ORANGE - SENQU RIVER COMMISSION
BOTSWANA LESOTHO
ORASECOM
NAMIBIA SOUTH AFRICA
Established 2000

Economic Analysis of Water based on Water Accounting for the Orange-Senqu River Basin

Integrated Water Resources Management Plan for the Orange-Senqu River Basin

2014

Report No. ORASECOM 011/2014

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Support to Phase 3 of the ORASECOM Basin-wide integrated Water Resources Management Plan

Economic Analysis of Water based on Water Accounting for the Orange-Senqu River Basin

Integrated Water Resource Management Plan for the Orange-Senqu River Basin

Compiled by : Guy Pegram and Hannah Baleta

ECONOMIC ANALYSIS OF WATER BASED ON WATER ACCOUNTING FOR THE ORANGE-SENQU BASIN

Integrated Water Resources Management Plan for the Orange-Senqu River Basin – Phase 3

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1. Introduction

1.1 Background

The Orange - Senqu River originates in the highlands of Lesotho on the slopes of its highest peak, Thabana Ntlenyana, at 3 482m. It runs for over 2 300km to its mouth on the Atlantic Ocean. The river system is one of the largest river basins in Southern Africa with a total catchment area of approximately 1 million km^2 and includes the whole of Lesotho as well as portions of Botswana, Namibia and South Africa. The land covered by the basin in each country is reflected in the table below.

Table 1-1: Area and Percentage of the river basin in the four countries

Country	Area in each country(km²)	Percentage of Basin
Botswana	79,000	7.90%
Lesotho	34,000	3.40%
Namibia	245,000	24.50%
South Africa	642,000	64.20%
Total	1,000,000	

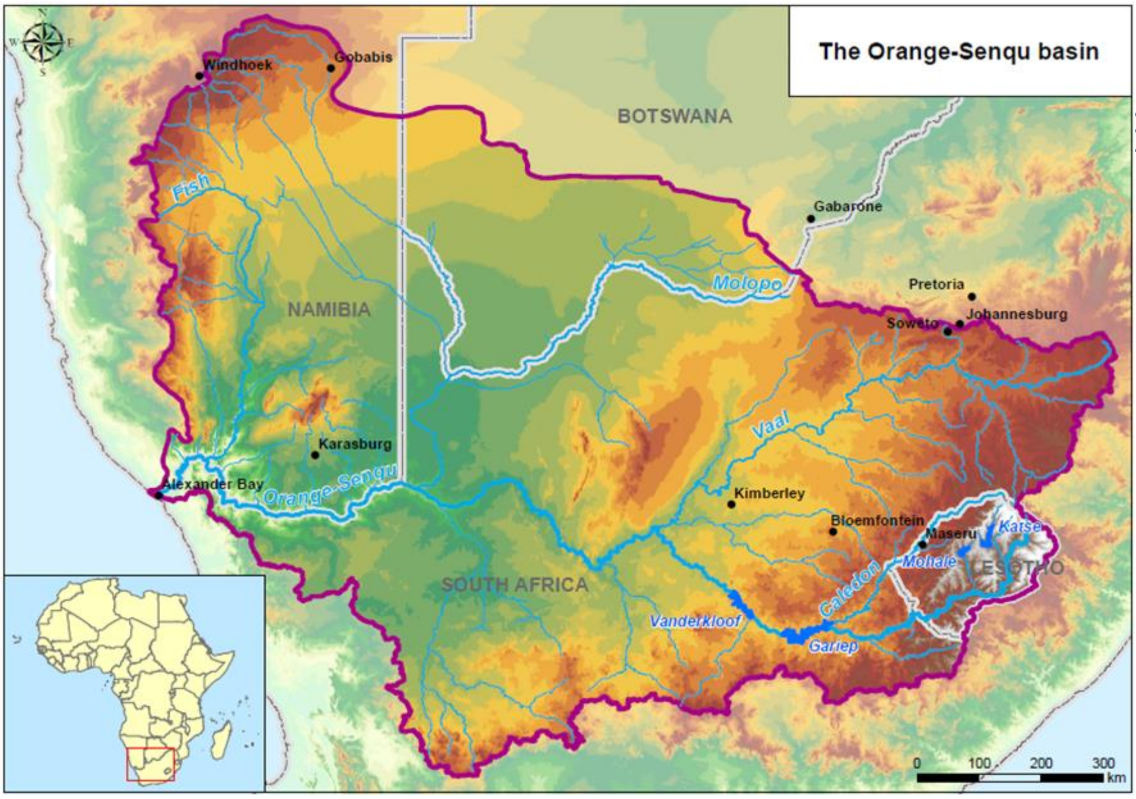

Figure 1-1: Map of the Orange Senqu River Basin

The Orange-Senqu river basin is a highly convoluted and integrated water resource system with several large inter-basin transfers. It is one of the most utilised river basins in the SADC region. For this reason, it is essential to have a sophisticated management system. This is one of the key drivers of the proposed project to develop an Integrated Water Resources Management Plan for the basin.

1.2 Purpose of the report

Water is essential for life. Basin Integrated Water Resource Management (IWRM) planning in highly developed basins, like the Orange-Senqu basin, usually requires trade-offs between allocation and development of the water resources in the basin. This is especially essential for basins that are shared between countries as these decisions affect the different sectors and each country. By improving the understanding of the supply of water, use of that water, value of water allocated to different users, the efficiency of that use, and the broader social and economic benefit to the basin and the country, the countries can make informed, efficient and equitable decisions.

There lies a challenge in doing such an investigation across an international river basin. This is because water needs to be understood within each country, but also across the basin as a whole. The national context of water within the basin is complex due to the difference in water management areas against administrative borders. Therefore, economic accounting within a country does not take into account the borders of where water was from. This complexity is further compounded when considering the economic gains of water use across countries. Many states do not have comparable administrative or water management institutions. In addition, accounting may be carried out in different manners, making comparisons across an international river basin difficult. These complexities need to be taking into account during this process of understanding the role of water in the economy of the Orange-Senqu River Basin.

In order to make decisions regarding the trade-offs between different water users, the water supply and demand as well as economic value of the different water users are required. A number of models and tools are used to inform the decisions being made regarding the resource allocation. This includes a review of the System for Economic Accounting for Water (SEEAW) model which investigates the stock flows of water between regions as well as the economic value thereof in the hybrid model. In addition, a water footprint analysis will be carried out to investigate the flows of embedded water within products traded between countries. In this work package, the primary output will be a report setting out the methods chosen and the sources (and limitations) of the data which will feed into a model. The report will summarize the implications of the water accounting results for the IWRM plan. This will be supported by a database model of water accounts in the basin, linking the physical water data to the economic environment.

The purpose of this report is to estimate water accounts for the Orange-Senqu basin and determine whether the basin is managing its water in an efficient, equitable and environmentally sustainable manner.

In order to achieve this output, the following four activities are proposed:

- Review of previous work done in water accounts and collect data
- Estimate basin water accounts
- Describe the trade in virtual water and water in the economy
- Interpret economic value efficient and benefit.

The methods used in order to carry out these four activities are expanded upon in each chapter.

1.3 STRUCTURE OF THIS REPORT

Following this short overview and introduction, the structure of this report is as follows:

- Chapter 2: Overview and background information on the Orange-Senqu Basin
- Chapter 3: Methodology and analysis of water accounting in the Orange Senqu River basin
- Chapter 4: Methodology and analysis of water footprinting in the Orange Senqu River basin
- Chapter 5: An analysis of water in the economy
- Chapter 6: Way forward, recommendations and implications for the IWRM plan

2. Overview of the Orange – Senqu Basin

2.1 Geography of the Basin

There are five countries within the Orange-Senqu catchment. Each country has a different proportional area and relative population based in the catchment.

Table 2-1: Summary of country area of riparian states within the Orange-Senqu River basin

Country	Area in orange Senqu river Basin (km²)	% of basin area	Total Population (country)	Population in the Basin	% of Country Population in the Basin	% of Basin Population
Botswana	79 000	7.9	1 680 883	47 667	2.8	0.3
Lesotho	34 000	3.4	2 127 539	2 127 539	100	13.5
Namibia	245 000	24.5	1 830 330	163 093	8.9	1.3
South Africa	642 000	64.2	44 819 778	13 357 298	29.8	84.9
Total	1 000 000		50 458 510	15 738 115		

Rainfall across the basin is highly variable as indicated in the figure below. Rainfall ranges from greater than 1000 mm/annum in the east to less than 50 mm/annum in the west. Evapotranspiration is indirectly proportional, whereby in the west, evaporation may exceed 3000 mm/year.

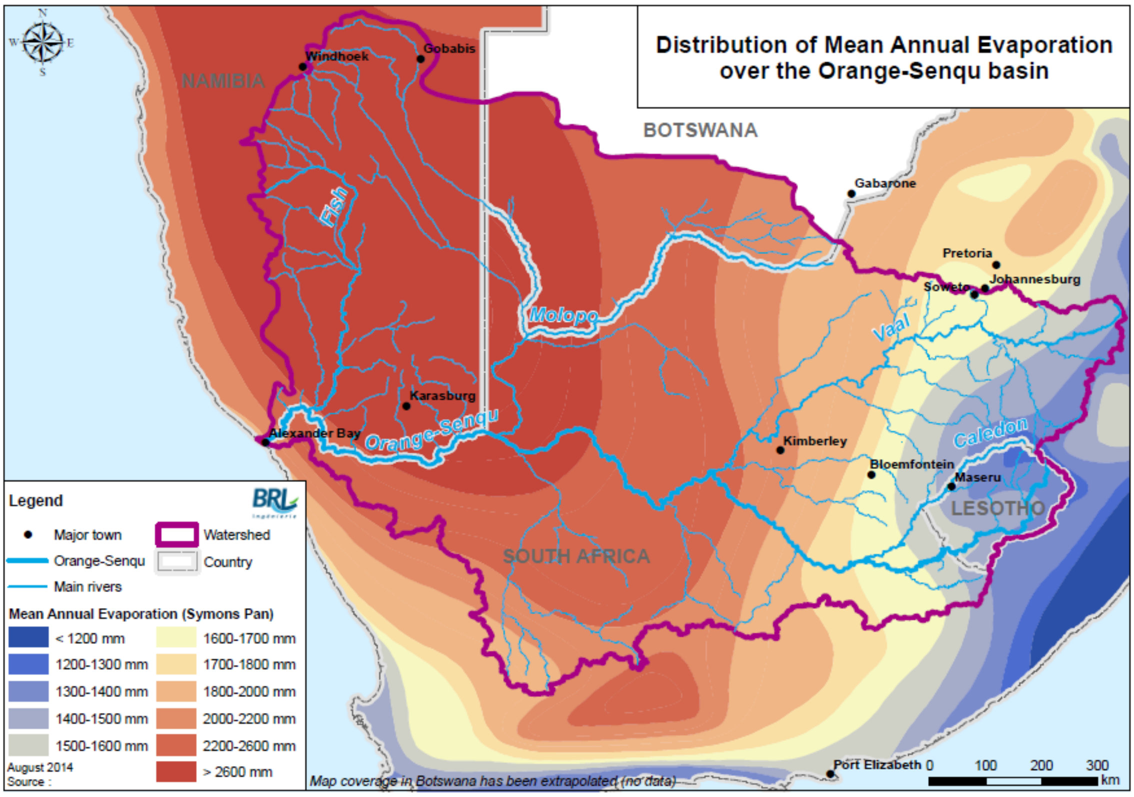

Figure 2-1: Mean Annual Precipitation (mm/year) in the Orange- Senqu River Basin[1]

[1] http://www.orangesenqurak.com/mapgallery.aspx?galleryimage=25866

The natural runoff of the Orange-Senqu River basin has been estimated to be 11 600 Mm³/a. The current actual runoff reaching the river mouth is now estimated to be approximately 5 500 Mm³/a (ORASECOM 2007), which is approximately 48% of the natural runoff described above. Estimates put the demand for water in the basin at 6 500 Mm³/a, with approximately 82% of this use attributed to South Africa (Turton et al 2005). The figure below gives an indication of the approximate contribution to total river flow for each major catchment.

The natural flow of the rivers in the catchment is controlled through the use of transfers and dams in and out of the region. There are over thirty-one major dams in the Orange-Senqu River system. Two of these dams are situated in Lesotho, five in Namibia and 24 in South Africa. The largest five being the Gariep, Vanderkloof, Sterkfontein, Vaal and Katse Dams. These dams supply water to agricultural (irrigation), power generation, industrial and domestic users within and outside of the catchment.

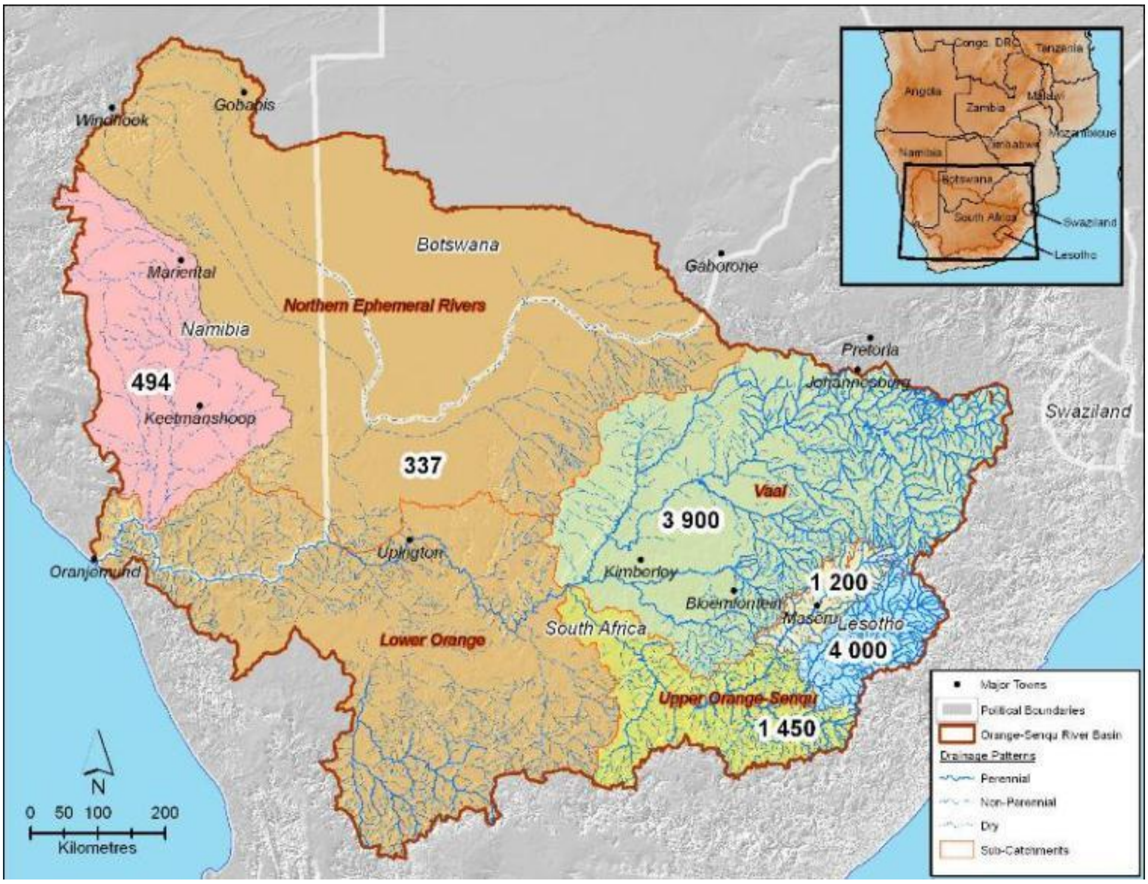

Figure 2-2: Approximate water balance for natural runoff in the Orange-Senqu River Basin[2]

The table below indicates that approximately 11 490 Mm³/annum of the 11 600 Mm³/annum is used (ORASECOM 2007). This implies that the basin in reaching a point where the river basin becomes 'closed.' When closed, the river no longer discharges runoff into the ocean, which has ecological implications for the environment of the river mouth.

[2] http://www.orangesenqurak.com/mapgallery.aspx?galleryimage=25948

Table 2-2: Orange-Senqu River Water Balance at 2005 Development Level

Water Balance Component Volume (million m³/a)	million m³/annum
Environmental Requirement (including natural evaporation from Orange River)	900
Namibia (Includes Orange and Fish River water use)	120
Lesotho & Transfers to RSA (With Full Phase 1 of LHWP active)	820
RSA Orange River Demand (Including Eastern Cape transfers)	2 560
RSA Vaal River Demand (Vaal demand supplied from locally generated runoff)	1 560
Evaporation & losses (Excluding evaporation included at top)	1 750
Spillage (2005 development level)	3 780
Total	11 490
Spillage under natural conditions	10 900

The water used in each portion of the catchment supports different sectors of the economy. These are distinct in each country within ORASECOM. An overview on the economy of the basin follows.

2.2 Economy

Each country on the Orange-Senqu has a differently structured economy. Depending on the nature of the economy, the GDP contribution of agriculture, industry and services may be different. The contribution of each sector of the economy, and the respective water use is covered in greater depth at a later stage in this document.

The following figure indicates the total GDP contribution per sector for the entire country. The water requirements of each sector in terms of quality and quantity of water are distinct, and thus have implications for the water use in the basin. Note that these figures indicate the national structure of the economy. On a basin scale, certain sectors of the economy may be more or less significant.

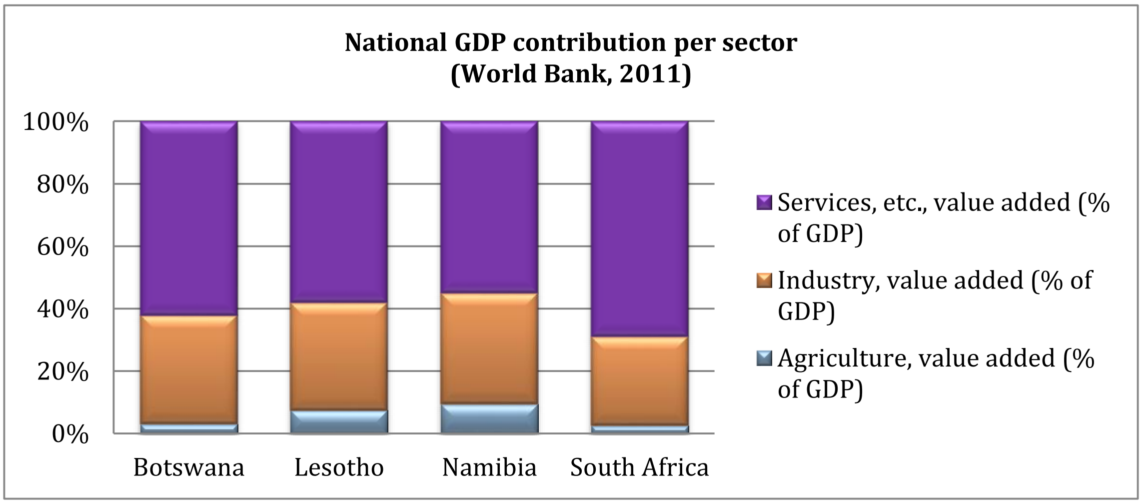

Figure 2-3: National GDP contribution per sector (World Bank, 2011)

2.2.1 Agriculture

Agriculture in the Orange-Senqu River Basin is an important sector through the provision of food, employment and support of the rural economy. The figure below indicates regions where land is cultivated. This is heavily dependent on the existence of dams in the region to supply irrigation water, and hence most irrigation takes place within South Africa. This does not give an indication of the extent of grazing for livestock, an important contributor to agriculture.

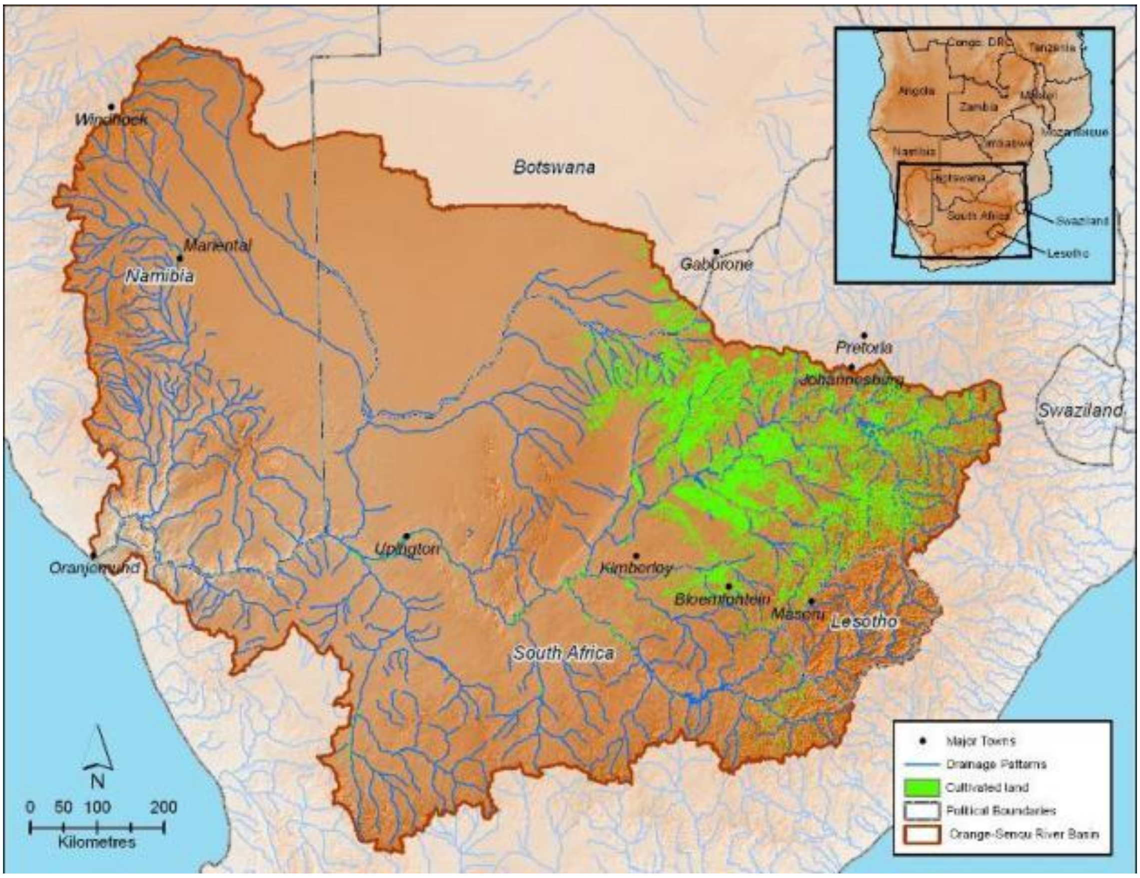

Figure 2-4: Cultivated land in Orasecom[3]

3 http://www.orangesenqurak.com/mapgallery.aspx?galleryimage=26790

2.2.2 Mining

Mining and power generation are important contributors to the Orange Senqu basin GDP. Although mining and power generation represent a smaller proportion of water withdrawal, the water needs to be supplied at a higher level of assurance of quantity (not necessarily quality). Mines include diamonds, gold, copper, manganese and iron. The figure below indicates the spread of mines across the basin.

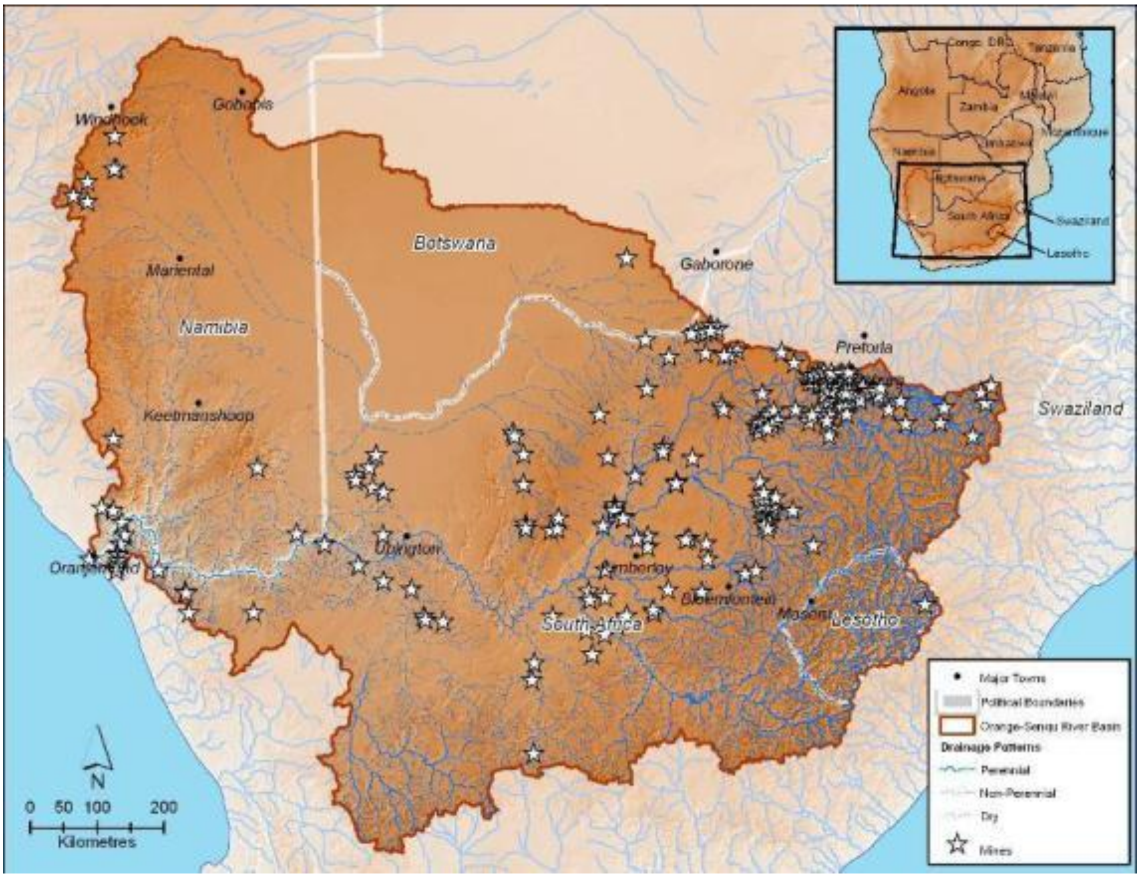

Figure 2-5: Mining in Orasecom[4]

[4] *http://www.orangesenqurak.com/mapgallery.aspx?galleryimage=26464*

2.3 Botswana

A very small percentage of Botswana is arable (0.7%). The majority of land cultivation takes place in the eastern region of the country. Botswana produces 50% of its food needs, accounting for 3% of the GDP. However, agriculture remains a livelihood for 80% of the population.

Subsistence farming and cattle farming are the predominant agriculture types. The key crops for domestic use are sorghum, corn and millet. In 2004, the sorghum and corn harvests comprised less than 10% of the annual requirement of 250,000 tons. In order to meet demand, grain is often imported from South Africa.

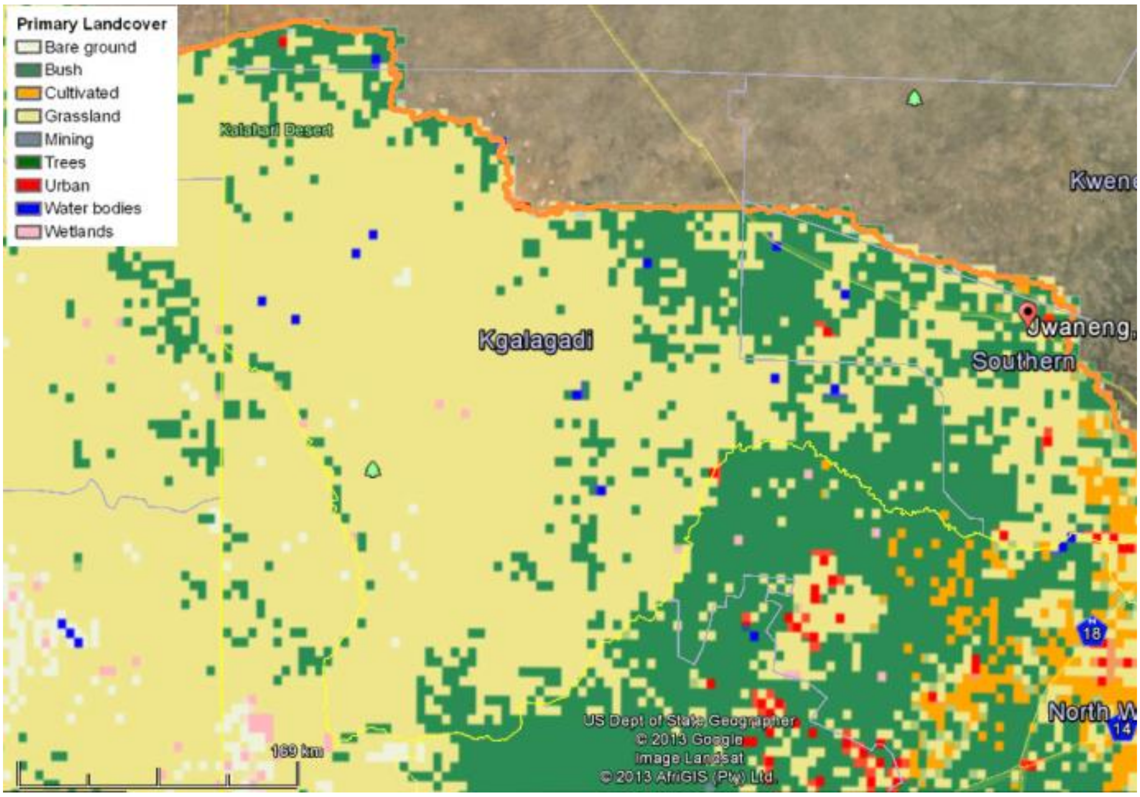

Figure 2-6: Landcover in Botswana within the Orange Senqu River basin

Tourism is also important to the economy of Botswana, contributing 12% to the GDP. The majority of tourism is connected to the Okavango Delta (which does not fall within the Orange Senqu River Basin). Mining contributes 36% to the national GDP. Industry in total contributes 52%, while services contribute 45%. Since the early 1980s, the country has been the world's largest producer of gem diamonds. Four large diamond mines in Botswana represent 25% of the world's diamond production, making Botswana the highest producer of diamonds by value in the world.

Most (70%) of Botswana's electricity is imported from South Africa's Eskom. 80% of domestic production is concentrated in one plant, Morupule Power Station near Palapye (outside of the Orange-Senqu Basin), operated by the Botswana Power Corporation. Debswana operates the nearby Morupule Colliery to supply coal to it.

Within Botswana, the Kgalagadi District and Sothern District fall within the Orange-Senqu Basin. The Botswana side of the basin is very flat and arid. Therefore the Orange is not a particularly important resource for Botswana, as most demand is far from the River.

30% of the Kgalagadi District is home to the Khalahari Trans frontier Park. The district is home to 42 000 people. Other than tourism to the Kgalagadi, there is little additional comprehensive industry or agriculture taking place in the region. The Southern District is home to 187 000 people, as well as the Jwaneng Diamond Mine, the single- richest diamond mine in the world. The region is also home to the second largest region of beef farming, as well as maize and sorghum farming. Not all of these districts are part of Orange Senqu River basin, however, and therefore the administrative level GDP contribution and population is not all attributable.

2.4 Lesotho

All economic activity in Lesotho may be attributed to the Orange-Senqu as the entire country lies within the basin. Agriculture, livestock and manufacturing are the basis of the Lesotho economy, while a large proportion of income is also gathered through a migrant workforce employed in South Africa. Nearly two thirds of the country's income is through the agricultural sector, while half of the population earn some income through crop cultivation or animal husbandry. The western lowlands are home to the majority of agriculture in Lesotho.

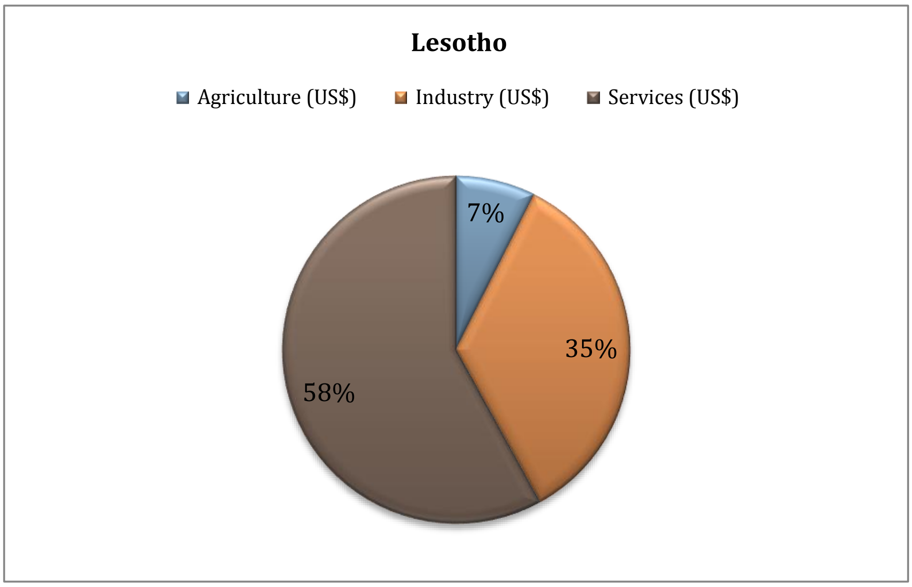

Figure 2-7 : Income generated per sector in Lesotho

With the reduction of mineworkers, a manufacturing base within Lesotho has been developed. Manufacturing includes agro-processing crops grown in the country as well as the development of an apparel assembly sector. As a result, manufacturing employment has become the largest formal sector employer in Lesotho, exceeding government employment. Income is also gathered through the transfer of water from Lesotho through the Lesotho Highlands Water Project for use in Gauteng and the Free State of South Africa.

The large manufacturing and industrial sector of Lesotho represents a large water abstraction of 49% of the country's total water use. The Letseng diamond mine in Lesotho abstraction is negligible in comparison. The following figure gives an indication of the types of land cover in Lesotho, of which, grasslands is the majority.

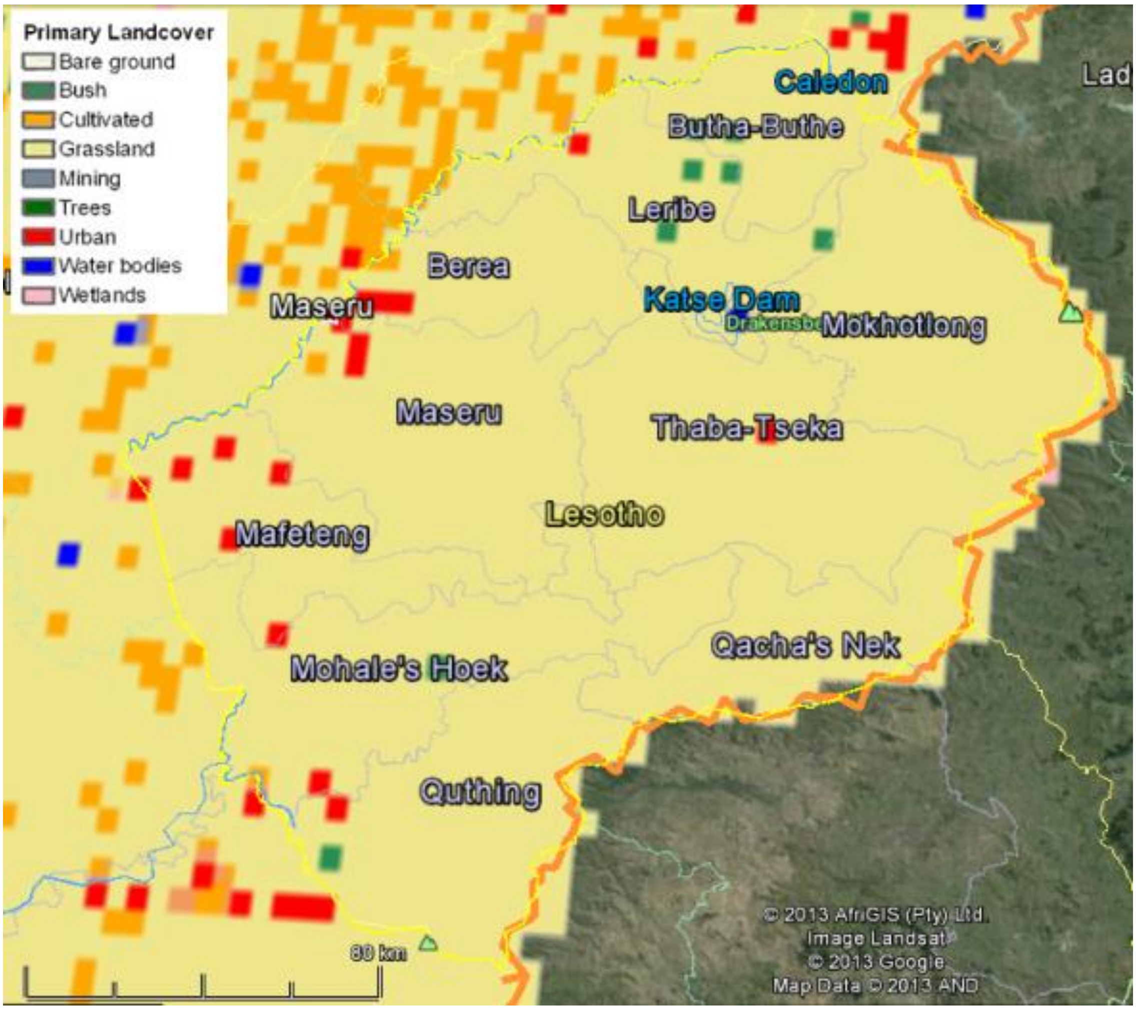

Figure 2-8: Land Cover in Lesotho

2.5 NAMIBIA

Like Botswana, the economy of Namibia is dependent on the extraction and processing of minerals for export. Mining accounts for 9.5% of GDP (2011), but provides more than 50% of foreign exchange earnings. The majority of revenue (7.2% of GDP in 2011) comes from diamond mining. The mining sector employs only about 3% of the population.

Agriculture is a critical sector to the economy of Namibia, and represents 10% of the Namibian GDP. However, 25% to 40% of the population depend on subsistence agriculture and herding. Primary products include livestock and meat products, crop farming and forestry. Animal products, live animals, and crop exports constituted roughly 10.7% of total Namibian exports.

2% of Namibia's land receives sufficient rainfall to grow crops. As all inland rivers are ephemeral, irrigation is only possible in the valleys of the rivers of the Orange, Kunene, and Okavango. Namibia normally imports about 50% of its cereal requirements; in drought years food shortages are a major problem in rural areas. Table grapes are predominantly grown in the arid south, along the Orange River. The industry is becoming an increasingly important commercial crop and a significant employer.

Presently, the total installed electrical generation capacity of 393 MW is insufficient to meet Namibia's demand for electricity. To make ends meet, Namibia imports the shortfall, mainly from South Africa and Zimbabwe. In 2009, Namibia's total annual electricity consumption amounted to some 3.6 billion kWh, of which 60% was imported from South Africa and Zimbabwe. A transmission network has recently been installed to link Namibia with Ruacana, a run-of the river station on the Kunene River supplied more than 92% of Namibia's locally-generated electrical energy. Van Eck is a coal fired power station north of Windhoek while Paratus is a heavy fuel-oil station in Walvis Bay. The newly-built Caprivi Link connects Namibia with Zambia, Zimbabwe and into the eastern parts of the Southern African Power Pool. The Caprivi Link will reduce Namibia's dependence on the South African transmission grid by providing a northern alternative for electricity imports and exports.

The regions in Namibia which form part of the Orange-Senqu include all of the Hardap and Karas, and half of the Khomas and Omaheke regions. The Hardap Region is home to the Hardap Dam, on the Fish River. The Hardap Dam is the largest reservoir in Namibia, with a capacity of 320 million m³. The dam provides water for irrigation to cultivate animal fodder, corn, fruit and vegetables. In addition to livestock such as sheep, ostriches and cattle, the region produces export grapes, cotton and dairy farming through the irrigation from the Hardap Dam.

The Karas region is characterised by predominantly small stock farming and game and irrigation farming along the Naute Dam and the Orange River. The Naute Dam has a capacity of 69 million me of water, and is the third largest dam in the region. The dam is home to a government-owned fish farm (Naute Aqua Fish Farms Project) and the Naute Fruit Farm which grows primarily dates for export to Europe.

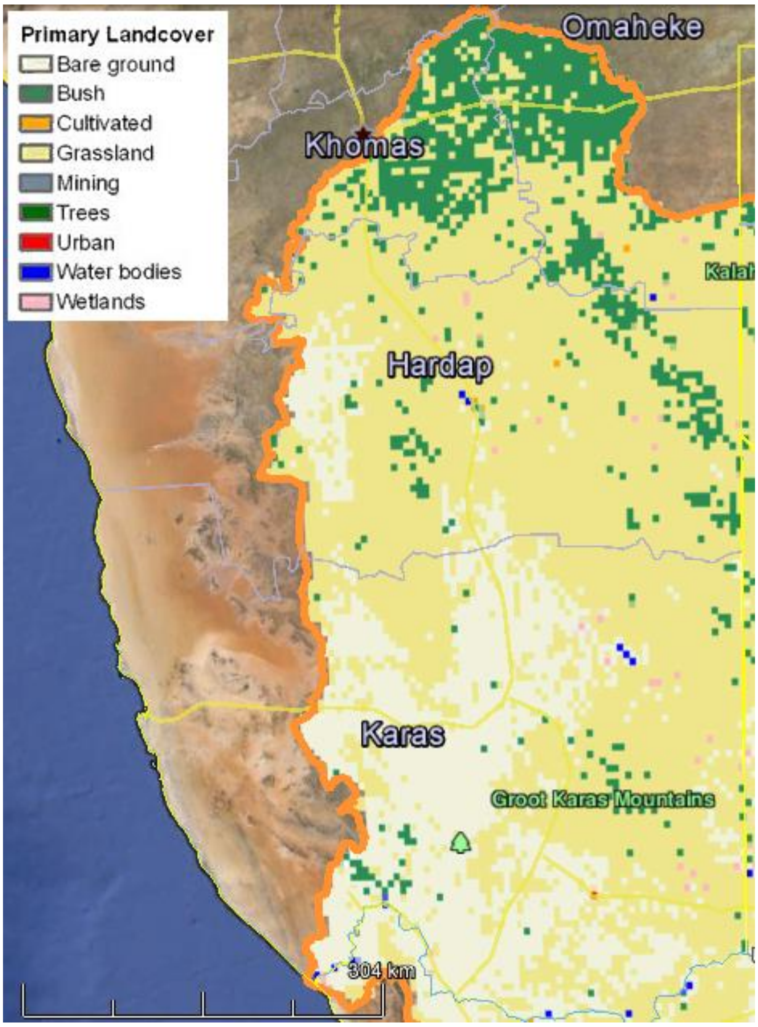

Figure 2-9: Landcover in Namibia within the Orange Senqu River basin

Near Luderitz there is a strong industrial presence with the Kudu Gas Field and fishing and boat building. Tourism is present in the Ai Ais and Fish River Canyon. The Khomas Region is home to the capital of Namibia, Windhoek (which lies just outside of the Orange-Senqu catchment). It has the highest density of people in Namibia. The Omaheke Region is predominantly Sandveld, where 900 commercial and 3500 communal farmers are involved in mostly livestock. Hunting is also a major source of income.

There are a number of diamond and metal mines in the region within the Orange-Senqu basin. The calculated water use for mines was 1.43 (Mm³/a) in 2000. This does not include diamond mines situated along the coast which use predominantly seawater for processing. The small amount of water used for industry in Namibia is mostly associated with agricultural goods.

2.6 South Africa

The analysis of South Africa has been divided into two distinct, but integrated catchments of the Orange and the Vaal Rivers. The linkages of the two catchments are shown in the figure below. The Vaal is made up of the Upper, Middle and Lower Vaal. A number of transfers take place between the Vaal and the Olifants and Tugela Water Management Areas. Due to the metropolis of Johannesburg in Gauteng bordering two catchments, 50% of the Vaal water is transferred into Northern Gauteng, and is discharged into the Crocodile River Catchment.

The Orange is made up of the Upper and Lower Orange WMA. The Upper Orange is downstream of the Senqu River in Lesotho. The Upper Orange becomes the Lower Orange at the confluence of the Vaal River. It is at this stage that the quality of the Orange deteriorates.

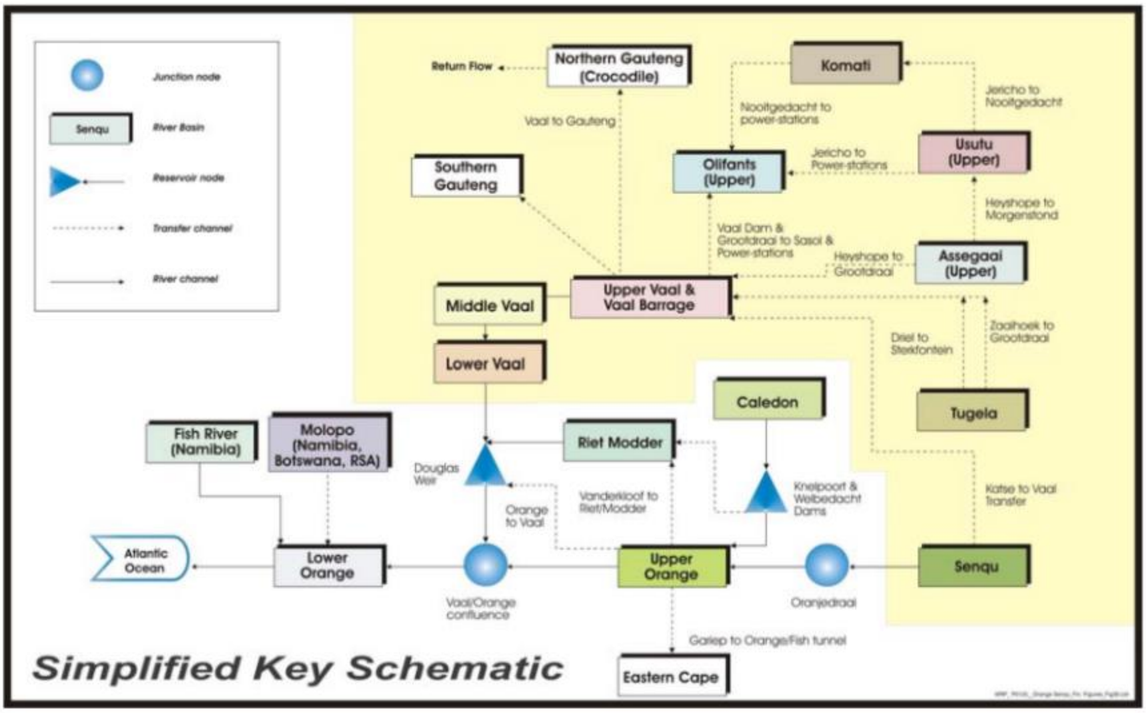

Figure 2-10: Schematic of the Integrated Vaal River and Orange River

The Vaal and Orange River catchments in South Africa represent a large portion of the South African economy. A range of economic activities from agriculture (cropping and livestock) to power generation and mining take place at a large scale in the catchment. Land use in the catchments is indicated in the figure below.

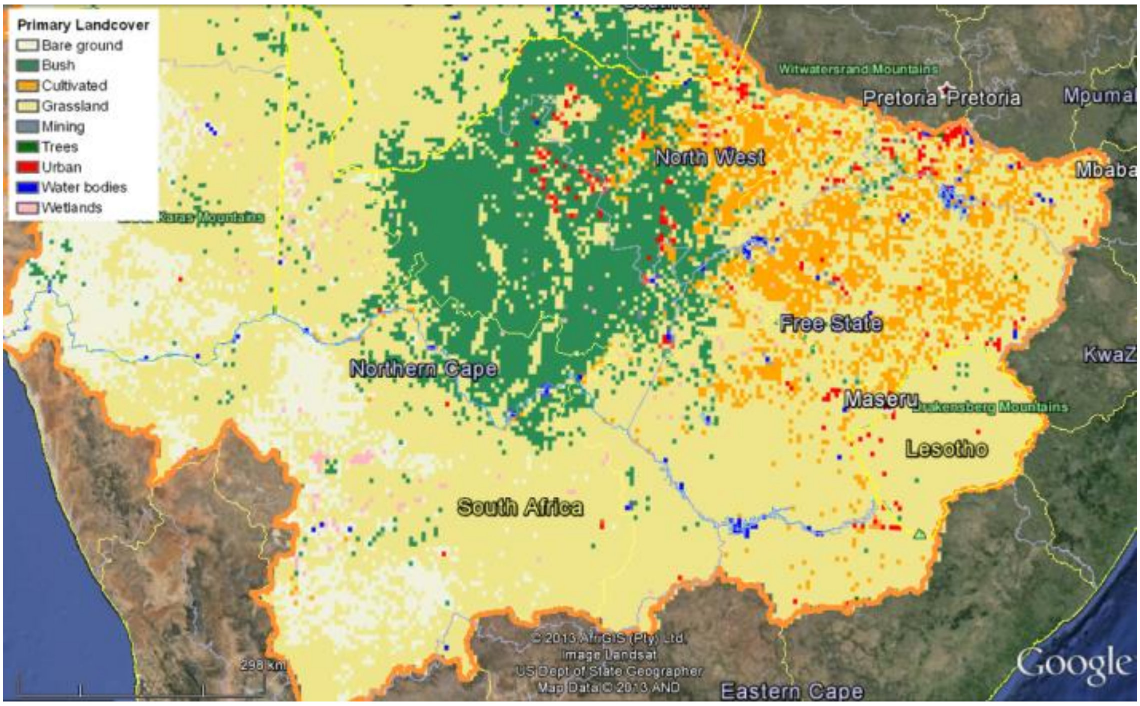

Figure 2-11: Landcover in South Africa within the Orange Senqu River basin

2.6.1 Vaal

The Upper Vaal in particular is critical to the South African economy, contributing nearly 20% of the GDP of South Africa. Sprawling urbanisation and industry (including mining) dominate the northern and western parts of the Upper Vaal WMA and represent 80% of the total water requirements in the Upper Vaal. Although these sectors abstract a large amount of water, they generate large return flows of treated effluent from urban areas and mine dewatering. This has significant quality implications for the remainder of the catchment.

The Middle Vaal is more rural in nature, home to extensive dry land agriculture. Irrigation is located downstream of major dams along the Vaal River. Mining is the most dominant GDP contributor of this region, generating more than 45% of the GDP in the WMA, and represents 20% of the total water used. The WMA contributes 4% of the GDP of South Africa. As in the Upper Vaal WMA, mine dewatering and the subsequent discharge to the river system impacts on the water quality.

The land use in the Lower Vaal WMA is primary livestock farming, with some dry land cultivation in the north east. Intensive irrigation is practiced at Vaalharts as well as locations along the Vaal River. Mining of diamonds, iron ore and other minerals takes place near Kimberley and the south-eastern parts of the WMA, however, the total water use of mining and industry is relatively small.

2.6.2 Orange

Approximately 6 % of the country's Gross Domestic Product (GDP) originates from this area (5% from Upper Orange WMA & 1% from Lower Orange WMA). The potential for economic growth can be found in the agriculture sector converting to higher value products. Agriculture, mining, trade and Government are the main sectors contributing to the GDP in the two WMAs.

Presently, land use in the Upper Orange WMA is mostly natural vegetation with livestock farming as the main economic activity. Extensive areas under dry land cultivation, mostly for the production of grains are found in the north-eastern parts of the water management area. Large areas under irrigation have been developed along the main rivers and downstream of irrigation dams. Major mining in the region is of diamonds and salt, which do not represent large proportions of the total water use in the region.

In the Lower Orange, from a land use perspective, the water management area almost totally still natural vegetation. Sheep and goat farming is practised over most of the area, with large parts falling within conservation areas. Irrigation takes place in the fertile Orange River. There are no large urban developments or power stations in the WMA. However the mining of copper and diamond mining does take place near Springbok and along the coast respectively.

The energy sector although only using 2% of water, contributes about 15% to the GDP of South Africa and creates jobs for 250000 (GCIS, 2011). It generates about 95% of the electricity in South Africa and also exports it to countries in Africa. The energy sector, including Eskom, the national power generator, is highly dependent on reliable supplies of water for the generation of electricity (steam generation and cooling processes), and an elaborate and sophisticated network of water transfer and storage schemes have been developed specifically to support this sector and ensure high levels of reliability. The water sector is on the other hand highly dependent on a constant and reliable supply of electricity to "move water."

3. Water accounting methodology

Water accounting is the conceptual framework for organising water information in order to study the interaction between the economy and the environment. It analyses the contribution of water to the economy and the impact of the economy on the water resources in terms of abstraction and emissions. The compilation of the water accounts is important for designing and evaluating macro-economic water policy. The indicators resulting from the water accounts cover many aspects of water management under Integrated Water Management (IWRM) such as:

- Water resource availability: the water accounts depict the status of water resources and the pressure exerted on the stocks of water.
- Water use for human activities: the water accounts provides details of how water is used in the economy, what pressure is on the water resources as well as opportunities to increase water use efficiency,
- Opportunities to increase effective water supply by managing return flows, reuse and system flows:
- Water cost, pricing and incentives for conservation: The hybrid accounts in water accounting assess the costs of supplying water compared to revenues generated by water tariffs.

The different flows of water can be classified into the following categories:

- **Flows of Water Within the environment.**

  This relates to the natural flow of water between surface, soil and ground water;
- **Flows of Water from the environment to the economy.**

  This relates to the abstraction of water from the environment for production and consumption purposes in the economy.
- **Flows of Water within the economy.**

  This relates to the flow of water in physical and monetary terms, from water supply agencies (water utilities) to agriculture, industry, mining, manufacturing, and households
- **Flows from the economy back to the environment.**

  After using water, the economy discharges wastewater back to the environment (return flows), either into rivers and lakes, or directly into the ocean.

These flows of water can be seen in the figure below:

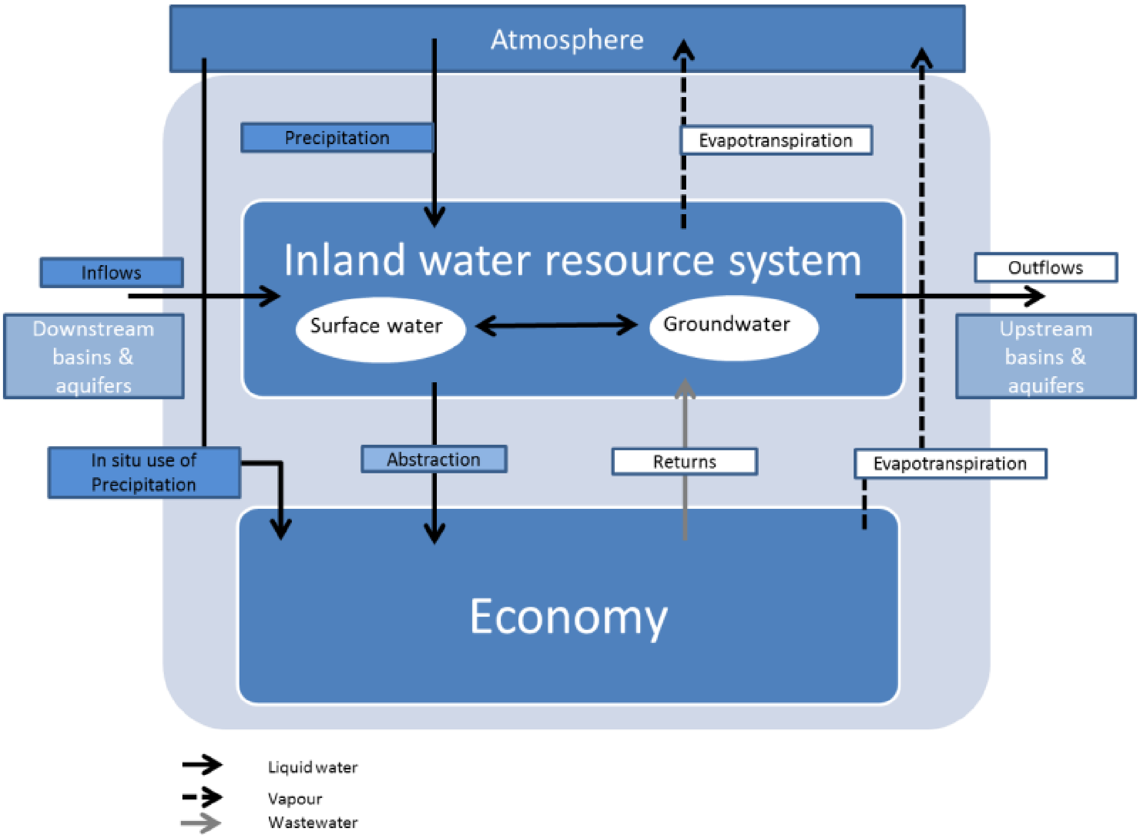

Figure 3-1: Flows between the Economy and the Environment captured by the water accounts

3.1 Components of Economic Accounts of Water

The analysis below is based on the System of Environmental-Economic Accounting for Water (SEEA Water) framework (UN, 2012). The SEEA framework is based on practical experience and best practice and standardises the methods used in water accounting. The SEEA-water has been recommended as the International standard for water statistics. It has been designed to link economic information with hydrological information for integrated analysis. The framework comprises the main categories as per the figure below. SEEA-Water functions in support of IWRM as it assists policymakers in making informed decisions on subjects such as allocating water resources efficiently, improving water efficiency, understanding the impacts of water management on all users and getting the most value for money from investing in infrastructure etc.

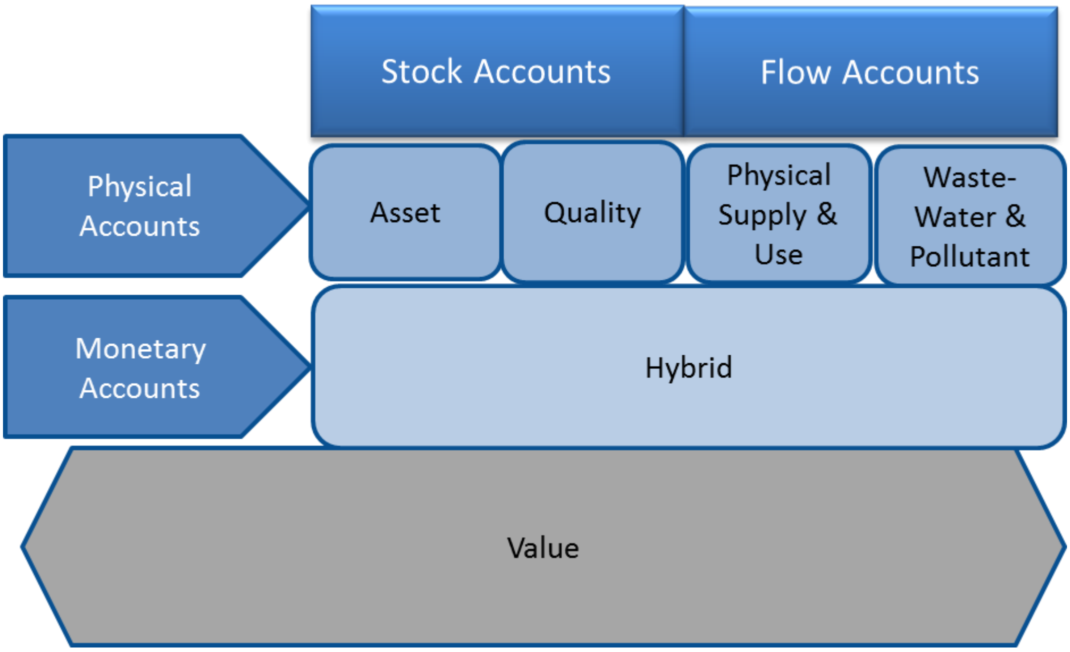

Figure 3-2: Components of Economic Accounts of Water

3.1.1 Asset Accounts

This section comprises information on physical stocks or asset account of water. The stock of water is usually reflected as reconciliation between the opening balance and closing balance for a period of time. The movement of stock relates to increases such as precipitation, inflows, returns and decreases such as abstraction, outflows and evapotranspiration. The asset accounts also include infrastructure put in place to abstract, distribute, treat and discharge water. The asset accounts can be used for the management of shared water in the basin as the accounts facilitates the formulation and monitoring of policies for the allocation of water among the different regions in the basin.

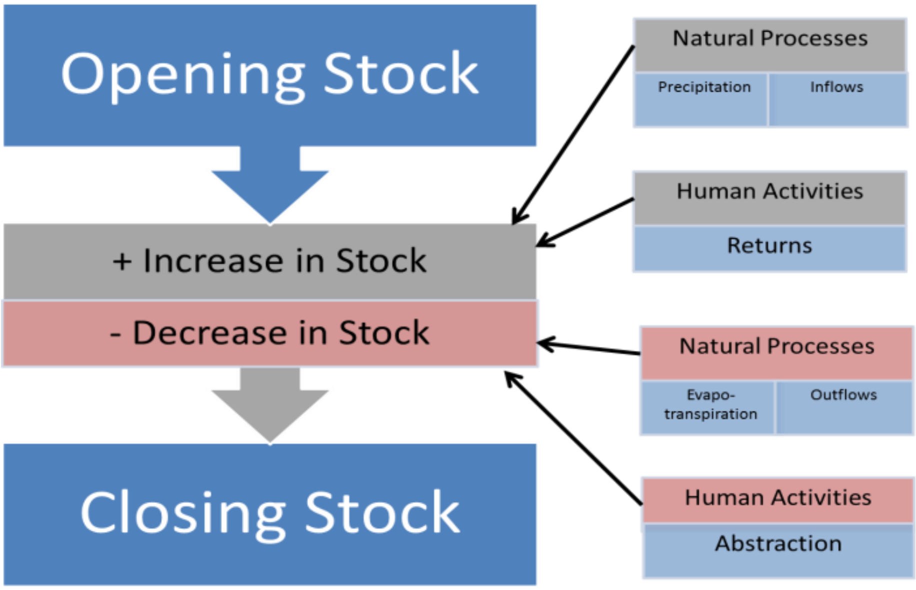

Figure 3-3: Components of the Asset Accounts

The volume of water being held as stock in a river is calculated using the flow rate and the average retention time of water to the middle of the rivers reach. The centre of the river reach is used to negate overestimation of the total volume within the river. This is because the flow rate is not constant throughout the course of the river,

In this research, evapotranspiration is calculated as the mass balance of stocks entering and leaving the asset account. Therefore, precipitation + inflows + transfers in, subtracted by abstraction, outflows and transfers out is equivalent to the evapotranspiration. The surface – groundwater interface is assumed to be constant within a single year.

3.1.2 Physical water supply and use tables

This section provides information on volumes of water exchanged between the economy and the environment (abstraction and returns) and within the economy (supply and use within the economy).

The table used to generate this section is divided into two parts to reflect the supply and use separately. The Supply of water reflects the flow of water within the economy; namely transfers between economic users. The table also reflects the flows from the economy to the environment e.g. discharge of water into the environment.

Physical Supply			Agriculture	Industrial	Power generation	Mining	Urban wastewater	Other
Within the economy								
	Supply of water to other economic units							
		of which						
		Reused water						
		Wastewater to sewerage						
To the environment								
	Returns/ Losses in distribution due to leakages							
		To water resources						
		To other sources (e.g. Sea water)						
Total Supply of water								
Consumption								

Figure 3-4: Components of the Physical Supply table

The physical use part of the table describes the flow of water from the environment to the economy e.g. abstraction from the water resources by the different users. The table also summarises the flow of water within the economy (transfers between the economic users).

Physical Use			Agriculture	Industrial	Power generation	Mining	Urban wastewater	Other
From the environment								
	Total abstraction							
		From Water Resources						
		From Other sources						
Within the economy[1]								
	Use of water received from other economic units							
		of which						
		Reused water						
		Wastewater to sewerage						
Total Use of water								

Figure 3-5: Components of the Physical Use tables

3.1.3 Quality Accounts

This section describes the stock of water in terms of its quality. Not many countries have implemented Quality Accounts. The SEEA-Water accounts has thus still to draw conclusions on best practices in this regard. This report analysis the quality of the water in the different water resources based on indicators such as Electrical Conductivity (EC) to provide an indication of salinization of water resources, sulphate as an indicator of mining impacts, chloride as an indicator of agricultural impacts, sewage effluent discharges to indicate industrial impacts and other indicators which are explored in the section below.

Quality Assessment	Quality Classes			
	Ideal	Acceptable	Tolerable	Unacceptable
	Mm³/a			
Stock of water				
Electrical Conductivity (EC) mS/m				
Sulphate (SO_4) mg/l				
Chloride (CL) mg/l				
Ammonia (NH_3-N) mg/l				
pH				
Ortho-Phosphate (PO_4-P) mg/l				

Figure 3-6: Components of Quality Accounts

3.1.4 Emission Accounts

This section provides information on amounts of pollutants added to waste water by the different economic units as result of their economic activities. This applies to pollutants added to the environment either directly (without treatment or through a treatment plant) or indirectly through sewerage. This is measured in terms of quantities of a pollutant released during a certain period.

Emissions	Agriculture	Industrial	Power generation	Mining	Urban wastewater	Other
Gross emissions						
Direct emissions to water						
Without treatment						
After on-site treatment						
To inland water resources						
To the sea						
To sewerage						
Reallocaton of emissions						
Net Emissions						

Figure 3-7: Components of Emission Accounts

3.1.5 Hybrid and economic accounts

This section contains the information on the economy of water in monetary terms. It is referred to as "hybrid" as it contains a combination of different types of measurement units in the same accounts. The accounts consist of costs associated with water and supply, revenue generated for wastewater treatment, infrastructure costs, their associated maintenance costs, and financing of these costs.

Some of the key data sets required to compile these accounts include:-

- Total income generated by each economic sector (value added)
- Amount of water used to generate this income
- Cost of production
- Stock of water and sanitation assets (infrastructure)
- Investment in new water and sanitation infrastructure
- Tariffs
- Emission produced (pollution) during the production process

3.1.6 Value

The value portion of economic accounting for water includes the investigation of the hybrid account data (costs and revenue collected of water supply, GDP contribution of each sector etc.) and converts this into information which is useful at a policy and planning level. The interpretation of the data into key messages regarding the efficiency of water use within and between sectors is carried out. In addition to the economic value of water use, the social aspects of water use are investigated. The social value of water use per sector considers the employment of each m³ of water used. In some respects the type of employment (semi-skilled, permanent, contract) is also of relevance. Therefore, these additional considerations include the productive use of the water, the value of the water in stabilising an economy and the value of water in ensuring social upliftment. This portion of the method is less prescriptive, and is highly dependent on data availability.

3.2 WATER ACCOUNTS ANALYSIS

The water accounts for the Orange Senqu River Basin have been split into five geographical areas; namely Namibia, Botswana, Lesotho, Vaal Water Management Area (WMA) and the Orange WMA. The data has been collected from various sources and input into the conceptual model for Water Accounting. This has been challenging as the structure of hydrological models are somewhat different to that of the accounting model resulting in different formats that needs to be transposed accordingly. This has also required the hydrological modelling team to undertake model runs that were different in focus to those that would be normally undertaken for hydrological purposes. The complex hydrological schematics for the basin is in the process of being re-configured so as to produce a more simplistic and collective network of inputs and outputs. Thus, the Water Accounts is a live model subject to change based on results from the hydrological modelling.

The results here are based on data collection from various sources for example, the Integrated Strategic Plan, the Department of Water Affairs, IWRM Phase 1 reports and various other reports. The compilation of the accounts has been constructed based on the applicable data available. The time frame has been from the first available date of information. In some cases this is 1920 (for dam levels and river flow rates), while in other cases, in particular the billing and infrastructure cost information, this has been over the previous 20 years.

3.3 ASSET ACCOUNTS

Water asset accounts describe the stocks of water resources and their changes during a particular period of time. The water resources found in the basin can be split between groundwater, and surface water. Surface water relates to all water that flows (or stored) over the ground surface. Groundwater refers to water beneath the surface which collects in layers of underground formations called aquifers.

The table below gives an overview of the total (ground and surface) water stocks for the region. The opening stock represents the water stored in dams within the respective catchments. Note that due to limited available information on groundwater, there is substantial missing data for Botswana. This information is currently being collected from specialists in this field.

The Orange River Catchment represents the largest opening stock, followed by the Vaal River Catchment. In terms of abstraction, the largest use of water stems from the Vaal River Catchment, followed by the Orange.

Table 3-1: Overview of Orange Senqu basin Asset Account

Asset Accounts (Mm³)	Vaal	Orange	Namibia	Botswana	Lesotho
Opening Stock	38 641	28 955	4 002	5 925	11 543
Increase in stock					
Precipitation	87 825	103 942	12 255	15 800	34 038
Inflows	7 302	13 476	1 713	614	7 475
Transfers in	1 034	2	54	-	-
Return flows	755	181	15	9	18
Decrease in stock					
Abstraction	3 557	2 554	163	188	108
Evaporation/ Actual evapotranspiration	85 634	100 744	11 846	16 186	36 221
Transfers out/Outflows	7 726	14 303	2 028	48	5 202
Closing stock	38 641	28 955	4 002	5 925	11 543

Note that this data required manipulation in order to ensure the mass balance remained in a steady state. See Appendix 8.1 for the results of the Asset Accounts.

3.4 Physical Water Supply and Use Tables

The objective of this section is to provide an overview of the water flows in physical units within the economy and between the environment and the economy. This helps in assessing and monitoring the pressure on water quantities by the different users who are responsible for the abstraction and discharge of water into the environment.

The flows from the environment to the economy refers to the water abstracted from groundwater and surface water (Rivers and Dams) by the different economic units (Agriculture, Mining, Industrial, Power generation and Urban wastewater).

The flows within the economy refer to water flowing between the different economic units. This includes wastewater supplied to treatment facilities before being discharged into the environment.

The flows to the environment refers to returns or losses in distribution e.g. evaporation, leakages and illegal tapping. If these losses return back to the environment to be used again, these losses are referred to as return flows.

The difference between the water use and water supply is referred to as water consumption. This is due to use of water in products, plants, evaporation and general consumption of water by households or livestock. This water does not return to the water resources.

A summary of the total regional demand and supply per sector is given in the table and figure below.

Table 3-2: Overview of The Orange-Senqu River Basin water abstraction

Total Abstraction (Mm³/annum)	Botswana	Lesotho	Namibia	Vaal	Orange
Urban	-	49	11	1 201	79
Industrial	-	17	4	398	6
Mining	34	-	7	115	58
Power Stations	-	-	-	246	-
Strategic industries	-	-	-	134	-
Irrigation	32	35	119	1 318	2 353
Rural domestic	70	7	0	34	13
Livestock	47	0	21	112	45
Tourism	-	-	1	-	-
Other	6	-	-	-	-
Total	**188**	**108**	**163**	**3 557**	**2 554**

Table 6 is depicted graphically in the figure below. Note however that additional information regarding groundwater in particular is still required. Therefore these numbers are indicative of the current understanding of the system.

Agriculture is the largest user of water in the basin. However, industrial water use does represent a large portion of water use in the Vaal. Due to the high returns of industrial water, this does not represent a high consumptive use. However, the quality implications of industrial water returns do have a negative impact on quality in the basin.

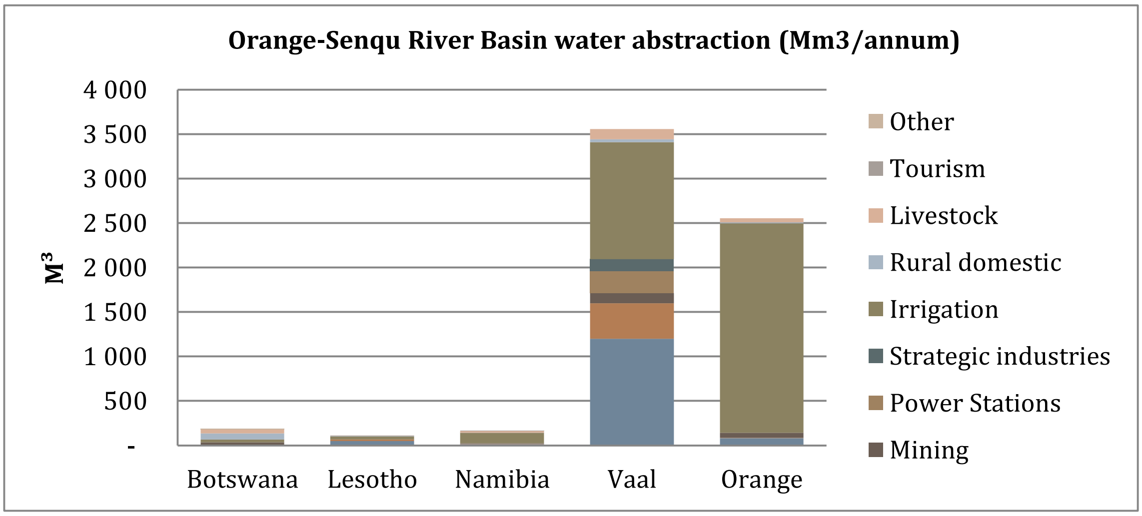

Figure 3-8: Orange-Senqu River Basin water abstraction (Mm³/annum)

The table in Appendix 8.2 describes the flows of water mentioned above. The level of detail is based on the available information.

3.5 Quality Accounts

Quality accounts describe the quality of the stock of water resources based on certain characteristics analysed. The structure is similar to the Asset Accounts above. The analysis of the quality of water is essential as this affects the usability of the water. There is no specific standard for recording quality. The analysis below takes into account the following indicators of quality:

- Electrical Conductivity (EC): provides an indication of salinization of water resources
- Sulphate (SO_4): provides an indication of mining impacts
- Chloride (CL): provides an indication of agricultural impacts, sewage effluent discharges and industrial impacts;
- Ortho-Phosphate (PO_4-P): provides an indication of the nutrient levels in water resources
- Ammonia (NH_3-N): provides an indication of toxicity
- pH: provides an indication of mining impacts

The volumes of water in the Asset Accounts above are split into quality areas from ideal to unacceptable per indicator above.

Data regarding surface water quality, using electrical conductivity as an indicator, is limited to the Orange, Vaal and Namibian catchments within The Orange-Senqu River Basin as indicated in the figures below. The analysis is kept to these three regions alone due to data unavailability.

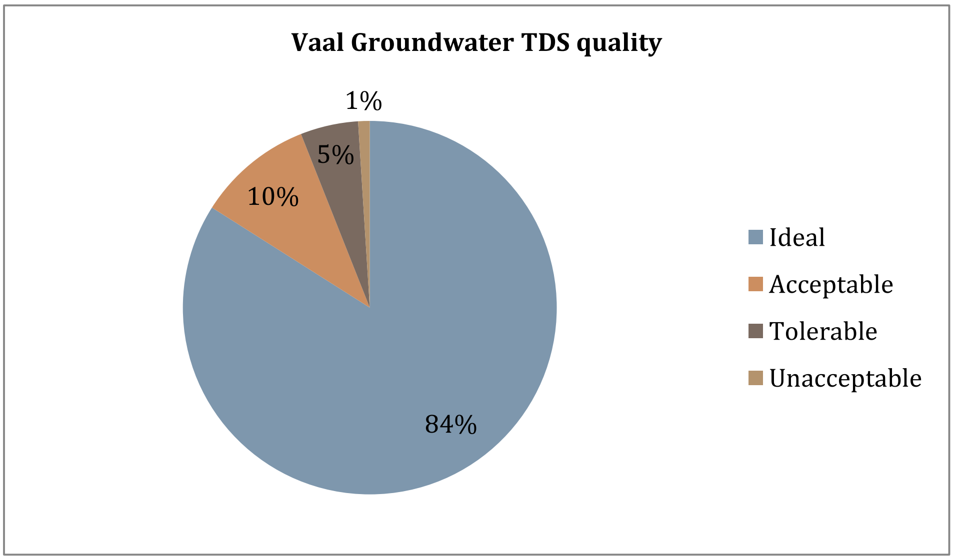

Figure 3-9: Vaal groundwater TDS quality

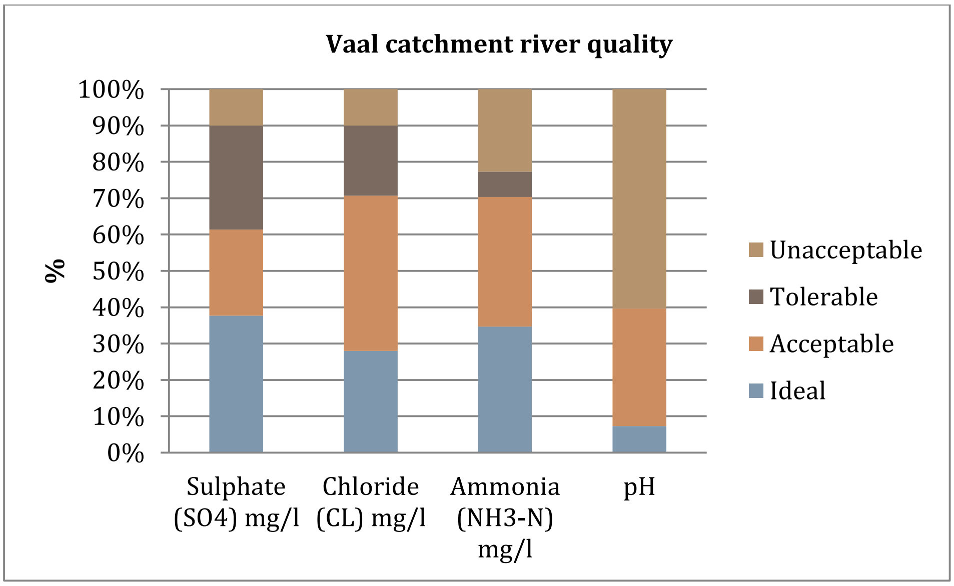

Figure 3-10: Vaal catchment river quality

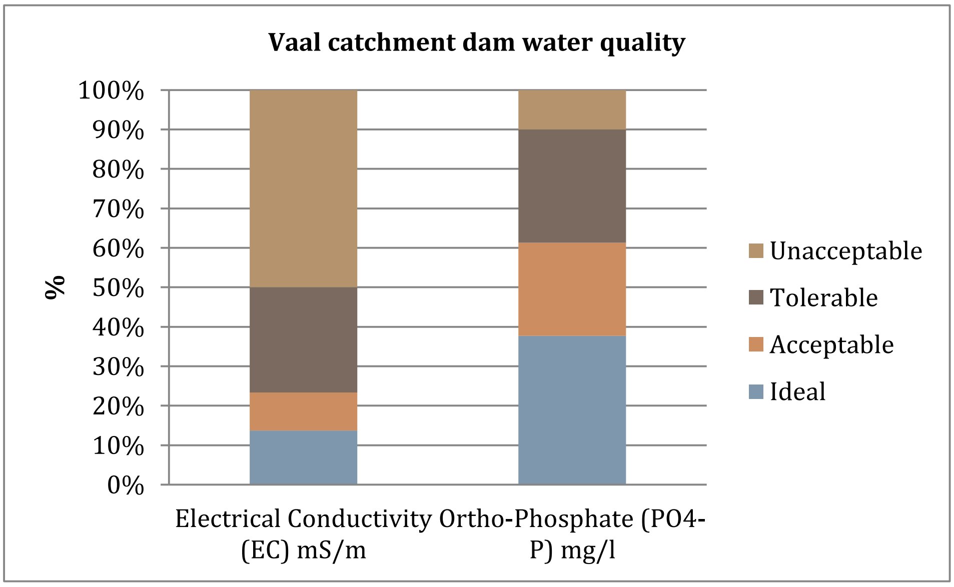

Figure 3-11: Vaal catchment dam water quality

The Vaal catchment has a significantly high level of unacceptable water quality. This is as a result of the amount of industry and urban water abstraction without sufficient treatment before being returned to the catchment.

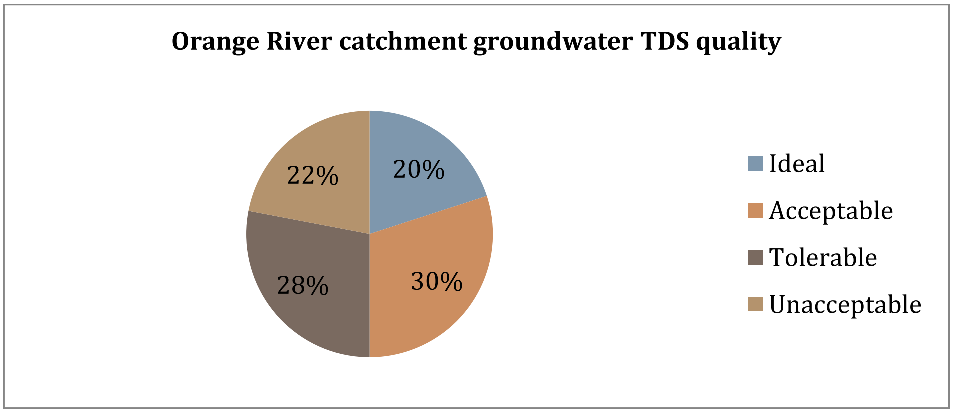

Figure 3-12: Orange River catchment groundwater TDS quality

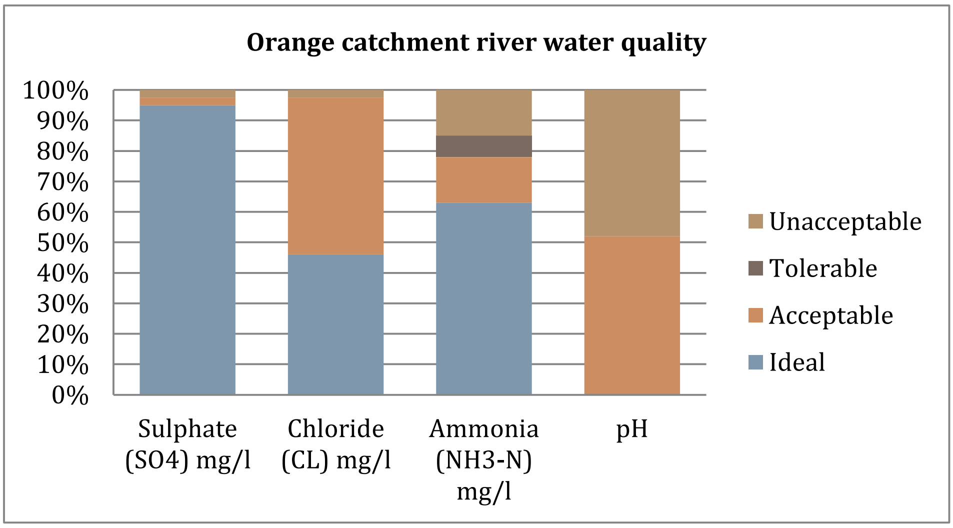

Figure 3-13: Orange catchment river water quality

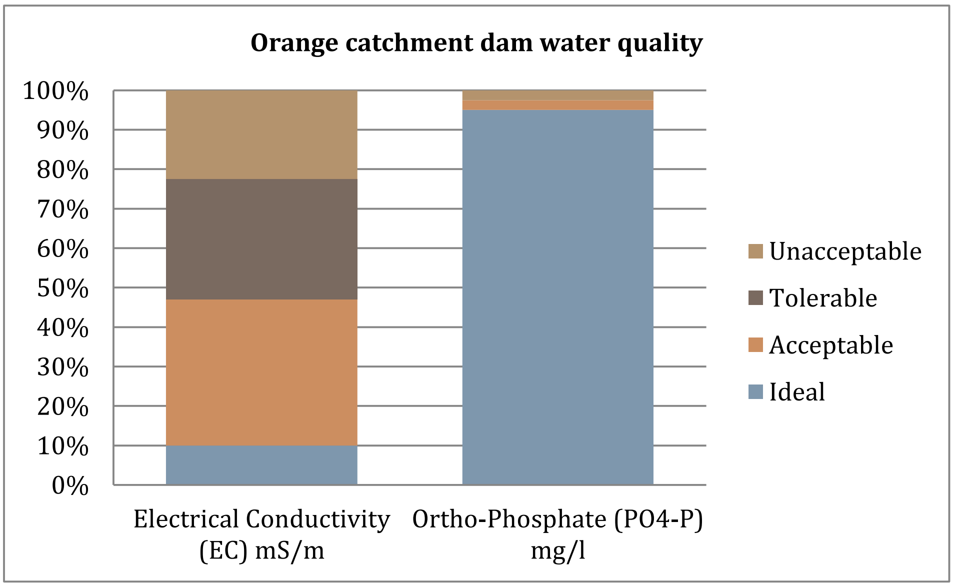

Figure 3-14: Orange catchment dam water quality

Water quality in the Orange River Catchment is significantly better than that in the Vaal. 23% of the river is deemed unacceptable. This is an improvement from 50% in the Vaal.

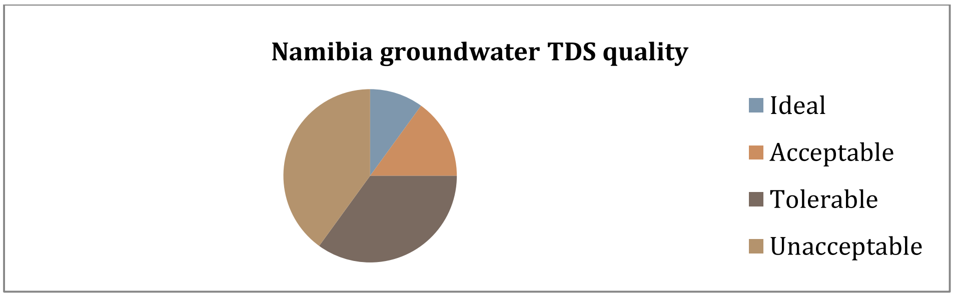

Figure 3-15: Namibia groundwater TDS quality

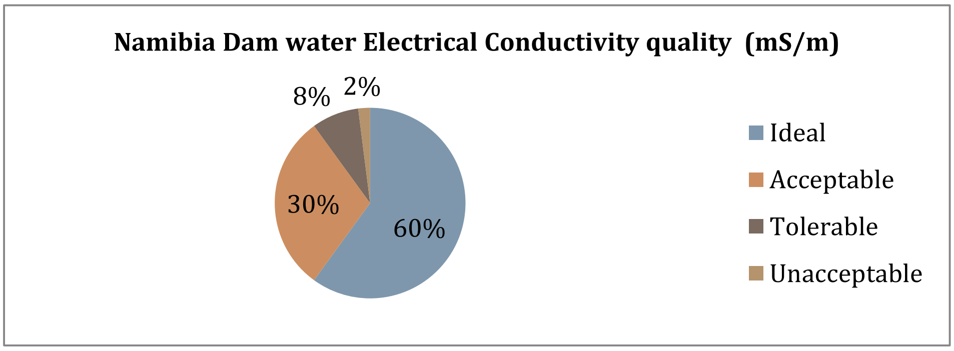

Figure 3-16: Namibia dam water electrical conductivity quality (ms/m)

Water quality in Namibia is mostly ideal. Resources in the Fish River are not negatively impacted by industry or agriculture as these sectors of the economy are not significant in the catchment, and the majority of resources are protected within National Parks.

See Appendix 8.3 for the full results of the water quality analysis.

3.6 Emission Accounts

Emissions are separated by water user. Urban, industrial, mining, power stations, strategic industries, irrigation, rural domestic, livestock, tourism and other are all considered according to where runoff or wastewater discharge is emitted to. Direct emissions to water can take place following treatment on site or without treatment. Wastewater which is not directly discharged into water is first sent to sewerage.

The majority of data regarding emissions stems from the Vaal catchment (755 Mm^3/annum). The majority of the emissions are urban (353 Mm^3/annum), of which 84% are emitted to sewerage, while the remaining 15.7% are discharged directly into surface water. This is followed by irrigation (134 Mm^3/annum) and then industrial (117 Mm^3/annum).

On the Orange River, the majority of the emissions are irrigation (167 Mm^3/annum) of 181 (Mm^3/annum). The same is true for Namibia (10 Mm^3/annum) or 15 (Mm^3/annum). In Botswana the emissions from mining are double that or irrigation 6 Mm^3/annum vs. 3 Mm^3/annum.

In Lesotho, the majority of emissions stem from urban waste water. 67% of the emissions are not treated in a sewerage works, and are discharged directly to surface water.

The pollutants added to waste water by the different economic units is shown in Appendix 8.4.

3.7 Hybrid and Economic Accounts

The hybrid account includes information from a number of sources and measurement units. The accounts consist of costs associated with water and supply, revenue generated for wastewater treatment, infrastructure costs, their associated maintenance costs, and financing of these costs.

Besides GDP, in Orasecom, there is only information on the cost of water supply, infrastructure assets and investment in future infrastructure for the Vaal and Orange catchments in South Africa.

The GDP contribution per sector at a high level is as shown in the following figure. The high level indication of sectors helps to identify the overall nature of the economy in each country. Resource dependent economies, especially water-dependant, have significantly different development pathways to others.

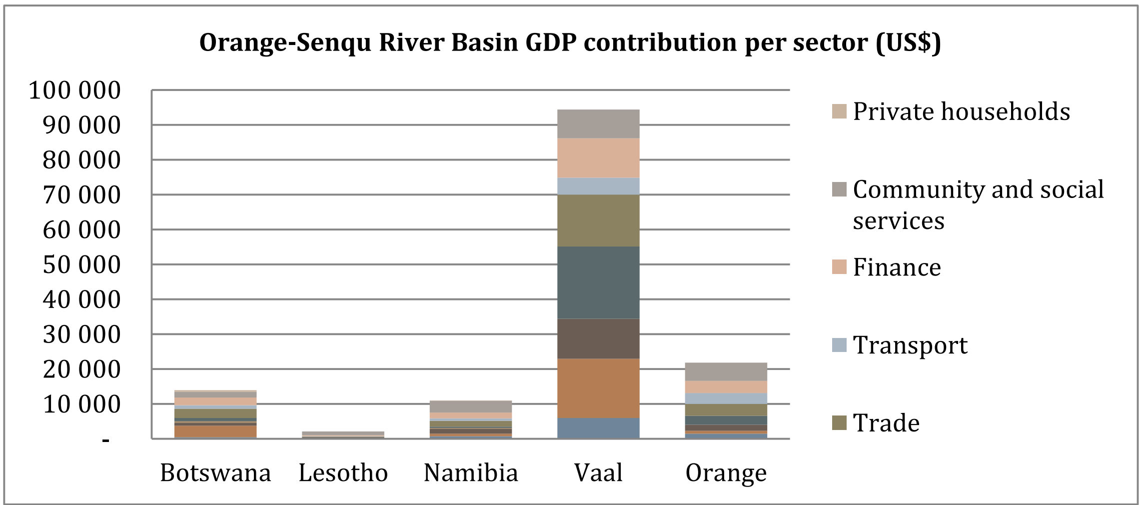

Figure 3-17: Orange-Senqu River Basin GDP per sector (US$)

The revenue and costs of water supply are shown in the following figure. Revenue is according to what is billed and not received. These numbers will be updated as further data becomes available.

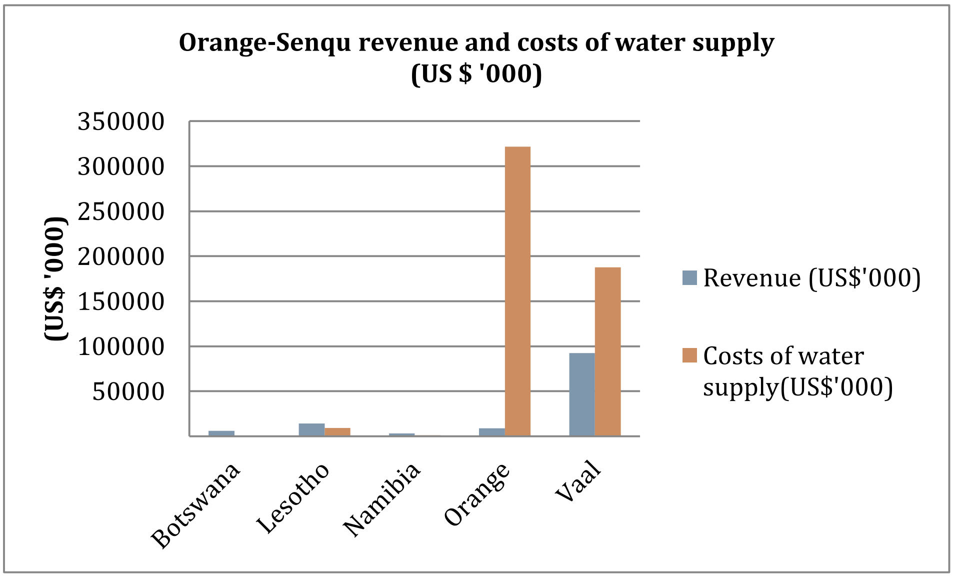

Figure 3-18: Orange-Senqu revenue and costs of water supply (US $ '000)

In addition to the costs of water supply, the infrastructure required to supply water is important. Each country within The Orange-Senqu River Basin has significantly different amounts of infrastructure invested in the catchment. The infrastructure asset values are depicted in the figure below. The planned investments in infrastructure are also shown in the figure below.

Note that the figure does not contain the future investments required for the Lesotho Highlands Water Project (LHWP). The LHWP (South Africa portion of the Delivery Tunnel North) total project cost is approximately R 16.8 billion and is fully covered by the payments from water users via water sales from the Vaal River System. The financing is explicitly government guaranteed. The South African Government is responsible for the full water costs incurred by TCTA and the Lesotho Highlands Development Authority.

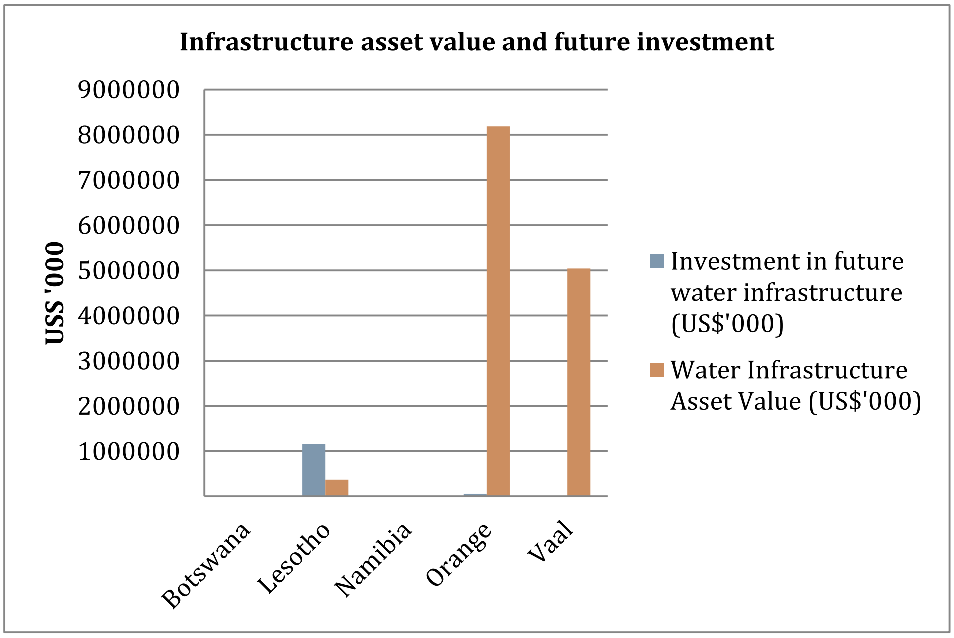

Figure 3-19 : Infrastructure asset value and future investment

Details of current infrastructure asset values as well as the future investments of other areas within the basin are currently being clarified before combining them with the hybrid model.

The hybrid accounts results are in the Appendix at the end of this document.

4. Water footprinting methodology

4.1 Background to Water Footprints

The water footprint concept was introduced in 2002 by Arjen Hoekstra at UNESCO-IHE, and has been further developed at the University of Twente and by the Water Footprint Network. A water footprint is a measure of freshwater used to make a product, measured throughout the entire supply chain. This includes the upstream processes for manufacturing raw materials, direct operations, and downstream consumer use of a product. The first water footprint studies were conducted around nations, similar to virtual water studies, in order to understand direct and supply water requirements to support a country's consumption. Water footprints have since gained traction and are now also conducted in the private sector around products and companies, and also commodities to help companies understand the supply market.

The concept of a "water footprint" was proposed as an alternative indicator of water use. A water footprint is different from traditional water statistics in that it looks at consumptive water use instead of water withdrawals (Hoekstra, 2003). It has been argued that examining consumptive, or in other words evaporative, water use is more relevant because parts of water withdrawals return to the water bodies from which they were taken and these parts can be reused.

The water footprint of a product is similar to what has been called alternatively the 'virtual-water content' of the product or the product's embedded, embodied, exogenous or shadow water (Hoekstra and Chapagain, 2008). The terms virtual-water content and embedded water, however, refer to the water volume embodied in the product alone, while the term 'water footprint' refers not only to the volume, but also to the sort of water that was used (green, blue, grey) and to when and where the water was used.

The water footprint of a product is thus a multidimensional indicator, whereas 'virtual-water content' or 'embedded water' refer to a volume alone. We recommend using the term 'water footprint' because of its broader scope. The volume is just one aspect of water use; place and timing of water use and type of water used are as important. Besides, the term 'water footprint' can also be used in a context where we speak about the water footprint of a consumer or producer.

It would sound strange to speak about the virtual-water content of a consumer or producer. We use the term 'virtual water' in the context of international (or interregional) virtual-water flows. If a nation (region) exports/imports a product, it exports/imports water in virtual form. In this context one can speak about virtual-water export or import, or more general about virtual-water flows or trade.

Definition of Water Footprint (The Water Footprint Assessment Manual, Hoekstra 2011.)

The three components of a water footprint that represent water use and quality are referred to as blue, green and grey water footprints.

A **blue water footprint** refers to the volume of surface and ground water required for the production of a good or service, and is the freshwater traditionally thought of when considering water resources. For the purpose of this assessment, blue water is also the most relevant given that it refers to the Orange-Senqu water abstracted and not returned to the water system.

A **green water footprint** refers to the volume of rainwater used to produce a product which does not run off or recharge groundwater, but is stored in or temporarily on top of the soil. Although it is important to consider green water use generally, for the purpose of this water footprint assessment, green water should be considered from the perspective of opportunity costs as most of the featured green water is on range land which would otherwise not likely be used for agricultural production.

A **grey water footprint** addresses pollution, and represents the volume of freshwater that is required to dilute or assimilate the load of pollutants based on existing ambient water quality standards.

A country's water footprint of production takes into consideration the use of domestic water resources only. However, when considering the water footprint of a country from a consumption perspective, one must consider both the internal and external portions of the water footprint. The internal water footprint of national consumption refers to the portion of the water footprint of consumption that is derived from the appropriation of domestic water resources (for producing the goods and services). The external water footprint of consumption, on the other hand, refers to the portion of the water footprint that is derived from the appropriation of water resources of other nations for the production of goods and services that are imported into and consumed within the focus country.

In this assessment, however, the focus will be on water footprints of production as well as virtual water flows (specifically virtual water exports).

4.2 METHODOLOGY

Data from the Water Footprint Network (WFN) has formed the basis of this water footprint analysis. For water footprints of national production and national virtual water exports, the data was taken directly from the database. Whereas in the case of the water footprints for the Orange Senqu region, the equivalent water footprints were calculated using a bottom-up approach, described in later sections. However, while calculating the latter, it was determined that certain of the WFN data must be incorrect. This was especially true for Lesotho. In order to accurately rectify these data, a full bottom-up recalculation of the national water footprints of production and national exports would be required, however to do so would not be in the scope of this analysis. Instead, a top-down approach was taken to reduce inaccuracies, using key assumptions around water requirements for production, changing production levels and average blue water-to-green water splits for agricultural production. These assumptions will be described more fully in the relevant sections.

4.3 National water footprints of production

Typically the most significant contributor to a country's national water footprint of production is water use in agriculture. Although there are exceptions to this, South Africa, Namibia, Lesotho and Botswana certainly exemplify this norm.

Green and blue water use for crop production (excluding animal grazing and water supply) in South Africa forms almost 80% of the country's total green and blue water footprint. If animal grazing and water supply is added to this, South Africa's total blue and green agricultural footprint increases to approximately 99% of the total green and blue water footprint of national production.

In Lesotho and Namibia the equivalent crop production water footprint ratios are approximately 63% and 53% respectively. However, in Botswana, given the relative aridity of the country and thus the preference for rangeland over cropland, water use connected to animal grazing and water supply forms a much greater percentage of the total green and blue water footprint (at approximately 77%) than does water use in crop production. This is mostly made up of green water (rainfall) inherent in grazing land.

The total blue and green water footprints of national production for each of the countries that form part of the Orange-Senqu River Basin are illustrated in Figure 4-1 below. It should be noted that for the purpose of this analysis, grey water has not been included in the water footprint totals. Although grey water is an important element of water footprint analysis, it is also a theoretical concept and thus cannot effectively be summed into the blue and green water footprint total. In addition, this analysis has also focussed on the agricultural sector from a footprint perspective, which is traditionally a small contributor to a country's total grey water footprint relative to the urban and industrial sectors. The latter sectors will be better dealt with in the accounts section of the project. And while grey water is an important issue for consideration, it still forms a relatively small portion of the accounts, and is also only truly relevant to South Africa.

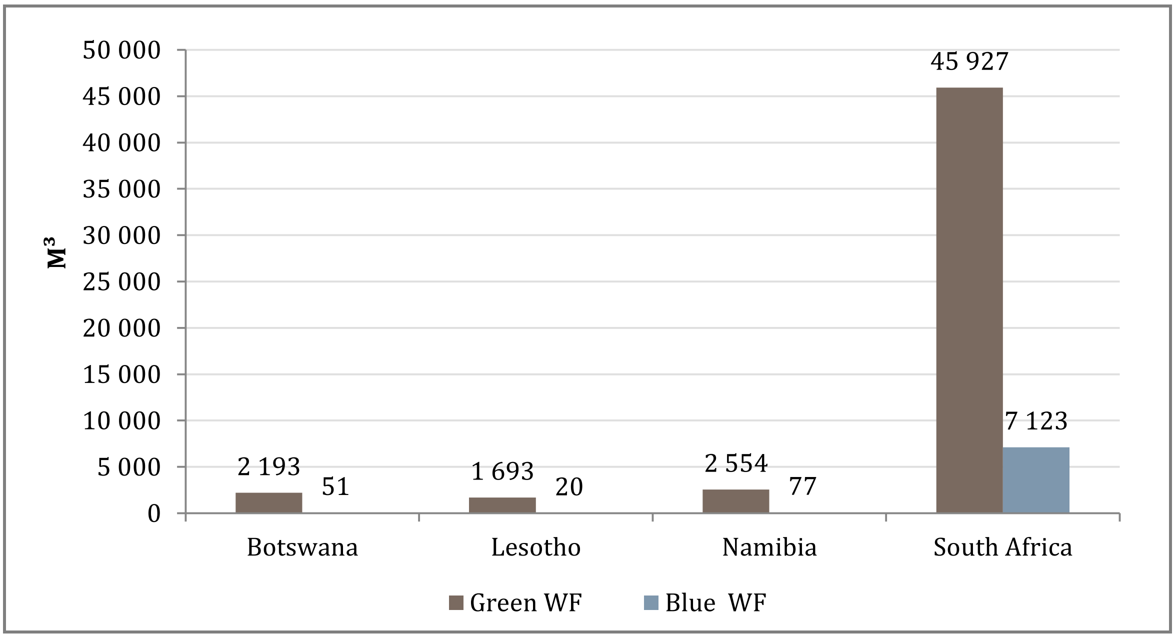

Figure 4-1. National water footprints of production, ave. 1996-2005 (Source: WFN, 2013)

Of these countries, South Africa is by far the largest producer of agricultural products. As such, it is also the largest user of water for agricultural activities. Figure 4-2 below provides the water footprint of production, split by sector for each of the countries. Here the magnitude of water use in agricultural production (particularly in South Africa) is clearly evident (noting that water use in this context refers to water that is not returned to the system).

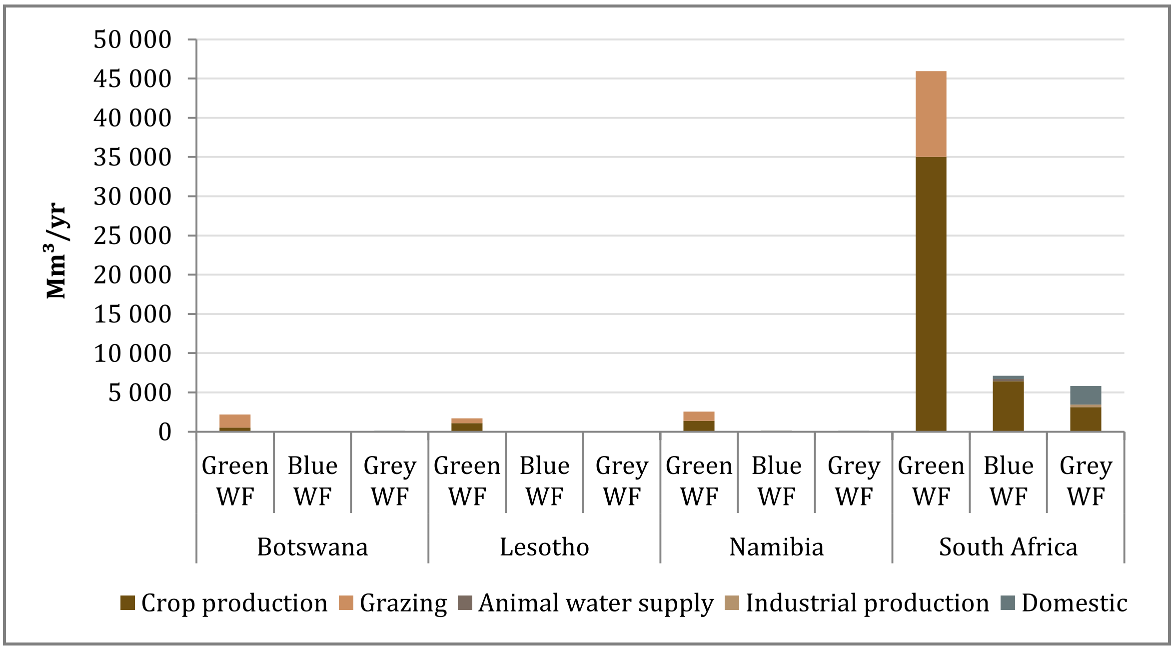

Figure 4-2. Water footprint of production splits, ave. 1996-2005 (Source: WFN, 2013)

4.4 NATIONAL VIRTUAL WATER EXPORT

Of the water used in the production of goods and services in these countries, a portion is exported in the form of "virtual water" or water inherent in the product's production process. Virtual water flow can be very useful for both water abundant and water scarce countries. For the former, for instance, water intensive crops can be grown and exported to water scarce regions, thereby generating foreign exchange through comparative advantage which can then be channelled into other purposes. For the latter, by importing water intensive crops, so can these countries save their limited resources and reallocate them to other uses including the preservation of environmental flows.

Each of the Orange-Senqu countries' total export water footprints for crop and animal products (split into blue and green water) are provided in Figure 4-3 and Figure 4-4 below. The graphs also show the net blue and green virtual water export flows for each of the countries. These net values indicate whether or not the country is a net importer or exporter of virtual water (a negative value implies that the country is a net importer of virtual water). In the case of Lesotho, it was determined that the WFN data for the country's virtual water export must be incorrect given that the blue water value greatly exceeded their combined blue water footprint of national production and virtual blue water import. To rectify this discrepancy the ratio of the blue-to-green water split for the export figure was recalculated using the same blue-to-green water ratio for the country's national water footprint of production. Although it cannot be assumed that the recalculated split is perfectly accurate, it does represent a more reasonable proxy for the country's exports.

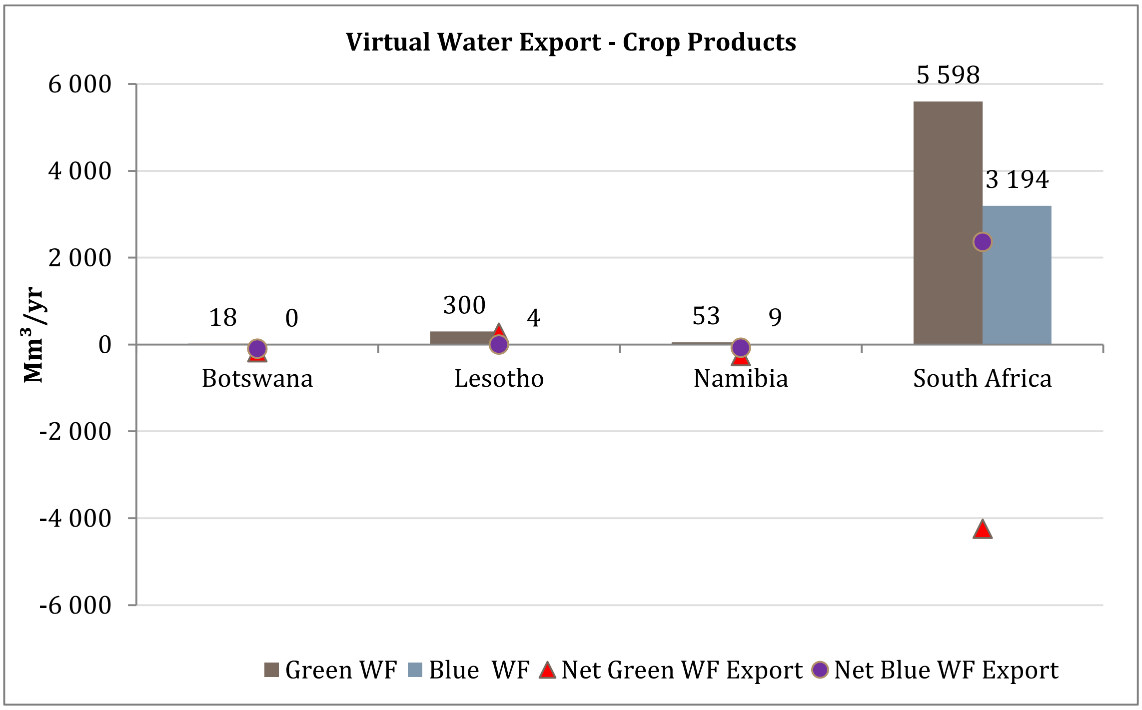

Figure 4-3. Virtual water export for crop products, ave. 1996-2005 (Source: WFN, 2013)

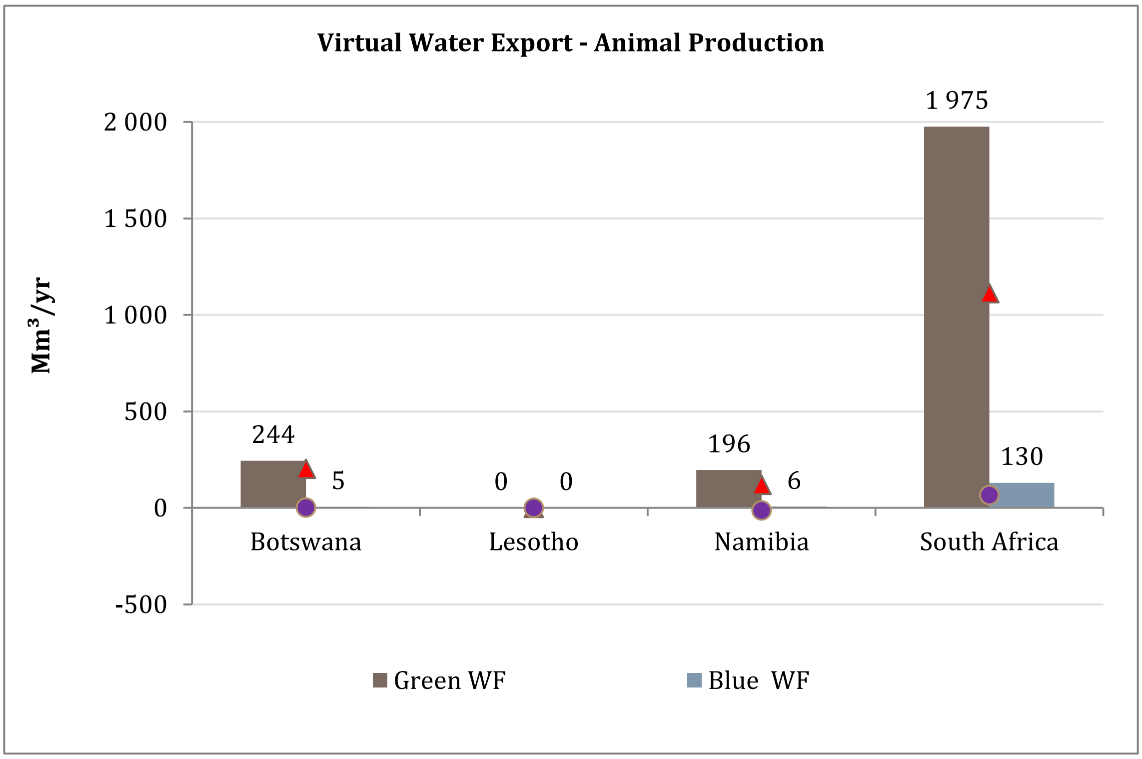

Figure 4-4. Virtual water export for animal production, ave. 1996-2005 (Source: WFN, 2013)

Over the years under analysis, Botswana, Namibia and South Africa all feature as net importers of virtual water in agricultural products (mostly made up of green water imports) while Lesotho is a net exporter. A breakdown of the net import or export status of each of the countries per agricultural category is provided in Table 4-1. Virtual water import and export status of Orange-Senqu countries below.

Table 4-1. Virtual water import and export status of Orange-Senqu countries

	Crop products		Animal products	
	Green WF	Blue WF	Green WF	Blue WF
Botswana	Net importer	Net importer	Net exporter	Net exporter
Lesotho	Net exporter	Net importer	Net exporter	Net exporter
Namibia	Net importer	Net importer	Net exporter	Net importer
South Africa	Net importer	Net exporter	Net exporter	Net exporter

On an absolute basis, South Africa's total virtual water footprint of its exported crop and animal products is significantly higher than those of the other Orange-Senqu countries. Thus, particular attention ought to be given to South Africa's import and export water footprint given the magnitude of these footprints relative to the other countries. The most significant contributor to South Africa's virtual water export is maize, with the bulk of the water footprint for the crop being made up of green water (most of the crop's planted land is rain fed - 91% versus 9% irrigated on a national level).[5] The blue and green water footprints of regional maize production are shown in the table below. Regions of particular relevance to this assessment include the Lower, Middle and Upper Vaal, and the Lower and Upper Orange.

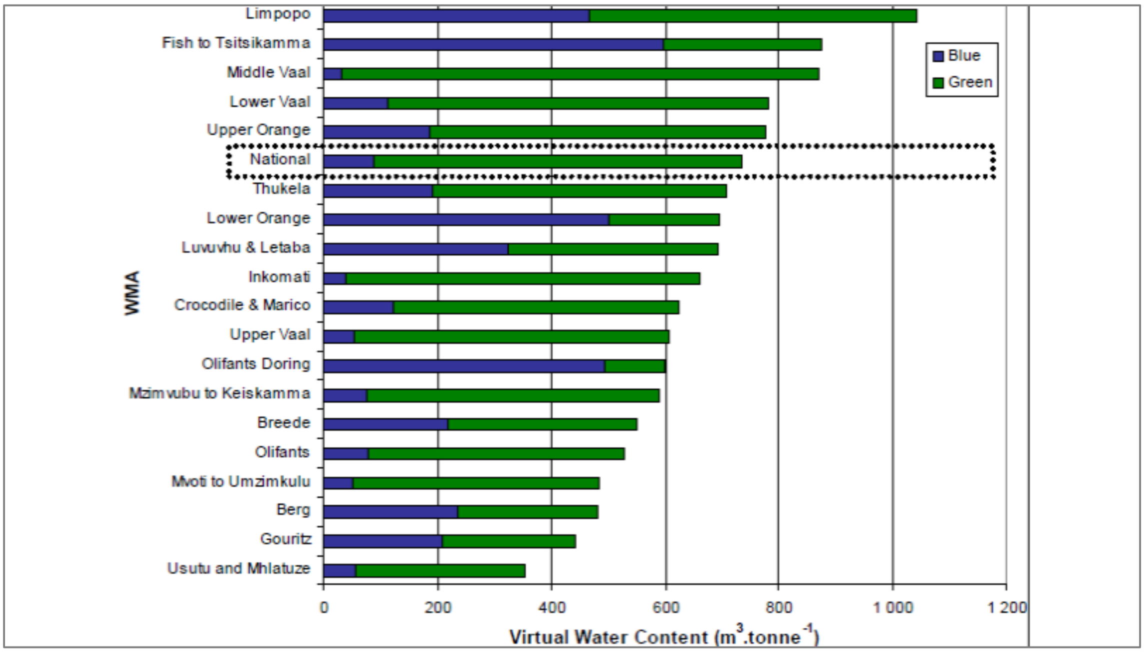

Figure 4-5. Virtual water content of South African maize on a WMA basis (Source: http://www.hydrol-earth-syst-sci-discuss.net/5/2727/2008/hessd-5-2727-2008.pdf)

[5] http://www.hydrol-earth-syst-sci-discuss.net/5/2727/2008/hessd-5-2727-2008.pdf

However, it should be noted that water footprints of imports and exports can vary considerably from year to year alongside changing production levels. This is especially true of South Africa given its fluctuating production of maize, coupled with the dominance of the crop in the country's overall virtual water exports. Figure 4-6 below illustrates the country's trade balance in maize over the past decade and a half. The increasing levels of export volumes in recent years could translate into a shift from being a net virtual water importer to a net virtual water exporter.

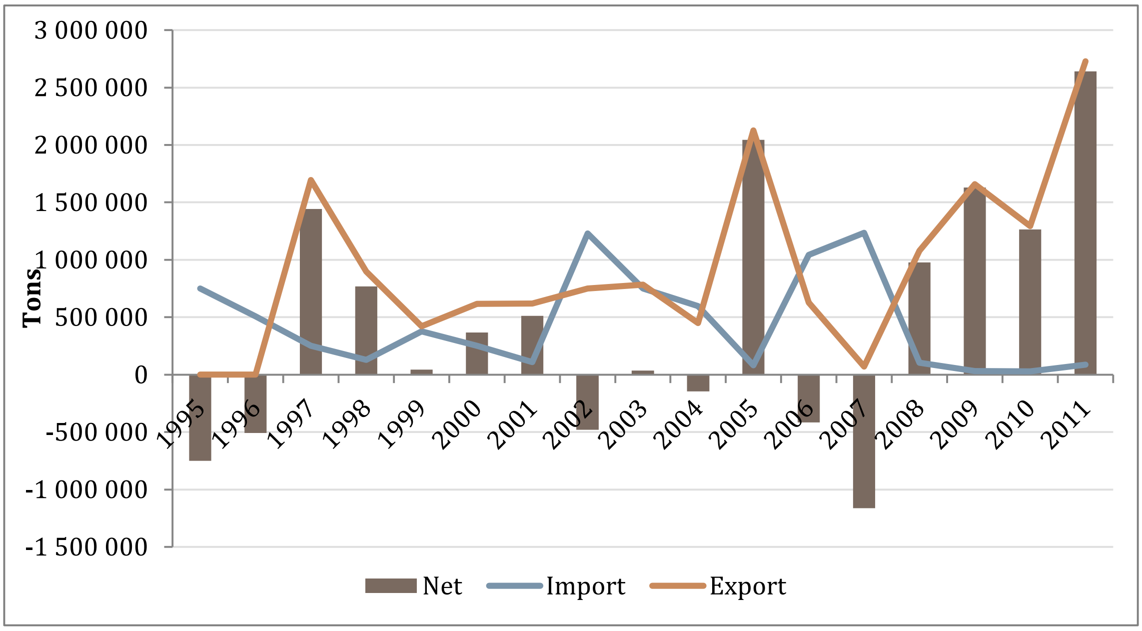

Figure 4-6. Maize trade in South Africa (Source: FAO, 2013)

The table below shows the net virtual blue water savings in SADC countries generated through trade in maize. South African production and export of maize to Botswana especially generates a large positive net blue water savings for the region. However, a caveat needs to be added to this data: It is appropriate for those countries with large blue water endowments to be exporting blue water intensive products. Thus, expenditure for these countries needs to be viewed in this light.

Table 4-2. Trade matrix showing net virtual blue water savings (positive numbers) and expenditure (negative numbers) associated with the import and export of maize between SADC countries (in Mm³/yr). (Source: http://www.hydrol-earth-syst-sci-discuss.net/5/2727/2008/hessd-5-2727-2008.pdf)

		IMPORTING COUNTRY														
		Angola	Botswana	Congo	Lesotho	Madagascar	Malawi	Mauritius	Mozambique	Namibia	South Africa	Swaziland	Tanzania	Zambia	Zimbabwe	NET
EXPORTING COUNTRY	Angola	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Botswana	−0.81	–	–	–	–	−0.04	−0.01	−0.16	−0.02	−7.71	−0.01	–	−0.49	–	−9.3
	Congo	–	–	–	–	–	–	–	–	–	−0.25	–	−0.14	−0.01	–	−0.40
	Lesotho	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Madagascar	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Malawi	–	0.28	–	–	–	–	–	0.02	–	−1.13	–	−4.89	−0.09	22.04	16
	Mauritius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Mozambique	–	–	–	–	–	−9.38	–	–	–	−0.26	–	−7.73	−16.28	–	−34
	Namibia	4.32	0.66	–	–	–	–	–	–	–	−1.18	–	–	–	–	3.8
	South Africa	107.63	688.29	14.06	–	7.11	17.45	−0.001	291.19	6.38	–	–	24.55	169.72	1659.76	2986
	Swaziland	–	–	–	–	–	−0.23	–	–	–	–	–	–	–	–	−0.23
	Tanzania	–	–	6.17	–	–	20.00	–	2.65	–	−0.44	–	–	61.26	40.45	130
	Zambia	1.43	9.46	3.49	0.14	–	4.37	–	–	–	−5.93	0.33	−0.11	–	23.36	37
	Zimbabwe	–	–	–	–	–	−0.03	−0.01	–	–	−1.86	–	−0.002	−1.43	–	−3.3
	NET	112.58	698.69	23.72	0.14	7.11	32.14	−0.02	293.70	6.36	−18.76	0.32	11.68	212.67	1745.61	

In terms of export water footprint as a percentage of water footprints of production, the Orange-Senqu countries are more comparable. Table 4-3 below compares the blue and green virtual water export of each of the countries as a percentage of blue or green water footprints of production, respectively. On a relative basis, both South Africa and Lesotho's blue water export (of crop production) as a percentage of the total blue water footprint of national production are comparatively high. It can also be assumed that blue water use in Lesotho is currently likely to be noticeably higher relative to the period over which the WFN data was calculated. However, blue water export as a percentage of blue water use in production should remain relatively unchanged.

Table 4-3. Virtual water export as a percentage of total water use in national production, ave. 1996-2005 (Source: WFN, 2013)

	Virtual water export (as % total WF of production)			
	Crop products		Animal products	
	Green WF	Blue WF	Green WF	Blue WF
Botswana	1%	0%	11%	9%
Lesotho	18%	18%	0%	0%
Namibia	2%	11%	8%	8%
South Africa	12%	45%	4%	2%

4.5 INTER-COUNTRY TRADE IN AGRICULTURE

Strong patterns of trade exist amongst the Orange-Senqu countries. For instance, approximately one third of Namibia's agricultural exports go to South Africa. This includes almost all of the country's live animal exports. In return, approximately 85% of Namibia's agricultural imports come from South Africa, including almost 100% of the country's meat imports, over 90% of its beverage imports and virtually all of its sugar imports. Botswana also supplies Namibia with sizable volumes of beer on an annual basis. [6]

Maize is arguably the most traded crop in the region, and South Africa is Namibia's primary source of the grain. Wheat is also highly traded, however with all SACU member states being net importers, most of the wheat is sourced outside of the SACU.

Lesotho is also highly dependent on South Africa with approximately 90% of its imported goods coming from its sole neighbour.[7] Maize, wheat, pulses, sorghum and barley are Lesotho's primary crops under production, however less than 30% of the country's needs are met by local cereal production.[8]

Botswana and South Africa are similarly important trade partners. Grains, for instance, are imported into Botswana from South Africa. The primary traded grains include maize and wheat. In volume, other major imports from South Africa include refined sugar, sorghum, and fruit and fruit products.

In terms of exports from Botswana, South Africa is the primary recipient of Botswana's cattle meat. Other recipients of smaller volumes of cattle meat include Namibia and Lesotho.

[6] http://paulroos.co.za/wp-content/blogs.dir/12/files/2011/uploads/20061128_Vink_%20AgriculturalTradeandInvestment.pdf

[7] http://agoa.info/profiles/lesotho.html

[8] http://www.new-ag.info/en/country/profile.php?a=2208

4.6 Water Footprints of production and export in Orange-Senqu River Basin

The above data consider production and trade on a national level. However, for the purpose of this study, production and trade specific to the Orange-Senqu River Basin needs to be considered. In order to calculate the water footprints of crop and animal production in each of the regions, the key crops and animals for each region were identifed and their corresponding water footprints (per ton/animal) obtained from the Water Footprint Network Database. Average production volumes for each region were then used to calculate water footprint totals for each product. However, in two instances the WFN water footprints in m³/ton were not used. For both grape production in Namibia and cattle farming in Lesotho, the WFN values appear to be noticeably inaccurate. Thus, the former value was recalculated using Cropwat and appiled to the production volumes while WFN's water footprint value (in m³/ton) for South Africa was used as a proxy for Lesotho.

For the Orange-Senqu regions of South Africa, the key categories were maize, wheat, soybeans, citrus, cattle and sheep; for Namibia the identified categories were table grapes, sheep and goats; for Lesotho, potatoes, cattle, sheep and goats; and for Botswana, cattle. (Separate water footprint values per ton were determined for table grape production in Namibia using Cropwat because of significant inaccuracies in the WFN data). It should be noted that these selected crops and animals do not cover all crops and animals farmed in the regions, however they do account for the bulk of agricultural products produced in these regions. Agricultural maps of the Orange-Senqu countries are provided below:

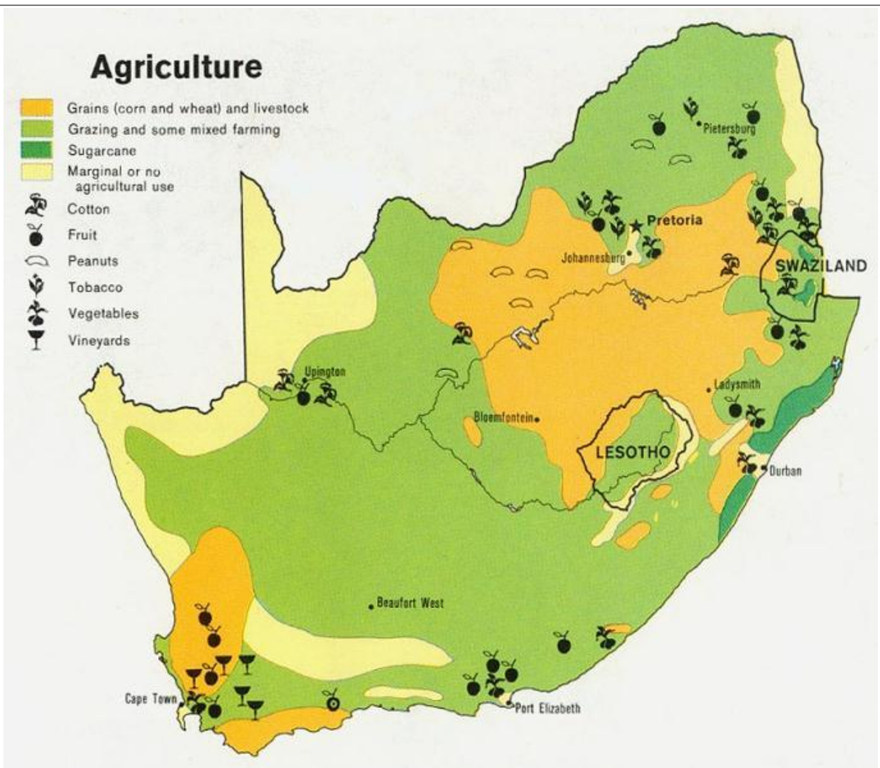

Figure 4-7. Agricultural map of South Africa and Lesotho (Source: http://www.nationmaster.com/country/sf-south-africa)

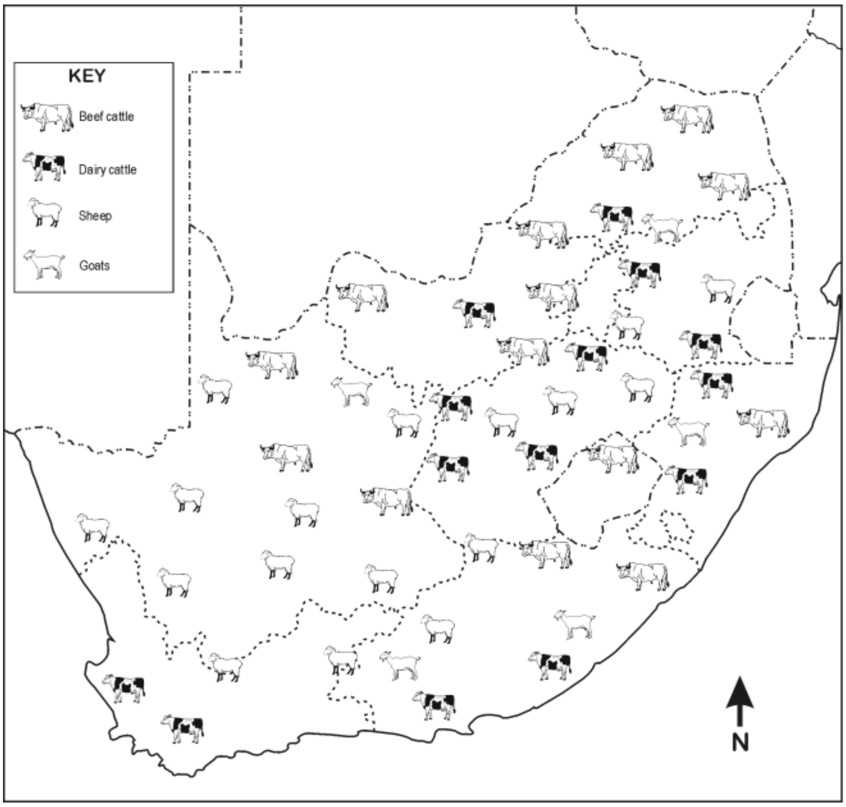

Figure 4-8. Livestock map of South Africa and Lesotho (Source: http://cnx.org/content/m25393/latest/?collection=col11084/latest)

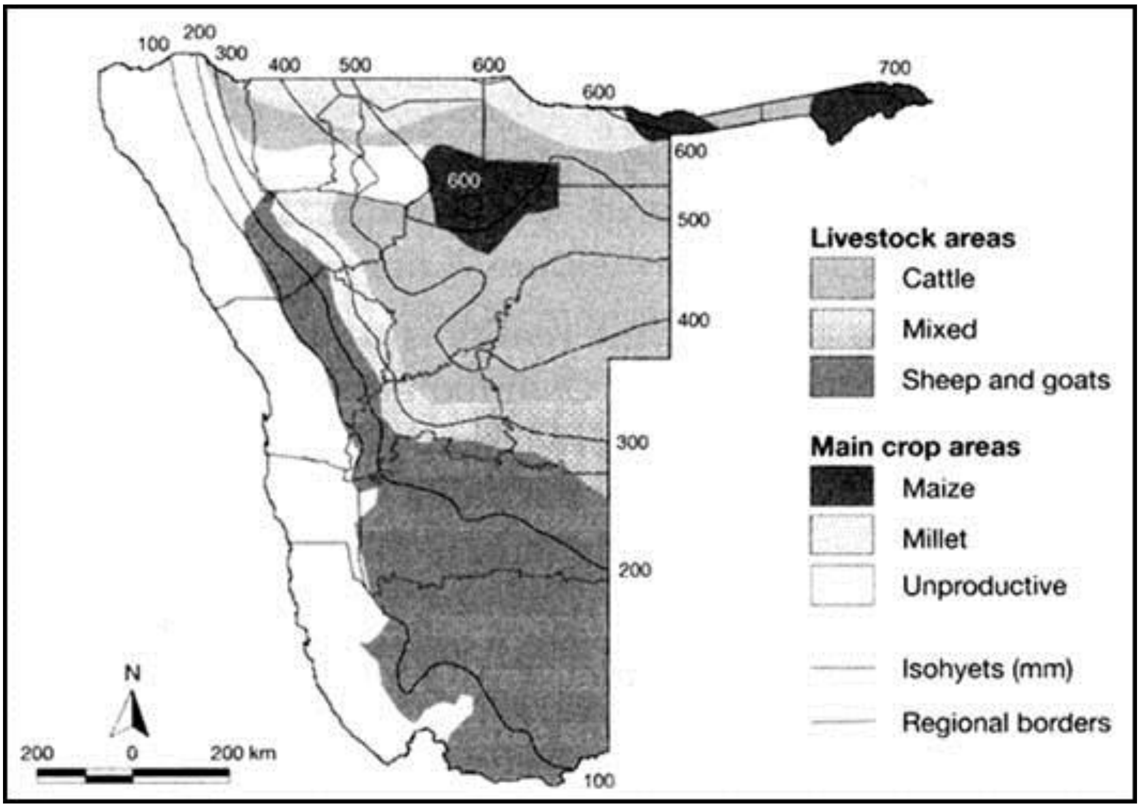

Figure 4-9. Agricultural map of Namibia (Source: http://www.fao.org/docrep/007/y5639t/y5639t05.htm)

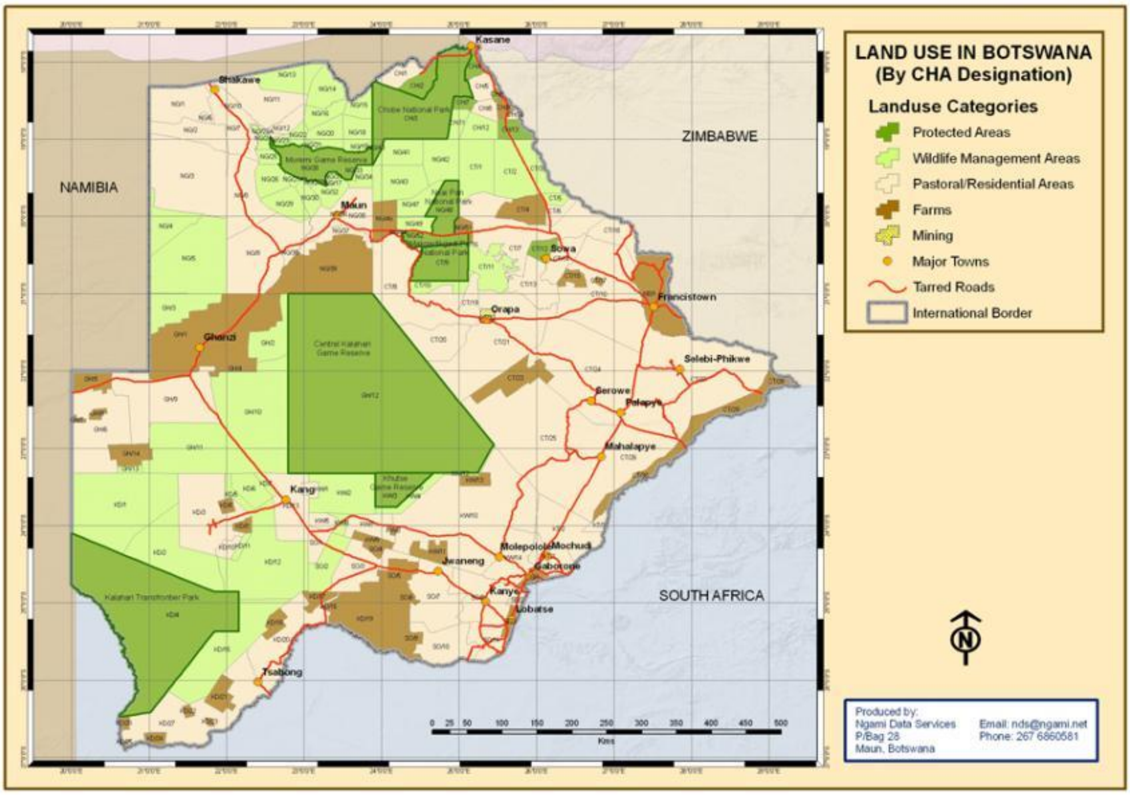

Figure 4-10. Agricultural map of Botswana (Source: http://www.justconservation.org)

The tables below provide the estimated green and blue water footprint total for both crop and animal categories for each of the Orange-Senqu countries.

Table 4-4. Water footprints for Orange-Senqu regions (Source: WFN, Cropwat, 2013)

Orange-Senqu River Basin - Crop WFs	Total Green WF (Mm³/yr)	Total Blue WF (Mm³/yr)
South Africa	11 588	2 019
Namibia	7	51
Lesotho	520	14
Botswana	0	0

Orange-Senqu River Basin - Animal WFs	Total Green WF (Mm³/yr)	Total Blue WF (Mm³/yr)
South Africa	11 275	208
Namibia	1 458	42
Lesotho	1 947	30
Botswana	418	6

Ultimately greater consideration ought to be given to the blue water footprints of each category given that it is the blue water that is being allocated to production while green water use is more associated with opportunity costs. As such, the category of crop production in the Orange-Senqu becomes more pertinent for this assessment due to the magnitude of blue water associated with it.

It should also be noted that the sum of the figures presented here for Lesotho exceed those totals supplied by the WFN and shown in section 4.3 above. The noticeable increase is likely due to both large increases in production in the country over the two periods under consideration (with the WFN data averaging a decade earlier), and errors in the WFN's assumptions.

4.7 Export from Orange-Senqu

Although the available water footprint trade data do not provide accurate export data specific to the Orange-Senqu River Basin, production and national export volumes can be used to estimate Basin-specific exports. This was done for crop production in the Basin due to the importance of blue water use for this form of agricultural in the region.

Given that Lesotho falls within the Basin in its entirety, it can be assumed that its national crop virtual water exports equate to the Orange-Senqu Basin crop virtual water exports for the country. However, due to certain inaccurate assumptions underlying the WFN Lesotho data, the export values represented for that country were ultimately based on the reweighted blue-to-green virtual water export splits.

For Namibia and Botswana, much smaller portions of the countries fall within the Basin, and especially so for Botswana. The Orange-Senqu region in Botswana is also predominantly range land and national parks, and is thus not relevant for crop water footprint analysis. In South Africa a much larger portion of the country falls within the Basin. For all three of these countries the ratio of national crop virtual water export -to-national crop water footprint of production was applied to the Orange-Senqu production figures in order to determine a rough estimate for Orange-Senqu country-specific export water footprints for crops alone. The results are presented in Table 4-5 below:

Table 4-5. Crop specific virtual water export from Orange-Senqu regions (Mm³/yr)

Orange-Senqu virtual water export - crops (Mm³/yr)							
South Africa		Namibia		Lesotho		Botswana	
Green WF	Blue WF	Green WF	Blue WF	Green WF	Blue WF	Green WF	Blue WF
2 459	428	0	2	300	4	0	0

4.8 DOMESTIC AND INDUSTRIAL WATER FOOTPRINTS

How water is used in the domestic and industrial sectors is also important for consideration. Although it is possible to calculate water footprints for these sectors, it is arguably more useful to consider these areas from a quality and quantity perspectives in the water accounts. The water footprint concept is better applied to the agricultural sector. For this reason, the other sectors will not be investigated in this portion of the analysis. However, the table below provides a high-level summary of the total water requirements for each of the South Africa's sectors in the Vaal and Wilge, as a comparative example (Note that these are not water footprints which would take water returned to the system into account).

Table 4-6. Water requirements, 2000 (Mm³/yr) (Source: National Water Resource Strategy, Department of Water Affairs, 2004)

Sub-area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Power generation (3)	Affore-station (4)	Total local require-ments	Transfers out	Grand Total
Wilge	18	27	15	0	0	0	**60**	0	**60**
Upstream of Vaal Dam	29	32	17	99	39	0	**216**	67	**283**
Downstream of Vaal Dam	67	576	11	74	41	0	**769**	1 343	**2 112**
Total	**114**	**635**	**43**	**173**	**80**	**0**	**1 045**	**1 379**	**2 424**

1) Includes component of Reserve for basic human needs at 25 ℓ/c/d.
2) Mining and bulk industrial water uses which are not part of urban systems.
3) Includes water for thermal power generation only. (Water for hydropower generally is available for other uses as well.)
4) Quantities given refer to impact on yield only.

5. Water in the economy analysis

5.1 Water use and GDP contribution

The relative GDP contribution of each Orange Senqu basin member state (with South Africa split into the Vaal and Orange River Basins) is shown in the figure below. As a result of the different GDP contributions of each sector, the water quality and quantity demands are likely to be different. The efficiency through which water is used is also likely to be different between sectors.

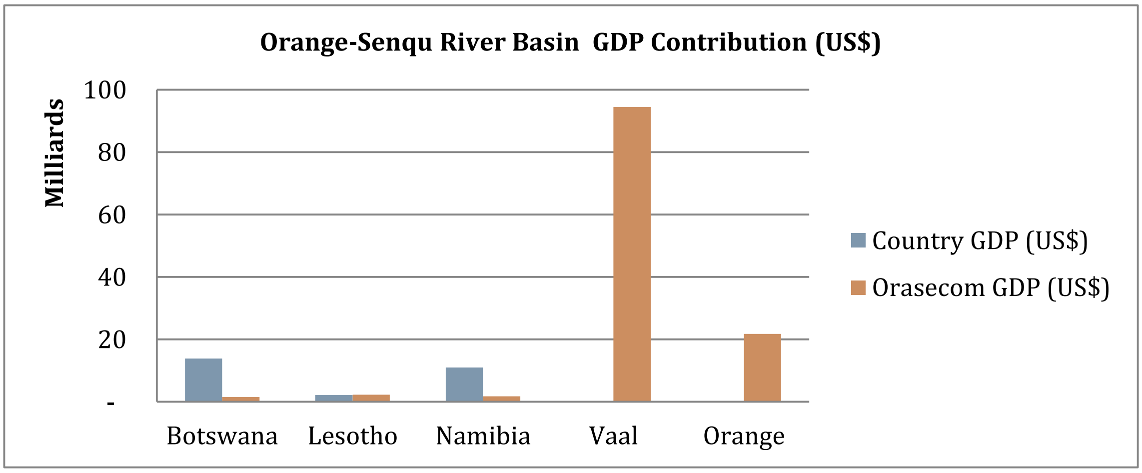

Figure 5-1: Orange-Senqu River Basin GDP contribution (US$)

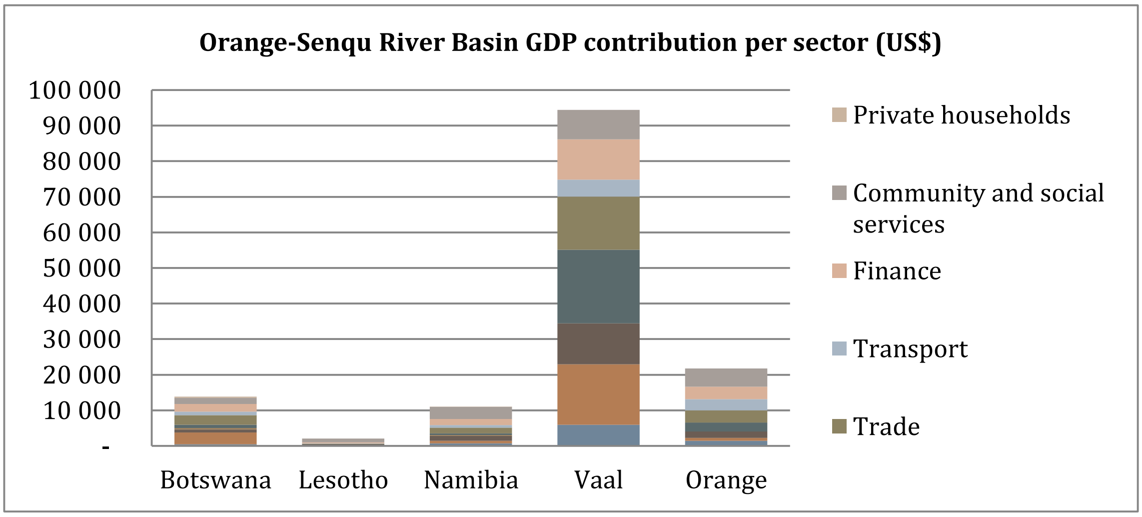

Figure 5-2: Orange-Senqu River Basin GDP contribution per sector (US$)

To better compare the relative sector contributions per catchment, the GDP contribution per sector is converted into a per capita comparison as shown below.

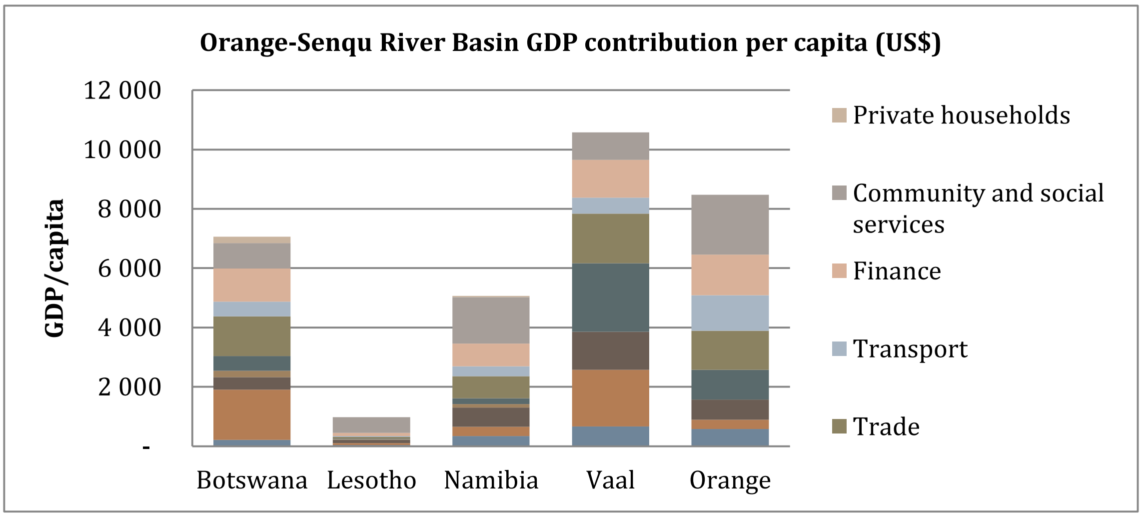

Figure 5-3: Orange-Senqu River Basin GDP contribution per capita (US$)

In addition to the distinct economic contribution, each sector of the economy has different employment needs. The skills required for the expansion of agriculture for example, are distinct to that of expanding the tertiary financial services. These employment considerations need to be made in conjunction with the economic (GDP) and water impacts of the sector. The employment per sector within the Orange-Senqu River Basin basins indicates the different economies which are dominant in providing employment. In Lesotho the importance of manufacturing, while in Namibia, the relative importance of agriculture is evident.

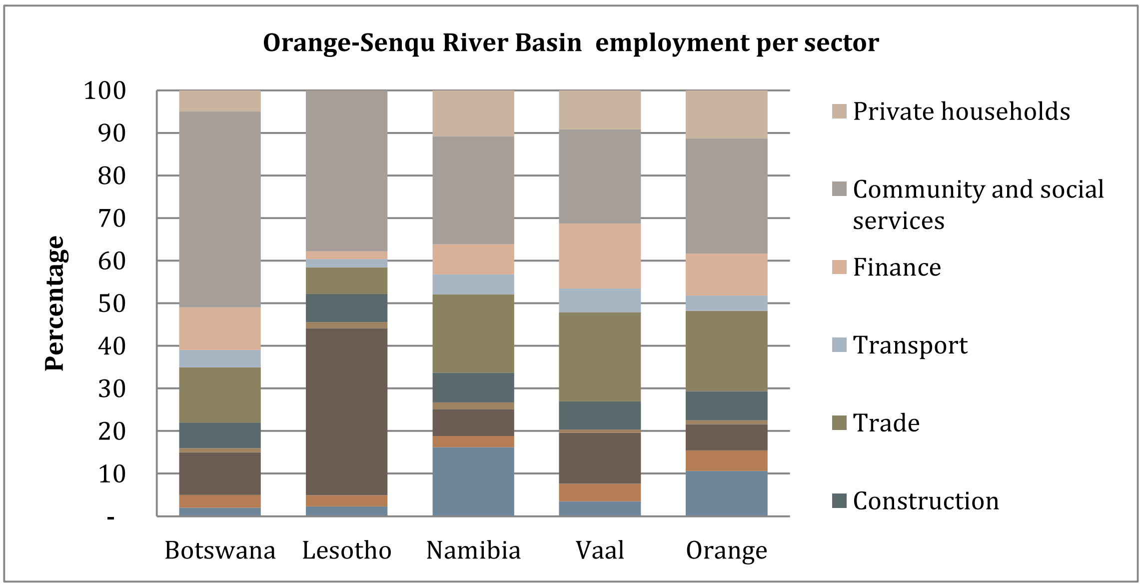

Figure 5-4: Orange-Senqu River Basin employment per sector

Water is an important input into an economy. This is especially true in primary industries such as agriculture or mining. However, water is also critical in the secondary and tertiary economy, in particular agro-processing manufacturing. In each sector of the economy, the nature of water required is different. For example, irrigated commercial agriculture has distinct water requirements in terms of quality and assurance of supply than that of small-scale and rain fed agriculture. Industry requires a higher assurance of supply than that of agriculture, while quality in some cases is less important. For example mining water quality needs are less than that of agro processing. Lastly, the services sector of the economy requires the least amount of water (per GDP contribution). However, for the people employed in the services sector, this water needs to be high quality (albeit a reduced quantity). Therefore, the nature of water use changes depending on the economic sector. The following indicates the relative water use per region. Irrigation is a major user of water. However in the Vaal area the urban requirements of water are sizeable.

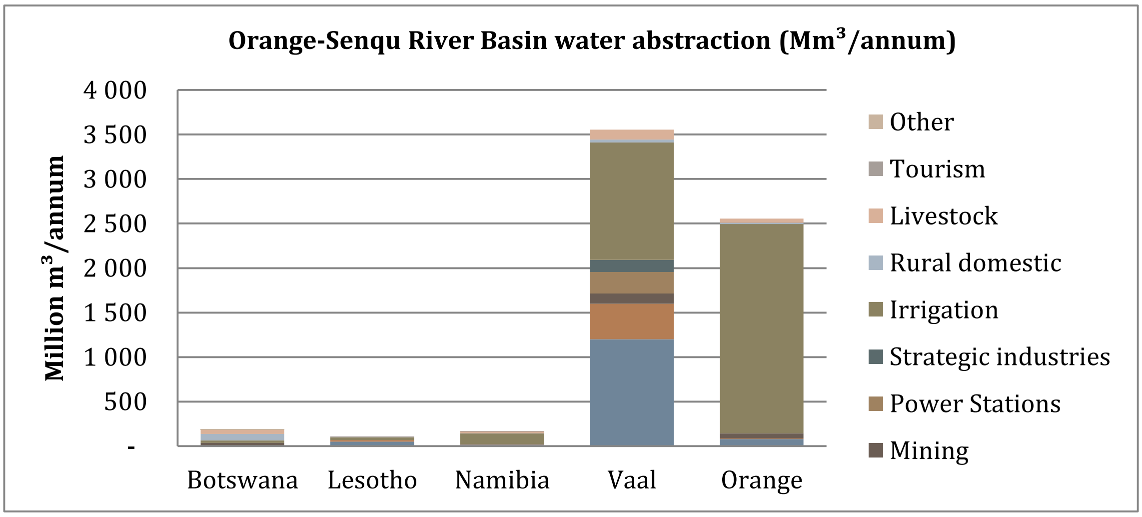

Figure 5-5: Water abstraction per sector (Mm³/annum)

Note that the water abstraction in Figure 5-5 is not directly linked to the GDP and employment statistics indicated in previous figured. Therefore they cannot be directly compared.

The relative economic contribution per m³ of water abstracted is a useful indicator as to the economic benefit of the water use. This becomes particularly important where water is stretched, and trade-offs need to be made. The following figure gives an indication of the US$/m³ ratio of different water users within each of the basin countries. Note however, that due to the segregation of sector information differently according to GDP and water abstraction, the depth of information used in previous analyses is not possible in this case. Therefore, industry and urban GDP and water abstraction have been combined. Also, as GDP is not particularly useful as a single indicator, this figure cannot be used for planning purposes alone. Mining in Namibia for example, contributes a large portion of the national GDP, and uses saltwater in the processing stages.

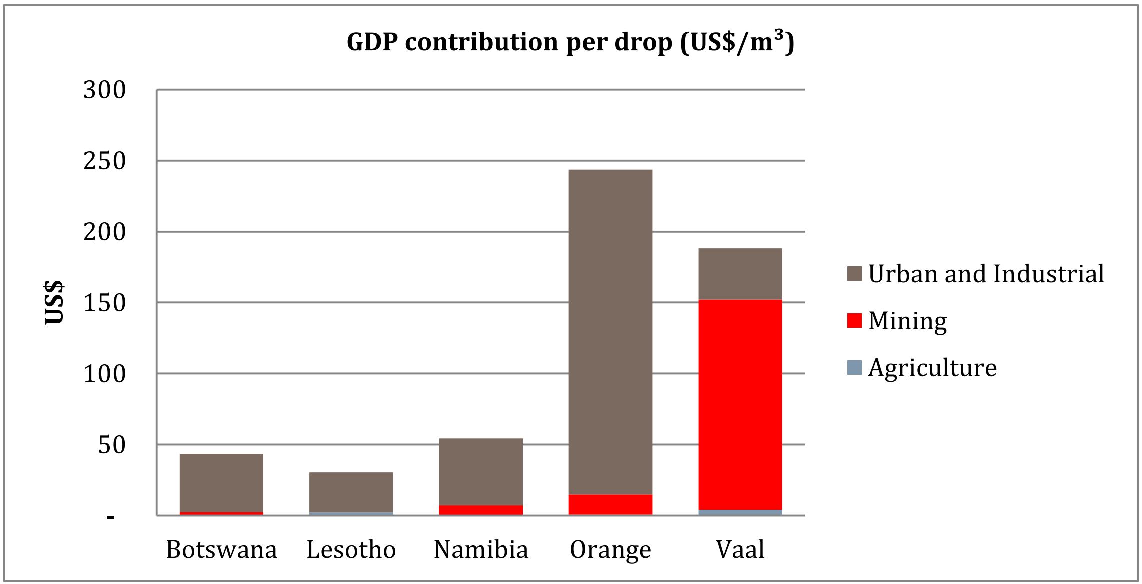

Figure 5-6: Orange-Senqu River Basin GDP per drop (US$/m³)

At a national level, the productivity of water may be different. This may be due to the nature of the economy which the water supports. This data stems from World Bank analyses, and therefore is not at the Orange-Senqu River Basin level.

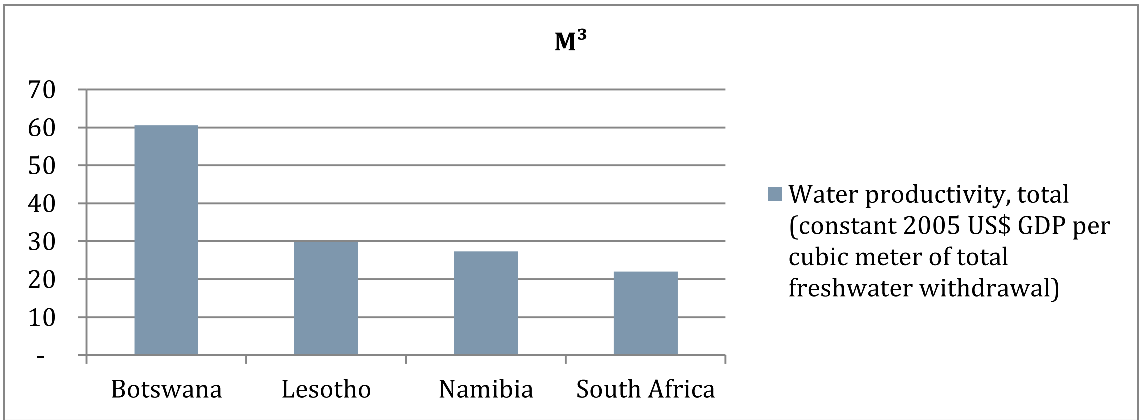

Figure 5-7: National water productivity (US$/m³)

Note however that GDP contribution alone is not indicative of efficient water use, as employment and other important social and economic considerations need to be made. GDP contribution alone is not sufficient to drive inclusive and sustainable growth. For functioning economies, employment is also an important consideration. Employment in particular is a useful indicator to consider due to the social benefits employment contributes to a society.

In terms of employment, a distinction needs to be made between rural vs. urban jobs, and what each of these mean in terms of economic contribution, social upliftment and water demand and supply implications. Consideration of GDP alone at a micro-economic level is not particularly useful as it does not reflect costs. Geographic value add (GVA) is likely a better indicator, but what not widely available for all sectors. With the current data availability, a jobs/m³ comparison per sector in each region is not possible. This data needs to be collected in order to better understand the role of each sector in providing employment.

Countries may use their water resources to support production which they consume. Alternatively, countries may use water resources to export products for foreign exchange. This may be in the case of agricultural produce, or industrial manufacturing. The figure below depicts the water footprint trade balance of each of the Orange-Senqu River Basin countries at a national scale. Data is collected from Mekonnen and Hoekstra (2011), and therefore is not aggregated to a regional scale.

The figure indicates that in terms of a water footprint, South Africa has the largest blue water footprint. A large proportion of the blue water footprint is also exported. In terms of green water footprints, Lesotho has the largest green water footprint per capita per year. At a gross level this is not the case however.

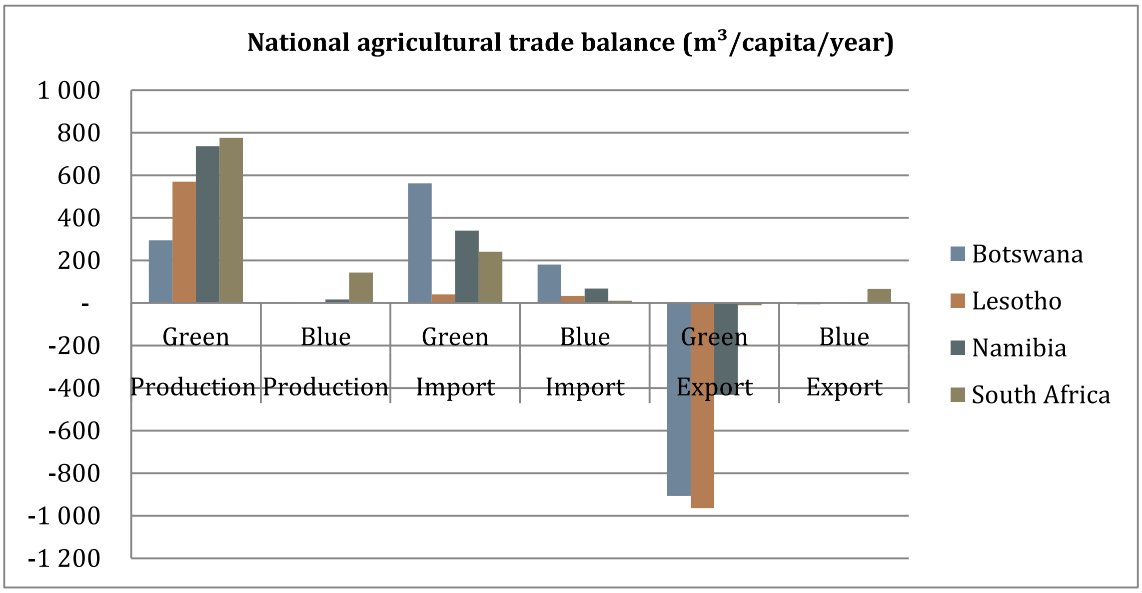

Figure 5-8: National agricultural trade balance (m³/capita/year)

Infrastructure is used to control the availability of water during times of stress. Impounding water also allows more intensive use of water resources. The relative dam capacity between the four Orange-Senqu River Basin countries at a national level is shown below. Because of development of infrastructure in managing water resources, South Africa has taken greater advantage of their internal water resource supply. Also, dams are not used for groundwater use, which is the predominant water source for many regions in Botswana and Namibia.

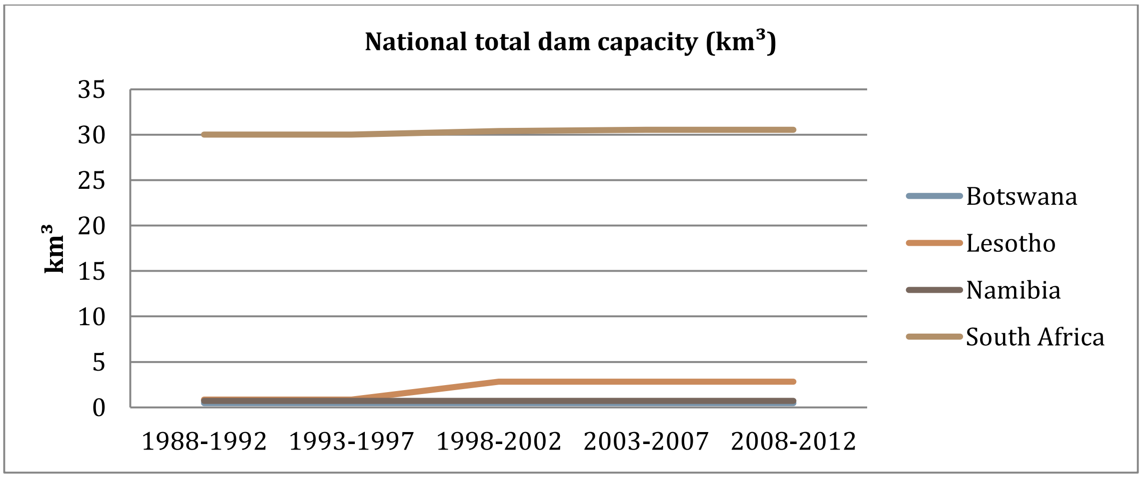

Figure 5-9: National total dam capacity (km³)

When translated into a per capita view, dam capacity discrepancies are less. The investments made into the Lesotho Highlands Water Project in particular indicate a stage where water storage per capita in Lesotho increased dramatically. The benefits of the water resource certainty from the dam are more for the benefit of the Gauteng region of South Africa than Lesotho itself.

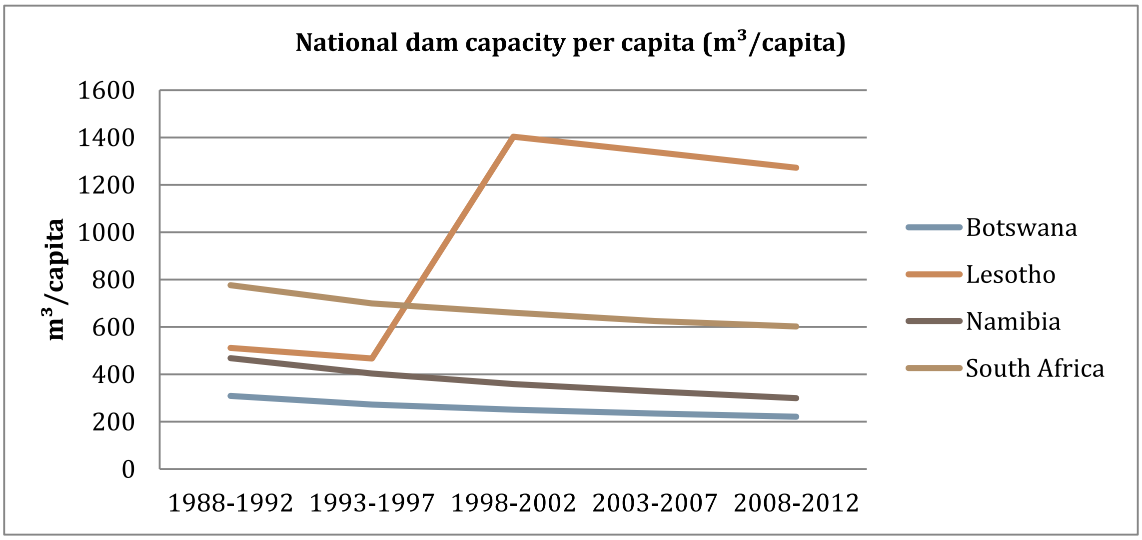

Figure 5-10: National dam capacity per capita (m³/capita)

Data at the Orange-Senqu River Basin level roughly mirrors the national trends. South Africa has invested a larger amount into building infrastructure within the basin. This is in order to support the mining, industrial and agricultural economies throughout the basin. At a per capita level, the low population of the Orange WMA indicates that the Orange WMA has the highest volume of water stored per capita.

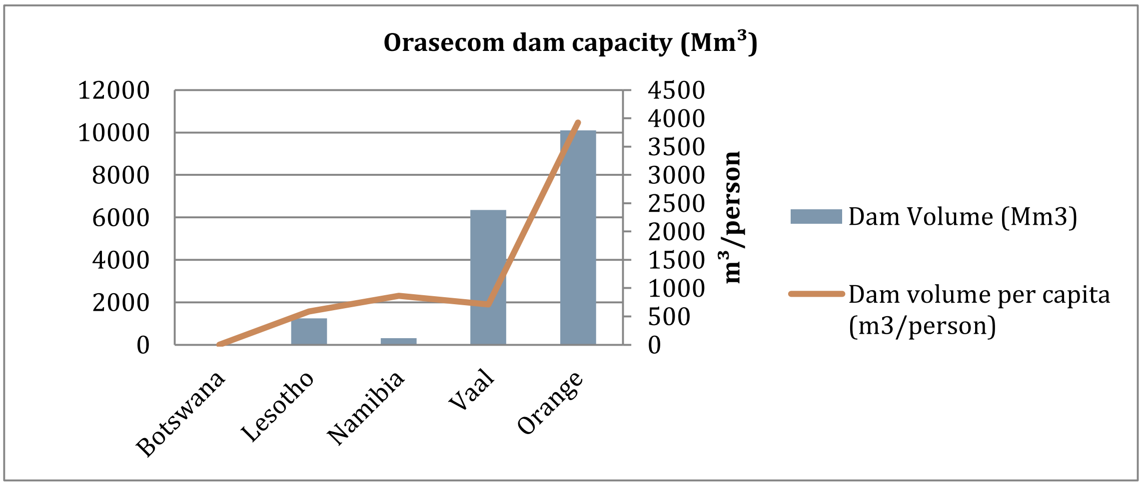

Figure 5-11: Orange-Senqu River Basin dam capacity (Mm³)

The efficiency at which water is used within each sector and between countries and sectors is of interest. Currently, there is not sufficient data to comment appropriately on the leakage and losses between sectors and between countries. Losses range from 45% urban leakage in Lesotho to 30% in Botswana and 24 and 29% respectively between Namibia and South Africa. Although comment could be made on the comparison between water scarcity and the amount of losses, there is not sufficient data as of yet to make such statements conclusively.

5. WATER IN THE ECONOMY ANALYSIS

One of the primary drivers of efficiency is the price of water to the consumer. Priced differ considerably between countries and sectors. For example, in Botswana, domestic water tariffs range from 0.65 to1.7 US$/m³ depending on the regional water supply system. Raw water supply prices range between 0.14 and 1.2 US$/m³. With irrigation, the charges of water depend on whether the scheme (ground or surface water) is subsidised.

In Lesotho, urban water supplies are managed by the parastatal Water and Supply Company (WASCO), while rural water is supplied through the Department of Water Affairs and Rural Water Supply. According to WASCO, the water tariff ranges from 3.36 US$/m³ to 13.76 US$/m³ for domestic and industrial water users. There is an additional standing fee of between 3.31 and 22 US$ for domestic and industrial water use respectively.

In South Africa, pricing is distinguished between the water resources infrastructure (WRI) and water resources management (WRM) charges. An indication of the range of charges is shown in the table below.

	WRI 2012/2013 Charges (c/m³)			
	Domestic and Industry		Irrigation	
	Lowest	Highest	Lowest	Highest
Vaal	15.18	43.14	1.03	2.19
Orange	15.18	51.97	2.14	2.19
	WRM 2012/2013 Charges (c/m³)			
Vaal	1.77	2.61	1.43	1.94
Orange	0.76	1.66	0.43	1.11

In Nambia, NamWater costs (abstraction, water treatment and transfer costs) and tariffs of water for 2001/2002 differed in most of the country's regions. Nation-wide average water cost (full cost recovery) stood at 2.79 N$/m³. Highest costs occurred in the NamWater Area Omaheke (0.9 US$/m³; tariff: 0.360 US$/m³), and lowest costs were found in Okavango area (0.153 US$/m³; tariff: 0.226 US$/m³). At the Hardap Dam, irrigation is subsidised, as farmers pay 0.0005 US$/m³.

5.2 WATER IN THE ECONOMY WITHIN EACH STATE

5.2.1 Botswana

The Orange-Senqu River Basin portion of Botswana covers the majority of the Kgalagadi and Southern Districts. The region has a very low population as the majority of the region is the Kalahari Trans frontier Park. In the Southern District is the Jwaneng Mine and large commercial scale beef farmers, with limited maize and sorghum agriculture.

The Botswana portion of the Orange-Senqu River Basin falls within the arid – semi-arid Molopo – Nossob Basin. The Molopo River is the major river which forms part of the Botswana region. 37% of the Molopo-Nossob falls within Botswana (Namibia: 33%; South Africa 30%). The population in the Kgalagadi District can be as low as 0.2 people per square kilometre, while livestock numbers are approximately 4.2 ELSU per km2. 13% of the total catchment water abstraction is attributed to Botswana (69% South Africa, 18% Namibia). Livestock watering represents a large portion of the water use, followed by domestic use. Irrigation and industry follow, with tourism representing only 0.1% of the total water use. The figure below indicates the total number of livestock in the Botswana regions within the basin in addition to the relative water requirements per livestock type.

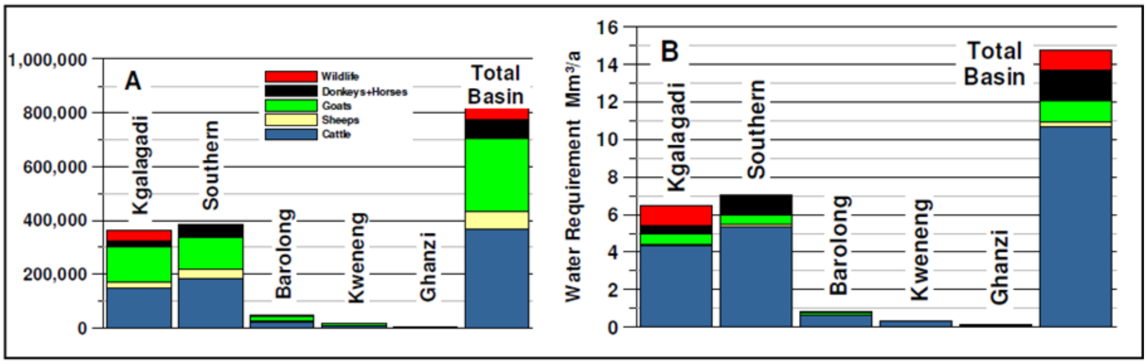

Figure 5-12: Botswana: Livestock in Nossob River Basin

However, the groundwater resources used within Botswana are stressed. The figure below gives an indication of the low recharge taking place within the Botswana area of Orasecom.

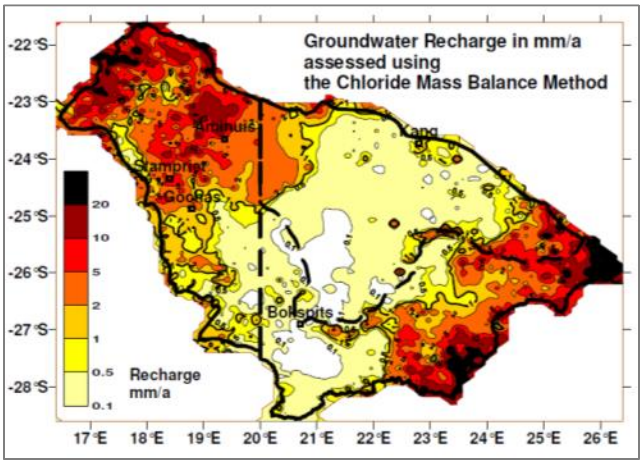

Figure 5-13: Groundwater recharge in mm/a

In addition to stretched water quantities, the quality of the predominantly groundwater in the catchment is not particularly good. The figure below indicates the high levels of a number of poor ground water quality indicators.

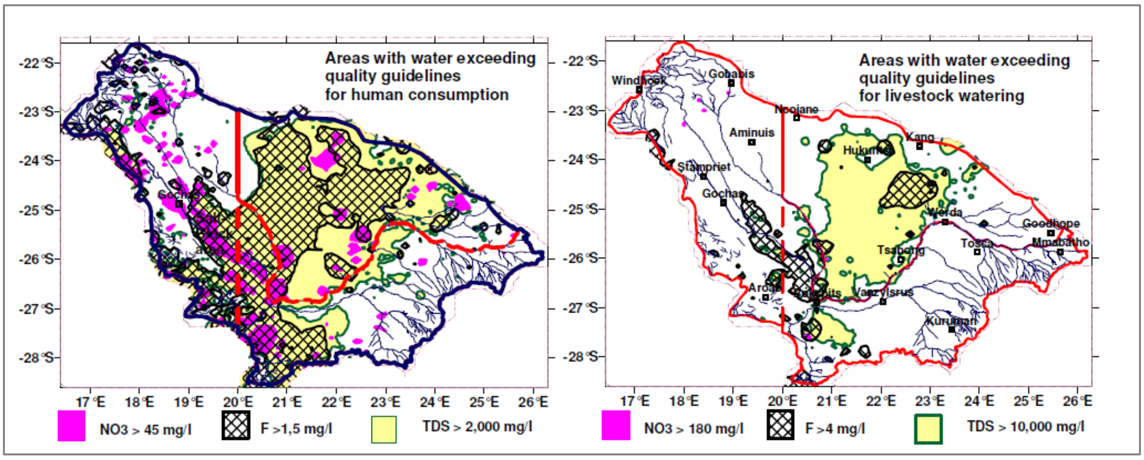

Figure 5-14: Groundwater quality in the Molopo-Nossob Basin

Development which requires a major quantity of water is foreseen in the Botswana part of the Basin where plans for irrigation developments will require about 6.2 Mm³/annum of water from the year 2015. The figure below indicates the projected water requirements going forward.

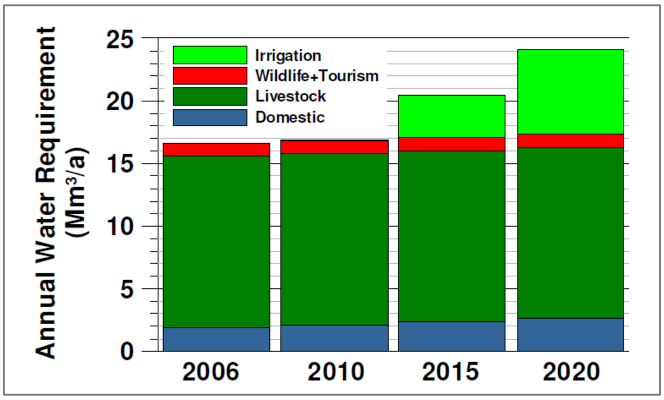

Figure 5-15: Predicted water requirements for Molopo-Nossob Basin in Botswana

Across Botswana, mining is the major contributor to the economy. Mining represents 34% of the country GDP and 50% of the tax revenues. 13 000 people are employed through the mining industry. Debswana, a 50% partnership between De Beers and the government of Botswana produces approximately 70% of Botswana's export earnings, 30% of the GDP and 50% of government revenue. The largest contributing mine is the Jwaneng Diamond mine, which falls within the Orange-Senqu River Basin. Jwaneng is the richest diamond mine by value. The major water source for the mining operations is groundwater. In this region of the Orange-Senqu River Basin, the Molopo River is the major catchment. However, as an ephemeral river, ground water resources are critical in supporting the economy. The Jwaneng Mine is situated in the south eastern part of Botswana and is totally reliant on groundwater for all its water supply purposes. The groundwater is supplied from the Jwaneng Northern well field situated approximately 55km to the north of the Jwaneng Mine. Debswana represents 25% of the total Botswana water demand, and therefore water use, impacts and reuse opportunities are investigated continuously. For example, at Jwaneng Mine, 0.92 m³ of new water per ton of treated has been reduced to 0.64 m³ in 2008 through slimes dewatering.

The relative GDP, water and employment contribution of the respective sectors in Botswana is as follows:

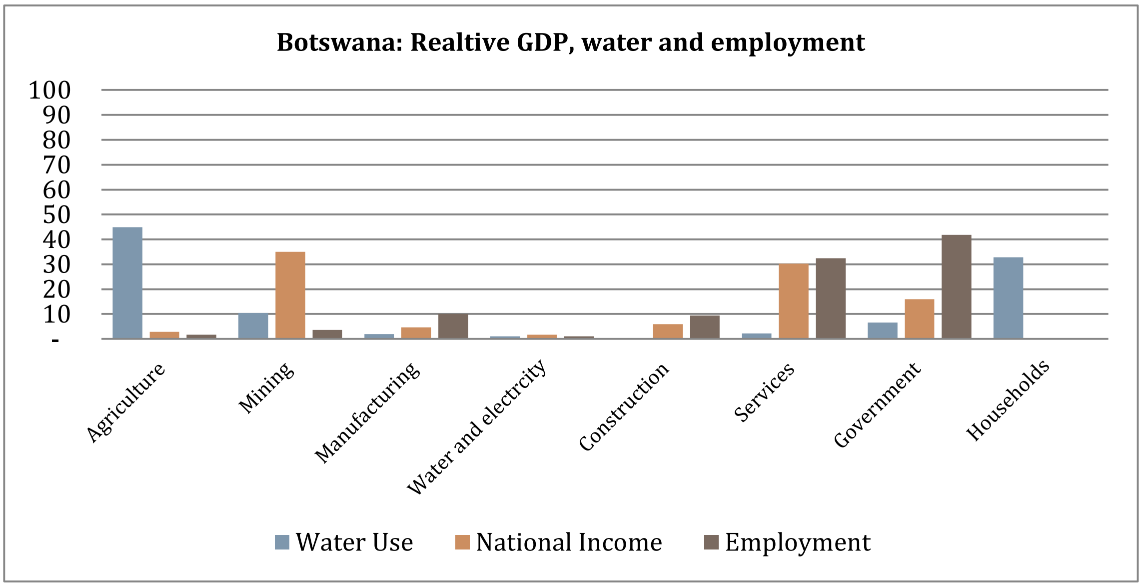

Figure 5-16: Botswana: Relative GDP, water and employment

As indicated in the figure, domestic water use is a large proportion of total water abstraction. Approximately 34 percent of the total water supply is from surface water, whereas the remainder (66 percent) is from groundwater. However, surface water accounts for 90 percent of the total supply of water in urban areas such as Gaborone, Lobatse, Francistown and Selibe-Phikwe. There are no dams in the Orange-Senqu River Basin Catchment of Botswana. Instead, there is a high dependence on groundwater.

In terms of water pricing, the Department of Water Affairs controls the water tariffs both in rural and urban areas. In urban areas the WUC parastatal proposes water tariffs which need to be approved by the Minister of Minerals, Energy and Water Resources. Urban water tariffs vary in different parts of the country due to differences in transport and corporation infrastructures. Gaborone has the highest tariffs due to the high transport costs of importing water from the Molatedi Dam in South Africa. Urban losses represent 30% of demand, while the per capita consumption in towns is 0.233 kl/day. Rural water tariffs are generally lower than urban as they aim to cover only the operational costs. Rural water charges are uniform regardless of the local supply costs. Irrigation water is subsidised in Botswana.

5.2.2 Lesotho

Lesotho is situated at the headwaters of the Orange-Senqu River Basin. The economy of Lesotho is agrarian, yet with an important manufacturing contribution in the urban regions as indicated in the figure.

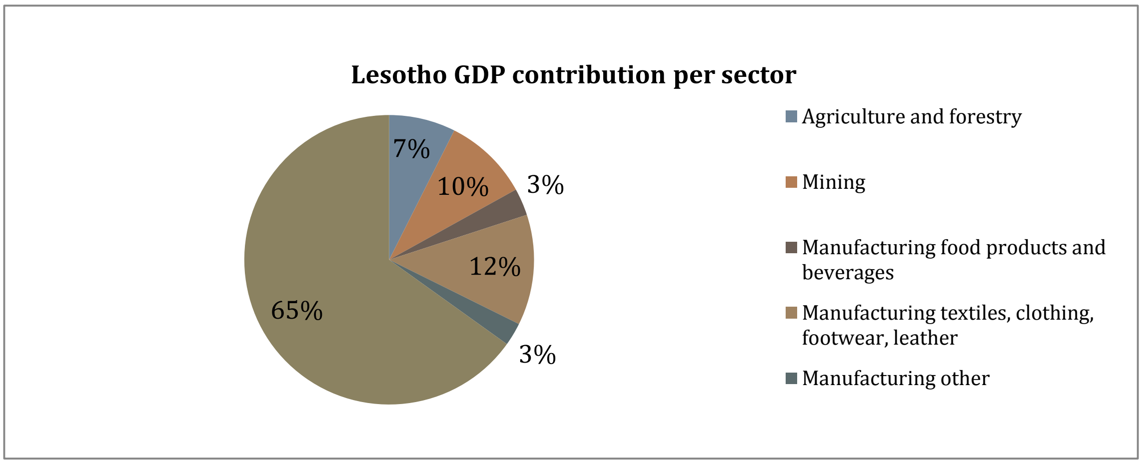

Figure 5-17: Lesotho GDP contribution per sector

Agriculture is an important sector of the economy for the rural regions, were maize, sorghum, beans and peas are grown. Maize, a staple food crop for the country accounts for 60 – 65% of the area planted. Domestic animals are also important in the agricultural sector both commercially and for own consumption. Milk, hides, skins, eggs, wool and mohair are all important products which stem from domestic animal farming. Due to the mountainous terrain, horses are also an important source of transport too. In addition livestock are important culturally due to their indication of wealth. The amount of livestock farmed in Lesotho has remained relatively stable in the past years as indicated in the following figure.

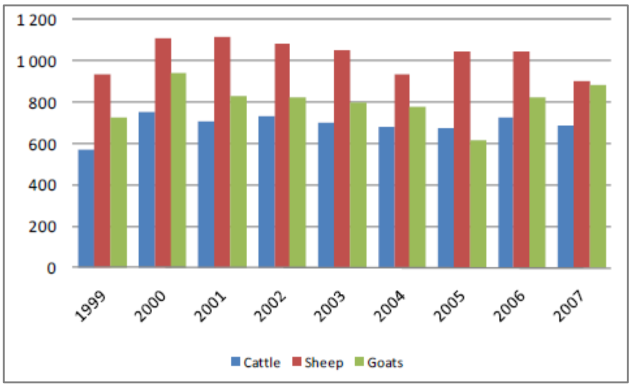

Figure 5-18: Number of cattle, sheep and goats

Although agriculture may be important in Lesotho due to the support it provides to rural small-holders, manufacturing is also an important sector in the country. The importance of manufacturing in particular stems from the textiles and clothing industry, which is supported through the African Growth and Opportunity Act (AGOA) preferential treatment with the USA.

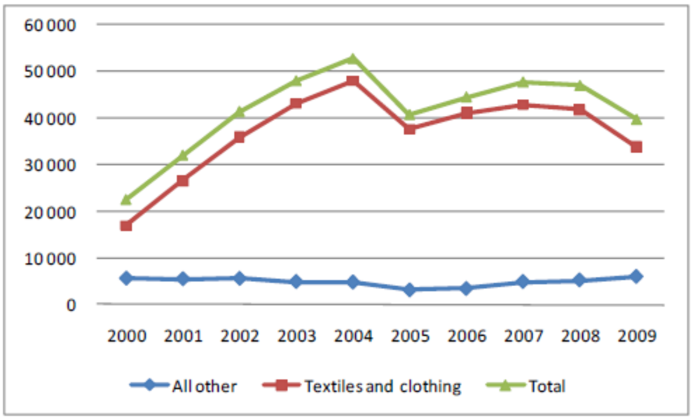

Figure 5-19: Number of people employed in manufacturing

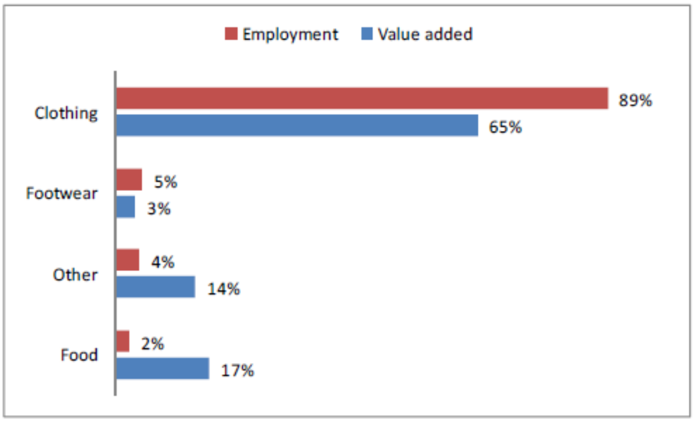

Figure 5-20: Share of manufacturing

The importance of the textiles and clothing industry is indicated through the large proportion of exports the sector represents. The net contribution of clothing is, of course, smaller; as a major part of the inputs, mainly textiles are imported. The growth of diamonds has helped to reduce the significant trade deficit which Lesotho faces. Exports of goods covered 21% of imports in 1999; in 2009 that ratio was 53%. Therefore, the exports of textiles and diamonds have helped to cover the deficit in trade. Currently, 53% of the value of imports is covered by the exports of primarily textiles and diamonds.

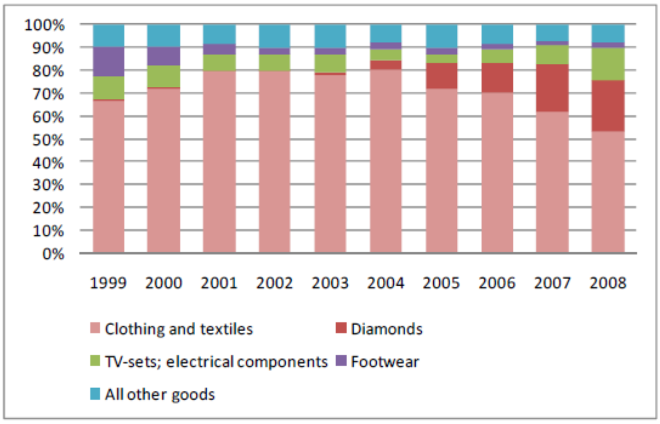

Figure 5-21: Major export products

The importance of textiles manufacturing is especially important in Maseru. The Water and Sewerage Company (WASCO) is responsible for the majority of urban water supply and sanitation in Lesotho, and in particular, Maseru. 60% of the water produced is for industries and commerce, with major textile factories as well as the Lesotho Brewing Company the major water users. In Maseru water is abstracted from the Caledon River which is supplemented with water from the Maqalika dam when turbidity is high or levels are too low. Other towns in Lesotho tend to abstract from rivers or through springs and boreholes to access ground water.

5.2.3 Namibia

The Namibian portion of the Orange-Senqu Basin spans the Hardap, Karas, Khomas and Omaheke Regions in Namibia. The Hardap region is home to the Hardap dam, the source of the Fish River. The Hardap Dam is responsible for 2260 ha of irrigation and urban water supply to Mariental. A further irrigation scheme in the Orange-Senqu River Basin region is the Naute Irrigation Scheme which is supplied by the Naute Dam. The dam is also a water source to Keetmanshoop. In addition to Hardap and Naute, the other major irrigation scheme within the Orange-Senqu River Basin is the Aussenkher Scheme in Noordoewer. Abstracted from the Orange River, this scheme irrigates 2000 ha of primarily table grapes for export. The region is also home to extensive small stock farming, game farming and irrigation along the Naute Dam. Tourism in the AiAis and Fish River Canyons is also important. The Khomas Region is home to Windhoek (of which The Orange-Senqu River Basin borders). Lastly, there is the Omaheke Region which is part of the Sandveld. 900 commercial and 3500 communal farmers depend mainly on cattle breeding and hunting as a main source of income.

The majority of the region is dependent on ground water from the Molopo – Nossob groundwater basin and Fish River Basin. In Namibia, the Fish River and the Molopo-Nossob catchments are the two major catchments which supply water to the Orange-Senqu River Basin region. The Molopo-Nossop has 33% of its area in Nambia, 18% of the total abstraction and has a population of 113 000. In the Namibian portion of the catchment, irrigation is the highest consumer, representing 45% of the water requirements. Namibian irrigation water is mainly from groundwater, whereas in South Africa surface dams have been constructed in some areas. Mining does not take place within the Namibian Molopo-Nossob at a large scale. Commercial farms in the region often have their own boreholes, and do not pay a water fee.

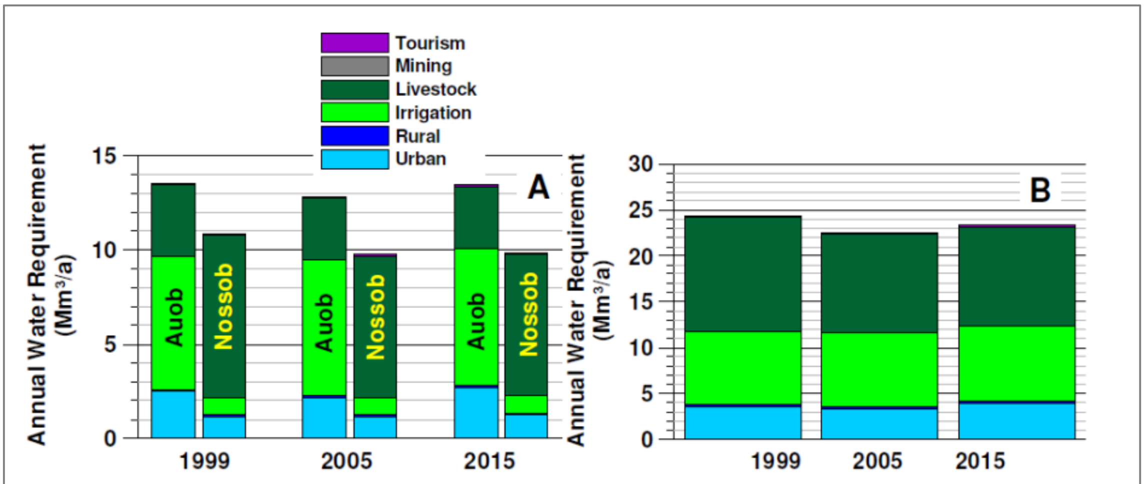

Figure 5-22: Water requirements in the Auob and Nossob River Basins

According to 2001 data on water resource use, GDP and employment in Namibia (at a national scale), the nature of water in the economy is indicated in the following graph. Traditional farming uses less water for a greater amount of employment, while manufacturing contributes a large amount of GDP relative to the employment contribution and water use. Services and the government sector remain large contributors to the GDO and employment with less water impact. However, without the primary and secondary sectors, the tertiary sector is less stable.

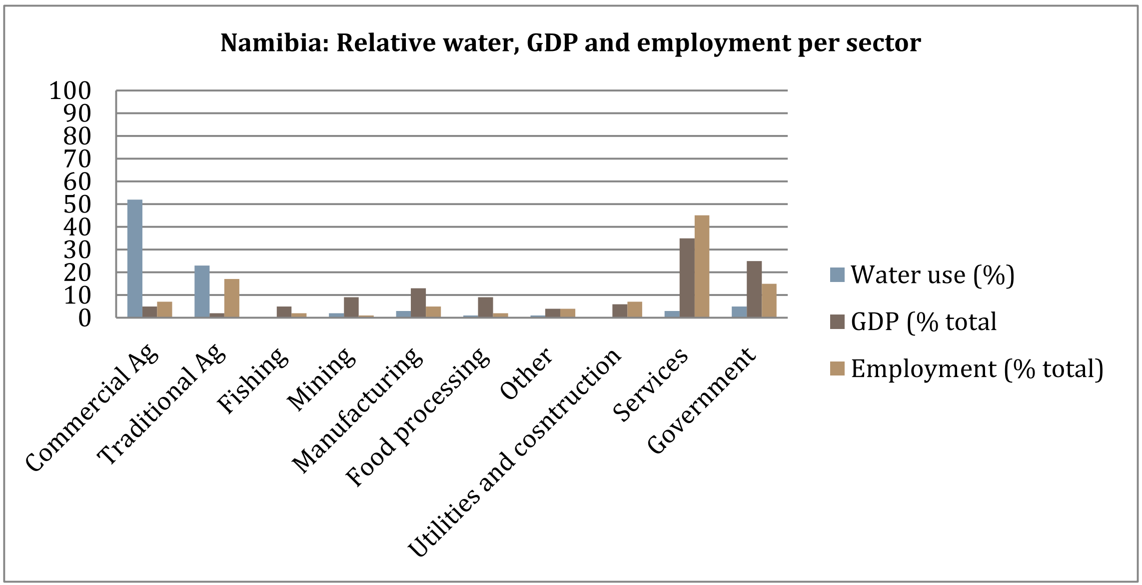

Figure 5-23: Namibia: Relative water, GDP and employment per sector

At the Hardap irrigation scheme, for example, NamWater supplies unprocessed water to farmers at a tariff of US$0.005/m³. The efficiency of irrigation water use is not measured. Therefore, farmers are not encouraged to invest in high value crops, which Namibia imports heavily.

5.2.4 South Africa (Vaal and Orange)

5.2.4.1 Vaal

The Vaal WMA experiences a large range in climatic conditions; from a Mean Annual Precipitation (MAP) of 800 to 100mm mirrored by potential annual evaporation ranging from 1300 to 2800mm. Land use is primarily urban and industrial sprawl as well as extensive mining in the northern and western parts of the WMA. Effluent return flows and mine dewatering returned back into the catchment have significant negative effects on water quality in the catchment.

Within South Africa groundwater plays a major role in the economy through supporting rural areas in particular. The Molopo-Nossob basin is the major basin through which ground water is abstracted, the majority if which lies within the Vaal WMA. South Africa represents 30% of the Molopo-Nossob Basin, and abstracts 69% of the supply.

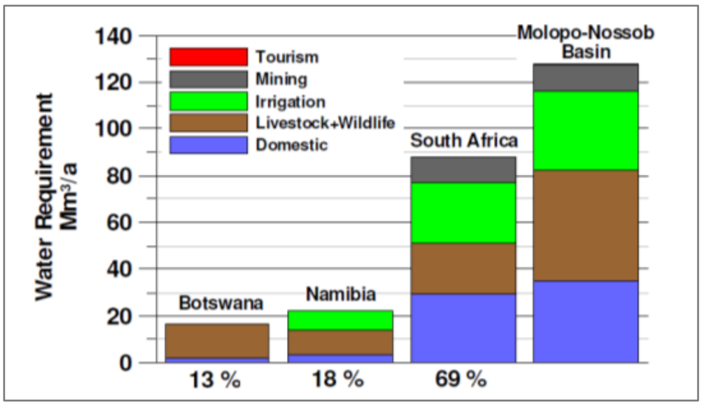

Figure 5-24: Water requirements in Botswana, Namibia and South Africa in Molopo-Nossob Basin

Large scale mining (for manganese ore, iron ore, tiger's eye and blue asbestos) take place in the catchment near Sishen and Hotazel. Future water consuming developments are for the mining industry in South Africa together with plans for increased irrigation will require further abstraction from an already stretched groundwater system. In addition to groundwater, surface water has been fully exploited in all three WMA's of the Vaal. Therefore, supply augmentation takes place through the transfer of water from the Thukela and Usutu to Mhlathuze in addition to the Lesotho Highlands Water Project (LHWP).

Economically, the Upper Vaal is important, contributing 20% of South Africa's GDP. Future economic growth potential is good, with the majority of growth likely to be connected with the urban and industrial economy. The middle Vaal is rural in nature, characterised by extensive dry land agriculture. Irrigation takes place along river tributaries or downstream of dams. 4% of South Africa's GDP stems from this WMA. Mining represents the largest GDP contributor (45%) to the WMA. The Lower Vaal is primarily livestock farming with dry land cultivation in the north east. Irrigation takes place at Vaalharts as well as along the Vaal River.

Conveyance losses in the irrigation sector range from 10 – 40%. In the Vaalharts Scheme, the largest irrigation scheme in South Africa, the percentage of conveyance loss ranges from 28 – 30%. Efficiency and leakage losses are often larger losses than evaporation, seepage and canal losses.

5.2.4.2 Orange

The runoff in the Orange River is generated in Lesotho (56%), the Upper Orange WMA (33%) and 10% from the Lower Orange. The majority of Lower Orange runoff stems from the Fish River in Namibia. The transfer of water from the Katse Dam via the Lesotho Highlands Water Project to the Upper Vaal area and the transfer from the Gariep Dam via the Orange-Fish tunnel to the Fish and Tsitsikamma water management area are the two key water transfers which take place in (or out of) the WAM.

Groundwater is valuable in the tributary catchments which do not have access to the surface water in the Orange River. Although an insignificant amount of water in total, 60% of tributary water use is groundwater, and therefore it is critically important.

Economic activity in the Orange River Catchment originally stemmed from the discovery of diamonds. The first irrigation scheme, built alongside the Orange at Upington was originally established as a trading post. Further irrigation was supported through the construction of the Gariep and Vanderkloof Dams, which also have hydropower stations. Approximately 6% of South Africa's GDP originates from the Orange WMA (5% Upper Orange, 1% Lower Orange). Agriculture, mining, trade and Government are the main sectors contributing to the GDP.

Irrigation is the dominant user of water, representing 88% of the total water use (excluding transfer). The remaining water user is split between urban, industrial, mining and rural sectors. 12 000 ha set aside for resource-poor farmers as well as urban and industrial growth in major towns are expected to increase demand for water supply.

The water quality in the upper Orange is reasonably good. This is not the case for the lower Orange which is negatively impacted by upstream water use, both in the Upper Orange and the Vaal.

6. Way forward, recommendations and implications for the IWRM plan

The preceding information and data can be used in a number of ways to formulate knowledge regarding the economy within a catchment. The System of Economic Accounting of Water as well as Water Footprint methodologies help to inform the manner in which water is used within a basin. The results from both investigations are not the same as the data and focus of each is different. Both however are useful.

The information gathered through this process can be used in a number of ways for improved water planning processes. The information is able to inform social development both within and between countries. Identifying the role of water in the economy as well as society of a basin helps in future planning regarding the nature and structure of the economy going forward.

The process of water accounting and water footprint are not sufficient alone in making decisions regarding water planning. A substantial amount of information regarding the political and development futures of the country may also inform how water allocation and planning may take place. However, the evidence-based approaches of both water footprint and water accounting can be used as catalysts for a discussion on sustainable water use.

Following the technical task team in January, the project team will have a discussion on how this information can be used to inform the IWRM plan and further planning.

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8. Appendix

8.1 Asset Accounts

Asset Accounts (Mm³)	Vaal	Orange	Namibia	Botswana	Lesotho
Opening Stock	**38 641**	**28 955**	**4 002**	**5 925**	**11 543**
Increase in stock					
Precipitation	87 825	103 942	12 255	15 800	34 038
Inflows	7 302	13 476	1 713	614	7 475
Transfers in	1 034	2	54	-	-
Return flows	755	181	15	9	18
Decrease in stock					
Abstraction	3 557	2 554	163	188	108
Evaporation/ Actual evapotranspiration	85 634	100 744	11 846	16 186	36 221
Transfers out/Outflows	7 726	14 303	2 028	48	5 202
Closing stock	**38 641**	**28 955**	**4 002**	**5 925**	**11 543**

8.2 Water supply and use

Total Abstraction (Mm³/annum)	Vaal	Orange	Namibia	Botswana	Lesotho
Urban	1 201	79	11	-	49
Industrial	398	6	4	-	17
Mining	115	58	7	34	-
Power Stations	246	-	-	-	-
Strategic industries	134	-	-	-	-
Irrigation	1 318	2 353	119	32	35
Rural domestic	34	13	0	70	7
Livestock	112	45	21	47	0
Tourism	-	-	1	-	-
Other	-	-	-	6	-
Total	**3 557**	**2 554**	**163**	**188**	**108**

8.3 Quality Accounts

Quality of stock of water			Vaal				Orange				Namibia				Botswana				Lesotho			
			Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable
			Volume of water (Mm^3/a)																			
	Groundwater	TDS	291	35	17	3	519	778	726	571	54	81	190	217	11	34	69	114	-	680	85	85
	Surface water: Rivers	Sulphate (SO4) mg/l	50	31	38	13	553	15	-	15	16	-	-	-					93	-	-	-
		Chloride (CL) mg/l	37	56	26	13	268	300	-	15									-	46	46	-
Stock of water		Ammonia (NH3-N) mg/l	46	47	9	30	366	87	41	87												
		pH	10	43	-	80	-	302	-	279												
	Surface water: Dams	Electrical Conductivity (EC) mS/m	868	614	1 694	3 176	1 010	3 737	3 081	2 273	187	93	25	6					1 125	125	-	-
		Ortho-Phosphate (PO4-P) mg/l	2 392	1 503	1 821	635	9 596	253	-	253												

8.4 Emission Accounts

Emissions	Vaal										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/domestic	Livestock	Tourism	Other	Total
Gross emissions	353	117	40	72	39	134	-	-	-	-	755
Direct emissions to water	55	-	40	72	39	134	-	-	-	-	341
	55	-	40	72	39	134	-	-	-	-	341
Without treatment	55					134					189
After on-site treatment			40	72	39						151
	-							-	-	-	-
To inland water resources											-
To sewerage	297	117									414
Reallocation of emissions[1]											-
Net Emissions	353	117	40	72	39	134	-	-	-	-	755

Emissions	Orange										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/domestic	Livestock	Tourism	Other	Total
Gross emissions	13	1	-	-	-	167	-	-	-	-	181
Direct emissions to water	2	-	-	-	-	167	-	-	-	-	169
	2	-	-	-	-	167	-	-	-	-	169
Without treatment	2					167					169
After on-site treatment			0	0	0						-
	-							-	-	-	-
To inland water resources											-
To sewerage	11	1									12
Reallocation of emissions[1]											-
Net Emissions	13	1	-	-	-	167	-	-	-	-	181

Emissions	Namibia										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/dome stic	Livestock	Tourism	Other	Total
Gross emissions	3	1	1	-	-	10	-	-	-	-	15
Direct emissions to water	2	1	-	1	-	-	10	-	-	-	-
	1	-	1	-	-	10	-	-	-	-	13
Without treatment	2		1					10			
After on-site treatment					1	0	0				
	-							-	-	-	-
To inland water resources											
To sewerage	11	1	1	1							
Reallocation of emissions[1]											-
Net Emissions	3	1	1	-	-	10	-	-	-	-	15

Emissions	Botswana										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/dome stic	Livestock	Tourism	Other	Total
Gross emissions	-	-	6	-	-	3	-	-	-	-	9
Direct emissions to water	2	-	-	6	-	-	3	-	-	-	-
	-	-	6	-	-	3	-	-	-	-	9
Without treatment	2		0					3			
After on-site treatment					6	-	-				
	-							-	-	-	-
To inland water resources											
To sewerage	11	1	-	-							
Reallocation of emissions[1]											-
Net Emissions	-	-	6	-	-	3	-	-	-	-	9

8. APPENDIX

Emissions	Lesotho										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/domestic	Livestock	Tourism	Other	Total
Gross emissions	11	4	-	-	-	3	-	-	-	-	18
Direct emissions to water	2	8	-	-	-	-	3	-	-	-	-
	8	-	-	-	-	3	-	-	-	-	11
Without treatment	2		8					3			
After on-site treatment					0	0	0				
	-							-	-	-	-
To inland water resources											
To sewerage	11	1	4	4							
Reallocation of emissions[1]											-
Net Emissions	11	4	-	-	-	3	-	-	-	-	18

8.5 Hybrid Accounts

Hybrid Accounts	Vaal									
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/dom estic	Livestock	Tourism	Other	Total
Total Abstraction (Mm³)	1 201	398	115	246	134	1 318	34	112	-	-	3 557
Revenue (US$'000)											92 474
Supply of water (Mm³)											259
Emissions (Mm³)	353	117	40	72	39	134	-	-	-	-	755
Costs of water supply(US$'000)											187 486
Investment in future water infrastructure (US$'000)											749
Water Infrastructure Asset Value (US$'000)											5 039 848
GDP (US$'000)	19 614 999	32 139 540	17 014 196			5 942 618			14 936 459	4 794 778	94 442 589
GDP per capita (US$'000)	2 196 491	3 598 991	1 905 252			665 455			1 672 587	536 920	10 575 697
Employment	1 484 900	615 800	130 550			112 550			668 900	176 900	3 189 600

Hybrid Accounts	Orange										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/ domestic	Livestock	Tourism	Other	Total
Total Abstraction (Mm³)	79	6	58	-	-	2 353	13	45	-	-	2 554
Revenue (US$'000)											8 974
Supply of water (Mm³)											274
Emissions (Mm³)	13	1	-	-	-	167	-	-	-	-	181
Costs of water supply(US$'000)											321 630
Investment in future water infrastructure (US$'000)											57 563
Water Infrastructure Asset Value (US$'000)											8 185 599
GDP (US$'000)	8 695 983	4 311 667	813 659			1 485 655			3 399 933	3 087 546	21 794 443
GDP per capita (US$'000)	3 379 983	1 675 873	316 256			577 449			1 321 497	1 200 077	8 471 135
Employment	259 800	74 700	25 950			57 450			101 700	19 500	539 100

Hybrid Accounts	Namibia										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/ domestic	Livestock	Touris m	Other	Total
Total Abstraction (Mm³)	11	4	7	-	-	119	0	21	1	-	163
Revenue (US$'000)											3 145
Supply of water (Mm³)											114
Emissions (Mm³)	3	1	1	-	-	10	-	-	-	-	15
Costs of water supply(US$'000)											875
Investment in future water infrastructure (US$'000)											-
Water Infrastructure Asset Value (US$'000)											9 421
GDP (US$'000)	857 063	347 969	111 898			122 870			269 785	117 545	1 827 130
GDP per capita (US$'000)	2 375 123	964 304	310 095			340 502			747 638	325 744	5 063 406
Employment	23 926	8 224	1 473			8 960			10 181	2 583	55 348

Hybrid Accounts	Botswana										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/ domestic	Livestock	Tourism	Other	Total
Total Abstraction (Mm³)	-	-	34	-	-	32	70	47	-	6	188
Revenue (US$'000)											-
Supply of water (Mm³)											-
Emissions (Mm³)	-	-	6	-	-	3	-	-	-	-	9
Costs of water supply(US$'000)											-
Investment in future water infrastructure (US$'000)											-
Water Infrastructure Asset Value (US$'000)											-
GDP (US$'000)	500 683	258 477	387 599			48 464			306 825	113 084	1 615 132
GDP per capita (US$'000)	2 187 534	1 129 312	1 693 460			211 746			1 340 550	494 074	7 056 675
Employment	111 693	31 128	5 493			3 662			23 803	7 324	183 104

Hybrid Accounts	Lesotho										
	Urban	Industrial	Mining	Power Stations	Strategic industries	Irrigation	Rural/ domestic	Livestock	Tourism	Other	Total
Total Abstraction (Mm³)	49	17	-	-	-	35	7	0	-	-	108
Revenue (US$'000)											14 224
Supply of water (Mm³)											-
Emissions (Mm³)	11	4	-	-	-	3	-	-	-	-	18
Costs of water supply(US$'000)											9 255
Investment in future water infrastructure (US$'000)											1 155 400
Water Infrastructure Asset Value (US$'000)											370 753
GDP (US$'000)	1 353 400	329 200	119 800			93 300			103 800	76 600	2 076 100
GDP per capita (US$'000)	636 134	154 733	56 309			43 853			48 789	36 004	975 822
Employment	475 448	566 813	32 189			27 373			74 261	23 923	1 200 006