 1990s, reflecting the cost recovery pricing policy that has recently been adopted.

Figure 2: Raw water tariffs in South Africa, 1986 to 2002 (R/m^3)



7.4 Expenditure and subsidies on water by distribution sectors

Cost recovery is a relatively new strategy in water pricing policy, having been enacted only after the implementation of the NWA of 1998. Under this system the water tariffs are set to cover the full costs of supplying water. These include the operations and maintenance costs for equipment including replacements and new capital investments. In addition the tariffs cover the return on assets, the costs associated with depreciation of equipment and other inputs. While data availability is relatively more problematic on the financial status of water distribution sectors, an attempt was made through surveys of various sources of primary and secondary data to compile relevant information on costs and revenue from water supply and distribution (see Tables 11 and 12).

Table 11: Income, expenditure and subsidy accounts for municipal, bulk and national water services in SA (R million)

Industry	Municipal water [a]			DWAF trading accounts [b]			Water sector [c]
	2002	**2003**	**2004**	**1998**	**1999**	**2000**	**2000**
Salaries, wages and allowances	1 115	1 211	1 412				1 057
Intermediate inputs	3 909	4 197	4 915				6 995
Interest/surplus/profit	208	200	219				2 168
Transfers to funds	288	188	447				
Other net expenditure	2 818	4 275	4 717				223
Total expenditure	**8 338**	**10 071**	**11 710**	**1 448**	**2 178**	**2 399**	**10 443**
Expenditure per unit water (Rand/m^3)	1,90					0,20	0,86
Revenue from sale of water	7 458	7 994	9 093	618	1 458	1 560	10 350
Intergovernmental transfers and subsidies	107	68	179				
District, metropolitan and regional councils	1	0	13				
Other local government institutions	0	161	8				
Interest	47	52	98				
Transfers from tariff stabilisation and other funds	13	1	64				
Other income	412	1 347	1 796				
Total income	**8 037**	**9 624**	**11 251**	**618**	**1 458**	**1 560**	**10 350**
Deficit	301	447	460	830	720	839	93
Total subsidy (deficit plus intergov. transfers)	408	515	639	830	720	839	93
% change in subsidy		26%	24%		-13%	17%	
Subsidy as % of total expenditure	4,9%	5,1%	5,5%	57,3%	33,1%	35,0%	0,9%
Subsidy as % of revenue from water	5,5%	6,4%	7,0%	134,3%	49,4%	53,8%	0,9%
Subsidy per unit of water (cents/m^3)	9,31					6,74	0,76

Sources: (a) Economic Activity Survey (Stats SA, various), (b) Hassan and Blignaut (2005) and (c) Supply and use tables 2000 (Stats SA, 2000) and National Accounts for 1995 (Stats SA, 1998)

Table 12: Cost of and subsidy on water supply in South Africa

Industry	**Agriculture**			**Domestic and industrial**			**Self-supply**
Raw water (2000) – First tier	Irrigation boards	Livestock	Average/ total	Water boards	Municipal	Average/ total	
Cost of water supply (cents/m^3)	20	20	20	20	20	20	
Average tariff (cents/m^3)	2,7	1,1	2,7	37,9	8,8	10,5	
Estimated subsidy (cents/m^3)	17,3	18,9	17,4	-17,9	11,2	5,7	
Amount supplied (million m^3)	7 921	313	8 234	4 092	116	12 442	
Total subsidy (R million)	1 370	59	1 429	-732	13	710	
Second tier	Bulk use	Municipalities	Industrial	Rural areas		Average	
From water boards (2002)							
Tariff (Rand/m^3)	1,16	1,44	2,4	3,9		1,4	
From irrigation boards (2002) in Rand/m^3	Central pivot	Sprinkler	Micro-drip	Flood irrigation		Average	
Average tariff charged by irrigation boards	0,06	0,07	0,28	0,33		0,19	0,09
Other costs to farmer in Rand/m^3	1,41	2,49	1,60	1,12		1,65	2,32
Total cost to farmer (R/m^3)	1,47	2,56	1,88	1,45		1,84	2,41
Third tier	Domestic	Industrial					
From municipalities (2002) in Rand/m^3	6,11	4,00					
Supply of water to mining (2002)							
Average tariff (Rand/m^3)	2,12						2,12
Cost of water supply (Rand/m^3)							1,36

Sources: DWAF (2001); Data from surveys conducted in 2004 (Hassan and Matlanyani, 2004); Stats SA (2005)

The Economic Activity Surveys (EAS) conducted by Stats SA (Unpublished data from the 2002 to 2004 Economic Activity Surveys) show that municipal authorities enjoyed a subsidy of 9,31 cents per m^3 of water distributed to domestic, commercial and industrial clients in 2002 (see Table 11). The subsidy to municipalities averaged about 5% of total expenditure and slightly over 6% of revenue collected from water sales between 2002 and 2004. The SUT of 2000 showed that the water sector as a whole received a subsidy of R93 million, equivalent to less than one cent per m^3 of water distributed during that year.

The Water Trading Accounts (WTAs) of DWAF displayed in Table 11 indicate that subsidies on bulk water supply decreased from 57% in 1998 to 35% of the total expenditure by bulk water supply programmes in 2000 (Hassan and Blignaut, 2005). This can mainly be attributed to the gradual application of the principles of the NWA which aim to reduce water subsidies. Nevertheless, the financial subsidy on water services in SA amounted to about US$121 million in 2000.

The direct financial subsidy calculated above however, does not reflect the total amount of financial subsidies to the water sector. In addition to the direct subsidies shown in the water trading accounts of Table 11, the water sector receives another form of indirect financial subsidy through the Working for Water (WfW) programme.

The WfW programme is a multi-departmental initiative coordinated by DWAF since 1995. The aim of WfW is to eradicate invading alien plants from rivers, mountain catchments and other natural areas to improve water runoffs, conserve biodiversity and restore the productive potential of the land. Although the initial emphasis of WfW was on water conservation, it also has significant environmental benefits. This subsidy amounted to the total expenditure of R824 million on WfW programme activities, which contributed a gain of 25 million m^3 of water yield at the cost of R34 per m^3 of water gained during the period 1995 to 2000.

Nevertheless, the WfW programme generates social benefits through its contribution to increased water yield (runoff) and other environmental services. The problem of alien infestation is countrywide, and alien vegetation is estimated to be responsible for massive losses of water as well as losses of biodiversity. Indeed, alien vegetation is seen as the single greatest threat to the biodiversity of the Cape Floral Kingdom, the world's smallest and richest floristic kingdom.

Attempts have been made to estimate such social benefits from eradication of alien species in the Western Cape. A study by Turpie et al (2002) estimated an average value of R3 700/ha/annum from clearing alien species in fynbos vegetation in the Western Cape at 1997 prices. The said study estimate was based on calculations of the value of water yield reductions (using hydrology models and available estimates of water supply costs) and losses of flow benefits of fynbos vegetation due to degradation of the resource quality caused by alien plant infestation.

Adjusted for annual inflation, the above figure gives an estimate of R4 660/ha/annum total benefits value of removal of alien vegetation at 2000 prices. The value of increased water yield contributes a share of R377/ha/annum to the above estimate of total benefits from removal of alien vegetation. Multiplied by the total area cleared by 2000 (1,06 million ha), this gives a total benefits value (only in terms of gains in water yield) of approximately R400 million, which is about half the total amount spent on the programme over the said period.

The total subsidy on total raw water supplied (first tier) during 2000 was calculated to be R710 million, most of which went to agriculture (see Table 12). On average, the cost of water supplied for own use by self-providers for irrigation and mining was higher than that of water supplied through irrigation and water boards. Irrigation costs to farmers however, varied according to the method used for irrigation. More information on the cost of pumping water for own use in mining and irrigation agriculture is found in Stats SA (2005).

8. Recommended further work

The work presented here has largely been developmental in nature. The challenge now is to apply this work to practical tools of use to water management authorities.

One of the key questions to be addressed in water management in SA is to achieve optimal water allocation as water scarcity increases. It follows that beneficial use of water, in the public interest, is an important parameter in the decision-making process. To this end, the following work is recommended:

- Stats SA's WRA and DWAF water accounting should become more closely aligned through the following aspects:
  - Aligning water accounting periods and timeframes.
  - Aligning DWAF water sector definitions with the SIC.
- It is important that Stats SA economic data should assist DWAF in obtaining economic (monetary) information per water management area. This information should assist DWAF in addressing allocation questions.
- The feasibility study of water quality account for SA published by Stats SA in 2005 must be further developed into water quality accounts, where the emphasis must be placed on the impact of emissions on water yield (the 'fit-for-use' concept). The monetary equivalent of this account should show the cost implications of loss and restoration of water yield due to emissions.
- Within the above, many data gaps exist which require attention.
- Alignment with SEEAW.

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Appendix 1: Water flow accounts: Input-output tables, 2000

		Environment						Distribution				
		Atmosphere and sea	Natural MAR	Surface water yield	Groundwater	Soil water	Ecological reserve	DWAF (Total yield)	Irrigation boards	Water boards	Municipalities	ROW and other WMAs
Environ-ment	Atmosphere and sea		49 040		1 088	55 400						-
	Natural MAR (including storage)	29 683		19 357								
	Surface water (including reserve)						9 545	9 812				
	Groundwater							1 088				
	Soil water											
	Ecological reserve	9 545										
Distribu-tion	DWAF (available total yield)	186							7 920	4 094	116	170
	Irrigation boards											
	Water boards										3 042	
	Municipalities							1 223				
	ROW and other WMAs	170						-				
Production	Agriculture	62 957	-	428	-	-	-	676	-	-	-	-
	Dryland and irrigation	52 244						676				
	Livestock and game	313										
	Plantation forestry	10 400		428								
	Mining	326									62	
	Electricity	234									63	
	Other bulk (industrial)	238									129	
	Other commercial and industrial	784									415	
	Total domestic	1 405	-	-	-	-	-	-	-	-	554	-
	Domestic – urban	1 144									554	
	Domestic – rural	261										
Theoretical ecological reserve							9 545					
Water balance							186					
Total use (U)		**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**	**12 799**	**7 920**	**4 094**	**4 381**	**170**
Total supply 1 (S1)		**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**	**12 799**	**7 920**	**4 094**	**4 381**	**170**
Consumption 1 (U – S1)		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total supply 2 (S2) excluding evapotranspiration		**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**	**12 799**	**7 920**	**4 094**	**4 381**	**170**
Consumption 2 (U – S2) – economic consumption		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Production											
Agriculture				Mining	Electricity	Other bulk: industrial	Other commercial and industrial	Domestic – urban	Domestic – rural	Domestic – total	Total
Dryland and irrigation	Livestock and game	Plantation forestry	Total								
			-							-	**105 528**
			-							-	**49 040**
		428	**428**							-	**19 785**
			-							-	**1 088**
45 000		10 400	**55 400**							-	**55 400**
			-							-	**9 545**
	313		**313**							-	**12 799**
7 920			**7 920**							-	**7 920**
			-	388,0	297,0	367,0				-	**4 094**
			-				1 199	1 698	261	1 959	**4 381**
			-							-	**170**
-	-	-	-	-	-	-	-	-	-	-	**64 061**
			-							-	**52 920**
			-							-	**313**
			-							-	**10 828**
			-							-	**388**
			-							-	**297**
			-							-	**367**
			-							-	**1 199**
-	-	-	-	-	-	-	-	-	-	-	**1 959**
			-							-	**1 698**
			-							-	**261**
			-							-	**9 545**
			-							-	**186**
52 920	**313**	**10 828**	**64 061**	**388**	**297**	**367**	**1 199**	**1 698**	**261**	**1 959**	**338 021**
52 920	**313**	**10 828**	**64 061**	**388**	**297**	**367**	**1 199**	**1 698**	**261**	**1 959**	**338 021**
-	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
46 440	**61**	**10 400**	**56 900**	**97**	**82**	**162**	**664**	**910**	**46**	**956**	**328 610**
6 480	**252**	**428**	**7 161**	**291**	**215**	**205**	**535**	**788**	**215**	**1 003**	**9 411**

Appendix 2: Water Supply Table: South Africa, 2000

			Supply table	Environment						Distribution				
				Atmosphere and sea	Natural MAR	Surface water yield	Groundwater	Soil water	Ecological reserve	DWAF (Total yield)	ROW and other WMAs	Irrigation boards	Water boards	Municipalities
To the environment	S1	D.1	**Total water returned**	**105 528**	**49 040**	**9 545**	**-**	**-**	**9 545**	**186**	**-**	**-**	**-**	**-**
			To water sources	***105 528***	***49 040***	***9 545***	**-**	**-**	***9 545***	**-**	**-**	**-**	**-**	**-**
			Atmosphere and sea (evaporation – losses)		29 683				9 545					
			Evapotranspiration											
			MAR (including storage)	49 040										
			Groundwater	1 088										
			Surface water (including reserve)		19 357									
			Soil water	55 400										
			Ecological reserve			9 545								
		D.2												
			To other sources	-	-	-	-	-	-	186	-	-	-	-
			Balance (to atmosphere or lower reserve)							186				
To economic activities	S2		**Supply of water to other economic units**	**-**	**-**	**10 240**	**1 088**	**55 400**	**-**	**12 613**	**-**	**7 920**	**4 094**	**4 381**
			of which:											
			Desalinated											
			Reused											
			Waste water to sewage											
			To distribution (bulk yield available)			***9 812***	***1 088***	**-**		***12 300***	**-**	**-**	***3 042***	***1 223***
			DWAF (available total yield)			9 812	1 088				-			1 223
			Irrigation boards							7 920				
			Water boards							4 094				
			Municipalities							116			3 042	
			ROW and other WMAs							***170***				
			To direct use by	**-**	**-**	***428***	**-**	***55 400***	**-**	***313***	**-**	***7 920***	***1 052***	***3 158***
			Agriculture – irrigation									7 920		
			Agriculture – dryland crops (excl forestry)					45 000						
			Agriculture – livestock and Game							313				
			Agriculture – plantation forestry			428		10 400						
			Mining										388	
			Hydroelectric power										297	
			Other bulk: industrial										367	
			Other commercial and industrial											1 199
			Domestic – urban											1 698
			Domestic – rural											261

	Supply table	Environment						Distribution				
		Atmosphere and sea	Natural MAR	Surface water yield	Groundwater	Soil water	Ecological reserve	DWAF (Total yield)	ROW and other WMAs	Irrigation boards	Water boards	Municipalities
C.1	Hydroelectric power											
C.2	Mine water											
C.3	Urban runoff											
C.4	Losses in distribution (leakages, etc.)											
Total supply of water (S1+S2)		**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**	**12 799**	**-**	**7 920**	**4 094**	**4 381**

Production – Agriculture: Dryland and irrigation	Production – Agriculture: Livestock and game	Production – Agriculture: Forestry	Production: Mining	Production: Electricity	Production: Other bulk: industrial	Production: Other commercial, industrial, institutional, municipal	Production: Domestic – urban	Production: Domestic – rural	**Total**
52 244	**313**	**10 828**	**326**	**234**	**238**	**784**	**1 144**	**261**	**240 216**
52 244	***313***	***10 828***	***326***	***234***	***238***	***784***	***1 144***	***261***	***240 030***
7 244	313	-	326	234	238	784	1 144	261	**49 772**
45 000		10 400							
									49 040
									1 088
		428							**19 786**
									55 400
									9 545
-	-	-	-	-	-	-	-	-	**186**
									186
676	**-**	**-**	**62**	**63**	**129**	**415**	**554**	**-**	**97 635**
									-
									-
			62	63	129	415	554	-	**1 223**
676									**28 141**
676									**12 799**
									-
-	-	-	-	-	-	-	-	-	**68 271**
									45 000
									10 828
				215					**215**
			291						**291**
							787		**787**
764	61		35	19	33	248	356	45	**1 561**
									-
52 920	313	10 828	388	297	367	1 199	1 698	261	**337 851**

Appendix 2: Water use table: South Africa, 2000

			Use table	Environment						Distribution				
				Atmosphere and sea	Natural MAR	Surface water yield	Groundwater	Soil water	Ecological reserve	DWAF (Total yield)	ROW and other WMAs	Irrigation boards	Water boards	Municipalities
From the environment	U1		**Total abstraction**	**39 398**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**	**10 900**	**-**	**-**	**-**	**-**
		b.1	***Abstraction for own use***											
			Hydroelectric power											
			Mine water											
			Urban runoff											
		b.2	Other											
			Abstraction for distribution											
		a.1	***From water resources***	***39 398***	***49 040***	***19 785***	***1 088***	***55 400***	***9 545***	***10 900***	**-**	**-**	**-**	
			Atmosphere and sea (evaporation – losses)		49 040		1 088	55 400						
			MAR (including storage)	29 683		19 785								
			Groundwater							1 088				
			Surface water (including reserve)						9 545	9 812				
			Soil water											
			Ecological reserve	9 545										
			Transfers in (ROW)	170						-				
		a.2	***From other sources***	-	-	-	-	-	-	-	-	-	-	-
			Direct rain harvesting											
			Abstraction from sea											
From economic activities	U2		**Use of water supplied by other industries**	**66 130**	**-**	**-**	**-**	**-**	**-**	**1 899**	**170**	**7 920**	**4 094**	**4 381**
			Supplied by distribution sectors	***186***	**-**	**-**	**-**	**-**	**-**	***1 223***	***170***	***7 920***	***4 094***	***3 158***
			DWAF	186							170	7 920	4 094	116
			Irrigation boards											
			Water boards											3 042
			Municipalities							1 223				
			Supplied by other sectors	***65 944***	**-**	**-**	**-**	**-**	**-**	***676***	**-**	**-**	**-**	***1 223***
			Evapotranspiration	55 400										
			Losses – evaporation	10 544										
			Return flows							676				
			Effluent											1 223
			Balance (surplus/deficit over current use)											
Total water use (U1+U2)				**105 528**	**49 040**	**19 785**	**1 088**	**55 400**	**9 545**	**12 799**	**170**	**7 920**	**4 094**	**4 381**

Production									
Agriculture									
Dryland and irrigation	Livestock and game	Forestry	Mining	Electricity	Other bulk: industrial	Other commercial, industrial, institutional, municipal	Domestic – urban	Domestic – rural	**Total**
45 000	**-**	**10 828**	**-**	**-**	**-**	**-**	**-**	**-**	**240 984**
									-
									-
									-
									-
									-
									-
									-
									-
45 000	***-***	***10 828***	***-***	***-***	***-***	***-***	***-***	***-***	***240 984***
									105 528
									49 468
									1 088
		428							**19 785**
45 000		10 400							**55 400**
									9 545
									170
-	-	-	-	-	-	-	-	-	**-**
									-
									-
7 920	**313**	**-**	**388**	**297**	**367**	**1 199**	**1 698**	**261**	**97 037**
7 920	***313***	***-***	***388***	***297***	***367***	***1 199***	***1 698***	***261***	***29 194***
	313								**12 799**
7 920									**7 920**
			388	297	367				**4 094**
						1 199	1 698	261	**4 381**
-	-	-	-	-	-	-	-	-	**67 843**
									10 544
									676
									1 223
									-
									-
52 920	**313**	**10 828**	**388**	**297**	**367**	**1 199**	**1 698**	**261**	**338 021**

Appendix 3: Key concepts and principles of water management in South Africa [extracted from the NWRS (DWAF, 2004)]

Mean annual runoff

Precipitation runs off the land surface to accumulate in streams and lakes, and also infiltrates the soil to become groundwater. The total quantity of surface flow, which is the average annual runoff originating from a certain geographic area is referred to as the MAR.

Yield

Water that can reliably be withdrawn from a water source at a relatively constant rate is referred to as the yield. Due to the erratic and unreliable nature of river flow in SA, only a small portion of the MAR is available as yield in its natural unregulated state. However, by storing water during periods of high flow for abstraction when natural stream runs are lower, the yield is increased.

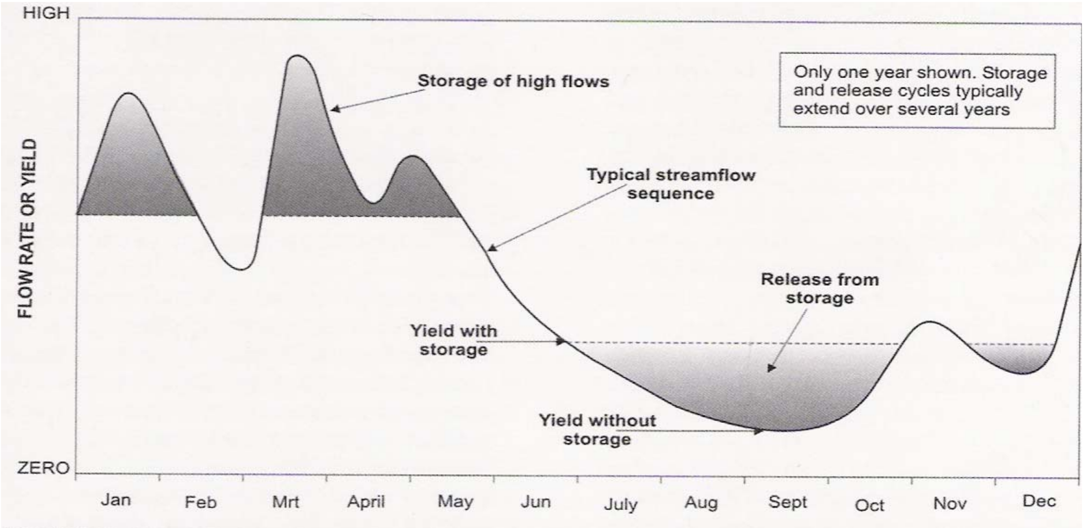
The yield from a water resource system is the volume of water that can be abstracted at a certain rate over a specified period (expressed in million m^3/a). For domestic, industrial and mining use water is required at a relatively constant rate throughout the year, whereas strong seasonality of use occurs with respect to irrigation. Because of the typically large fluctuations in stream flow in SA, as illustrated over a 12-month period in the figure below, the highest yield that can be abstracted at a constant rate from an unregulated river is equal to the lowest flow in the river. By regulating stream flow by means of dams, water can be stored during periods of high flow for release during periods of low flow, as shown by the dotted lines on the diagram. This increases the rate at which water can be abstracted on a constant basis and, consequently, the yield. The greater the storage, the greater the yield that can be abstracted, within certain limits.

It is possible to observe negative surface water *yields* in specific catchment areas (Middle Vaal, Lower Vaal and Lower Orange). This is a theoretical value resulting from the way in which water management areas in SA have been delineated and how *yield* within each WMA is derived. It is based on the following equation:

(1)	Surface water yield (SWY)
plus	Storage
minus	Ecological reserve
minus	River losses
minus	Alien vegetation use
minus	Dryland sugarcane
plus	Urban runoff
equal	MAR

Negative yields from surface water in some WMAs therefore reflect the fact that river losses (evaporation and seepage) are greater than the additional yield contributed by local runoff in these areas. It is of course not possible to have a negative amount of water in a WMA, and therefore the concept of 'available water' has been defined.

Figure 3: Explanation of the *yield* concept



Available water

The NWRS defines 'available water' as the total quantity of water that can be available for practical application to desired uses. It includes the yield from surface water and groundwater, and additionally includes return flows from the non-consumptive use of water as well as water transferred from one catchment to another:

(2)	SWY
Plus	Groundwater yield
Plus	Usable return flows
Plus	Water transfers
Equal	Available water

Water balance

The concept of a water balance provides a theoretical indication of the water demand/supply situation showing whether a WMA is a deficit or surplus area. Two equations are of importance here:

(3)	SWY
Plus	Groundwater yield
Plus	Usable return flow
Equal	Total local yield

(4)	Total local yield
Plus	Transfers in –
Minus	Local water requirements
Minus	Transfers out
Equal	Water balance

More than half of SA's WMAs have been defined by the 2000 NWRS (DWAF, 2004) to have a negative water balance. The reasons for this are twofold:

- Water demand by the ecological reserve is a significant variable of the surface water yield equation. However, ecological use of water is a theoretically calculated value, and in areas of water scarcity (i.e. where water has been over-allocated to local requirements or users) less water will simply be available for ecological use. This is a serious problem as it may indicate the vulnerability of wetlands and riparian zones.
- The quantity of available water further depends on the assurance of supply at which it is required. In the NWRS all yields and requirements have been standardised at a 98% assurance of supply, that is, a risk of some level of failure during two out of 100 years on average. Actual water allocations, however, take into account the required assurance of supply for specific uses. In the case of agriculture for instance, an assurance of supply of 90% (1:10 years) is a commonly used management consideration. The probability of a serious drought every 10 years is much lower than having a serious drought every 50 years, and therefore, practically speaking, more water is for use annually on a 1:10 assurance. Irrigation farmers can therefore grow more crops on an annual basis for 90 out of every hundred years than they can on an annual basis for 98 out of every 100 years. Therefore, when the 1:10-year water consumption is converted to a 1:50-year water consumption, it may yield a negative water balance.

Water quality

The quality of water in relation to the quantity requirements for particular uses has a direct bearing on the usability of the water. Poorer water quality will reduce water quantity.

Appendix 4: Raw-water tariffs in South Africa (c/m^3)

Year	Irrigation	Urban/industrial
1986	0,73	4,59
1987	0,67	5,01
1988	0,96	5,82
1989	0,98	6,34
1990	1,17	6,52
1991	1,19	6,78
1992	1,52	7,36
1993	1,56	7,81
1994	1,71	8,04
1995	1,89	8,36
1996	2,13	8,47
1997	2,49	8,85
1998	2,71	9,26
1999	3,13	9,63
2000	3,34	9,92
2001	3,38	10,17
2002	3,67	10,52

Source: Derived from DWAF (unpublished statistics)