TECHNICAL SUMMARY OF WATER ACCOUNTS

REPUBLIC OF NAMIBIA

MINISTRY OF AGRICULTURE WATER AND FORESTRY

Prepared by Department of Water Affairs and Forestry

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OF
WATER ACCOUNTS

Department of Water Affairs

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LIST OF ABBREVIATIONS

a	Annum
AugBlou	Augrabries Blouputs
Boegoe	Boegoeberg
CBS	Central Bureau of Statistics
DAC	Direct Allocateable Cost
DWA	Department of Water Affairs
FCR	Full Cost Recovery
ISIC	International Standard Industrial Classifications
GDP	Gross Domestic Product
GI	Gross Income
GM	Gross Margin
GW	Groundwater
MAWF	Ministry of Agriculture Water and Forestry
Mm^3	Million cubic metre
NDI	Net Disposable Income
NDP	National Development Plan
NPC	The National Planning Commission
NRA	The Natural Resource Accounts
NWRMR	Namibia Water Resource Management Review
PD	Prieska De Aar
RWS	Rural Water Supply
SAM	Social Accounting Matrix
UpKeim	Upington Keimoes
VdKl-HT	Vanderkloof/Hopetown
WCE	Windhoek Consulting Engineers

NAMIBIA WATER RESOURCE ACCOUNTS

1 INTRODUCTION

The Natural Resource Accounts (NRA) for water record the consumption levels of water for different economic sectors, the cost of supplying this water and the user charges levied by certain suppliers. The Accounts also document the sustainable amount of water available from various sources and the economic benefits that can be derived from using water.

Work to construct water resource accounts for Namibia began in 1995 under the Namibian Natural Resource Accounting Programme. This programme was initiated by the Ministry of Environment and Tourism in cooperation with the Department of Water Affairs (DWA) in the Ministry of Agriculture, Water and Forestry (MAWF). The first set of water accounts, for 1993, included both stocks and flows of water, but the information was limited (Lange, 1997).

The available water resources could only be quantified for the annual volumes of surface water stored in dams. The remaining available resources were summarised as a range of indicators of water availability for perennial surface water and groundwater: annual rainfall, annual runoff of major perennial and ephemeral rivers, and the annual abstractions from 'problem'[1] boreholes in water management areas.

Water flow accounts included the annual water usage by each economic sector, the cost of providing water, the tariffs paid, the subsidies received, and the socio-economic benefits of water use in each sector. The first water accounts classified water into 9 categories based on a combination of institutions supplying water (3) and natural sources (3). Water users were classified according to the classification of economic sectors used for the national accounts (17 industries + government) and two categories of households, urban and rural.

The water accounts were compiled initially to demonstrate that it was possible to produce such accounts and that the water accounts could provide policy-makers with a useful tool - a comprehensive economic assessment of water use in the country. This first set of accounts contained a number of limitations, notably, that much of the data had to be estimated.

There have been a number of developments since the initial accounts were constructed that have increased the demand by policymakers for water accounts and have also made it

[1] The term 'problem' refers to groundwater stocks considered to be experiencing serious, long-term depletion (as evidenced by continuously falling water levels in borehole without recovery for five or more years Lange (1997). The 'problem' borehole category is broken down further by Lange (1997) into two sub-categories. These are Boreholes with Very and Moderately Serious Depletion Problems. Very serious refers to those locations for which no readily available alternative supply exists whereas Moderately serious refers to those locations for which either an alternative source can be found or where there are a relatively small number of users.

easier to construct water accounts. From the policy perspective, Namibia has undertaken a water resources management review aimed at revising water policy and the institutions that manage water. This has resulted in the promulgation of the Water Resources Management Act (Act 24 of 2004), which emphasizes, among other things, an economic approach to water management.

This idea is stated more explicitly in the National Development Plan 2 which states in Section 49 of Chapter 12 that "establishing data collection activities and monitoring of the water resources in collaboration with other relevant institutions (is needed) to enable implementation of the relevant strategies and ensure progress can be measured".

In parallel, Namibia participated in a regional Water Demand Management study (Van der Merwe et al. 2001), which undertook case studies of water use by selected sectors and an economic assessment of water demand management as an alternative source of supply. The need to relate these case studies to national water use and water policy, through water resource accounts, was very clear.

In terms of data availability and quality, the provision of bulk water, which had been part of Central Government, was commercialised in 1997 and required to operate on a commercial, cost-recovery basis. NamWater, the newly-created parastatal body responsible for bulk water supplies, introduced a new database system that provides much more detailed information about water use, costs and tariffs. In recent years, municipalities have introduced or upgraded computerized billing systems that make annual information about water use and tariffs by end-user more accessible.

In 2001 MAWF took over responsibility for compiling the NRA for Water. In 2002 the Swedish International Development Cooperation Agency agreed to fund the current project which is to institutionalise the compilation of the NRA for Water by DWA and it is planned to compile these accounts on an annual basis.

The three objectives of this project are to:

1. Design and complete an accurate and comprehensive set of accounts to provide:
    1.1. breakdowns of water use, user charges levied and cost of supply by region, water source (i.e. ground water, ephemeral and perennial surface water) and by sector.
    1.2. a database which registers water users within Namibia
    1.3. indicators of the magnitudes and sustainable yields of resources classified by water source and by region or catchment basin area.
    1.4. the costs of resource management and environmental protection and pollution
    1.5. the socio-economic benefits of water by sector and region
2. Build capacity within DWA, other institutions and stakeholders involved in the water sector (specifically NamWater and municipalities) through collaboration and co-operation in developing the database.

3. Develop and inform decision makers and water sector stakeholders on the potential and use of water accounts in policy and decision making with respect to:
    3.1. promoting an efficient, equitable and sustainable allocation of water in Namibia
    3.2. the cost and sustainability of augmenting water supply and water demand management by region or catchment

To help guide the project towards meeting the above goals and plans a Steering Committee for the project was formed. This Committee meets at least twice a year and is comprised of representatives from various water sector stakeholders which include Rural Water Supply (RWS), Water Resource Management and the Division of Agricultural Engineering all from the Ministry of Agriculture, Water and Rural Development, the Namibia Water Resource Management Review, NamWater, Windhoek Municipality, the Ministry of Environment and Tourism, the Desert Research Foundation of Namibia, the Namibian Economic Policy Research Unit and some Namibian Water Sector Consultants.

2 FRAMEWORK

The framework for water flow accounts comprises the following components of the water supply and use system:

- the natural characteristics of water sources, such as groundwater and surface water
- the institutions that deliver water to end users
- the end users

2.1 WATER SOURCES

In Namibia, the classifications of natural sources as shown in **Table 2.1** of water supply include groundwater, ephemeral surface water, perennial surface water, recycled water, seawater, and unconventional water, which will include desalinated water if the planned desalination plant on the coast is implemented. (Groundwater is the most important source, accounting for 38 per cent of annual freshwater use in 2001/02. The rest is fairly evenly split between ephemeral and perennial surface water sources. Recycled water accounts for less than 1 per cent of Namibia's annual water use, but is a locally important source of water in urban areas, with potential for expansion in the future. It forms a significant share of Windhoek's water supply with between 13 and 30 per cent of water use in Windhoek coming from recycled water, with the exception of 2001/02 when the recycling facility was being upgraded. Water from unconventional sources is limited to desalination, which is expected to provide a major component of the water supply along Namibia's coast.

Table 2.1: Classification of Natural Sources of Water in Namibian Water Accounts

Water Source	Description
Groundwater	Groundwater can be classified as fossil and renewable.
Perennial surface water:	Perennial rivers run all year. Namibia's perennial rivers all cross national boundaries and the use of this water is therefore subject to international agreements.
Ephemeral surface water stored in dams	Ephemeral rivers flow only after periods of heavy rainfall. Water is captured and stored in large dams for distribution as well as in small farm dams for own-use.
Recycled water	Water that has been used once, treated and reused.
Seawater	Seawater is used in industrial processes along the coast such as diamond mining and fish processing.
Unconventional water sources	Desalination is planned for coastal communities but has not yet been implemented.

This report uses the term Freshwater which is comprised of Groundwater, Ephemeral and Perennial surface water.

2.2 WATER SUPPLIERS IN NAMIBIA

Institutional bodies as shown in **Table 2.2** are the agents that deliver water, directly or indirectly to end users. NamWater, the parastatal responsible for bulk water supply, abstracts water from primary sources and supplies some end-users directly, but the greater part of the bulk water supply is delivered to other suppliers who provide local reticulation systems for delivery to end users. These other suppliers are the Municipal Authorities, RWS and Rural Communities.

Municipal Authorities purchase most of their water from NamWater and deliver it to end users. In some cases, municipalities also operate their own facilities to abstract water from primary sources such as local boreholes.. The water accounts are compiled separately for most municipalities.

Table 2.2: Institutional Suppliers of Water

Institution	Description
NamWater	Bulk water supplier. Provides water directly to some end-users as well as to other suppliers for ultimate delivery to end-users.
Local Authorities,(City, Town and Village Councils), and Regional Councils	Deliver bulk water purchased from NamWater to end users mainly in urban areas, and in some cases abstract water from natural sources themselves.
Rural Water Supply	Water to some End-users in rural areas is provided by Government agency (RWS). Water may be purchased from NamWater, or abstracted directly from sources developed and/or maintained by RWS.
Rural Communities (Water Point Associations and Local Water Committees)	Communities that now manage their own water. Water is purchased from NamWater and supplied to these End-users in rural areas while some started to manage and operate their own supply systems.
Self-providers	Users that abstract their own water mainly for own-use such as livestock farmers, tourism sites and mining companies. In a few instances, such as mining and agriculture, excess water may be sold to other water suppliers or end-users.

RWS, a part of the MAWF, is responsible for providing water to rural communities in the communal areas, mainly for domestic use and livestock watering. RWS purchases some water from NamWater and provides the rest from local boreholes.

It is government policy that local communities should eventually take over the management of most rural supply of water from RWS and some rural communities are already doing so. The Local Water Point Committees and Water Point Associations, which make up the category of Rural Communities, receive all their water from NamWater. They then supply this water mainly to Rural Households in Communal areas and Communal Livestock. These Rural Communities are given support from the Directorate of Rural Water Supply to manage their water receipts and RWS has also gradually phased out the subsidy given to these Rural Communities according to the schedule in **Table 2.3**.

Table 2.3: Phasing Out Period for Government Subsidies to Rural Communities

Date	Government Payment of NamWater Bill	Community Payment of NamWater Bill
Before 1st Aug 1999	100%	0%
1st Aug 1999 - 31st Jul 2000	80%	20%
1st Aug 2000 - 31st Jul 2001	60%	40%
1st Aug 2001 – 31st Jul 2002	40%	60%
1st Aug 2002 – 31st Jul 2003	20%	80%
1st Aug 2003 -	0%	100%

Source: Rural Water Supply

Self-providers, as the term implies, are those who abstract water directly from natural sources primarily for their own use, mainly farmers and mining companies. In some instances, excess water may be sold to other water providers for delivery to other end users. National Parks is also a category included under self supply as wildlife in many parks in Namibia either has open access to surface water or is provided with water from groundwater sources by the park management.

2.3 END-USERS

The term End-users describes the different actors who finally consume the water. In the previous work done on the Natural Resource Accounts for water by Lange (1997), there were 20 categories of end users of which 17 were industries, 2 were different categories of households and the remaining end-user was government. In these accounts the categories have been expanded to 47 which cover 9 primary industries, 15 secondary industries, 15 service industries, 5 providers of government services and 3 household categories. These are shown in **Table 2.4.**

These industrial categories are in line with the United Nations International Standard Industrial Classification of all Economic Activities and are therefore compatible with the economic sector classifications that are used in the Social Accounting Matrix that is being developed for Namibia.

It will be seen in the NRA that there are figures for water supplied to the Diamond Mining and Other Mining and Quarrying sectors from a number of Municipalities such as

Windhoek where there is no mining abstraction activities. The figures in these circumstances refer to the offices of mining companies based in these Municipalities.

Table 2.4: End-users Classifications and International Standard Industrial Classifications (ISIC)

Economic Sector	ISIC Classification
Primary Industry	
Communal Livestock	not available
Commercial Livestock	012
Government Livestock	not available
Communal Irrigation	not available
Commercial Irrigation	011
Government Irrigation	not available
Fishing	05
Diamond mining	10-14
Other mining and quarrying	
Secondary Industries	
Meat processing	1511
Fish processing	1512
Grain Milling	1531
Other food Products	1513, 1514, 152, 1532, 1533, 154
Beverages	155
Textiles, wearing apparel; leather; footwear	17,18,19
Wood and products manufactured from wood excluding Furniture	20
Paper; printing & publishing	21,22
Chemicals, rubber & plastic products	24,25
Other non-metal mineral products	26
Basic metals; fabricated metal products & machinery & equipment n.e.c.	27,28,29
Other manufacturing including furnature	16,23,30-37
Electricity supply	40

Economic Sector	ISIC Classification
Water supply	41
Construction	45
Tertiary Industries	
Wholesale and retail trade, repairs	50-52
Hotels	551
Restaurants	552
Road transport, passengers & travel services	6021, 6022
Road transport, freight & freight related supporting activities (excl. port & airport)	6023
Other transport	601, 603, 61-63
Post and telecommunications	64
Financial intermediation	65-67
Owner-occupied dwellings	
Real estate activities; rental & business activities	70-73
Community, social and personal services	90, 91
Households with employed persons	95
Recreational, Cultural & Sporting Services	92
Other Business	74
Other Services	93
Public Sector	
Education (schools and tertiary	80
Hospitals/clinics	85
Civil service	75

n.e.c = not elsewhere classified

2.4 PHYSICAL FLOW ACCOUNTS

2.4.1 Water Supply

The early framework for water flow accounts in Namibia compressed the supply and use of water into one table, showing only the relationship between the end-user and the institution that first abstracted the water (**Figure 2.1**) The role of local authorities and other institutions as intermediaries in water delivery was not shown, and information about losses and wastewater was not included. Only three major institutions supplying water were included: NamWater, RWS, and Self-providers. The classification of End-users was limited to 20. This simplified framework was adopted due to a lack of more detailed data.

Accounts based on this early framework were constructed for 1993, 1996, and 1998, and are given in the **Appendix 1**.

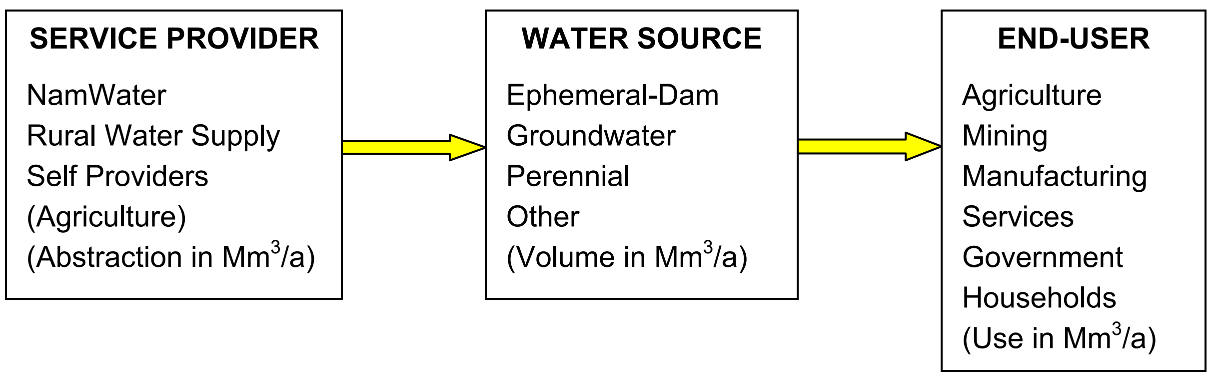

Figure 2.1: Schematic Framework for Previous Water Flow Accounts

To make the accounts more useful for policy, it was decided to expand the water accounts framework to include explicitly the role of all institutions, and to account for the transfer of water from one agency to another. NamWater produces roughly 40 per cent of Namibia's freshwater, about half of which it delivers directly to end users, while the other half is sold to municipal authorities and RWS for distribution to end users. Self-providers account for about 47 per cent of freshwater abstractions. RWS provides most of the rest, with a smaller amount provided by municipalities.

The new framework for physical flow accounts consists of 2 components Supply and Use. The Supply Accounts show the abstraction of water from the environment by institution, and the redistribution of water among supply agencies.

The following elements, which are defined below, in terms of water by natural source for each of the major institutions based on the classification of institutions and natural sources of water given are shown in **Figures 2.1** and **2.2**. *Abstraction*: Water Abstracted from the source with an indication of the entity responsible for the abstraction.

- *Water Consumed in Production*: This is the water that is lost during initial abstraction and the treatment processes which is required for surface water.
- *Transfers between Water Utilities*: Volume of water transferred between institutions from NamWater to Municipal Authorities, Rural Communities and Rural Water Supply as indicated in **Figure 2.2**.
- *Losses During Transfers to Other Utilities*: These are the losses due to leakages and other causes during the transfer of water from primary abstraction by one water supplier to other water utilities.
- *Volume Remaining for End-user, Including Own-use*: This is the net amount of water remaining from own abstraction after transfers to other water utilities, consumption during abstraction and losses in these transfers.
- *Abstraction + Net Transfers: Volume for End-users*: This is the amount of water that the utility has available to supply to End-users, including its own usage.It is the sum of the Volume Remaining for End-user, Including Own-use plus the total volume of water transfers to that water utility. (**Figure 2.2**)
- *Losses from Delivery to End-users*: These are the losses that are incurred in delivering water to the End-users, which is essentially a balancing item. These losses may be comprised of unauthorised connections, actual physical leakages and meter inaccuracies. Where additional data is available, these losses could be further disaggregated into estimated leakages and a remaining balancing item for unaccounted for losses as illustrated in **Figure 2.2**.

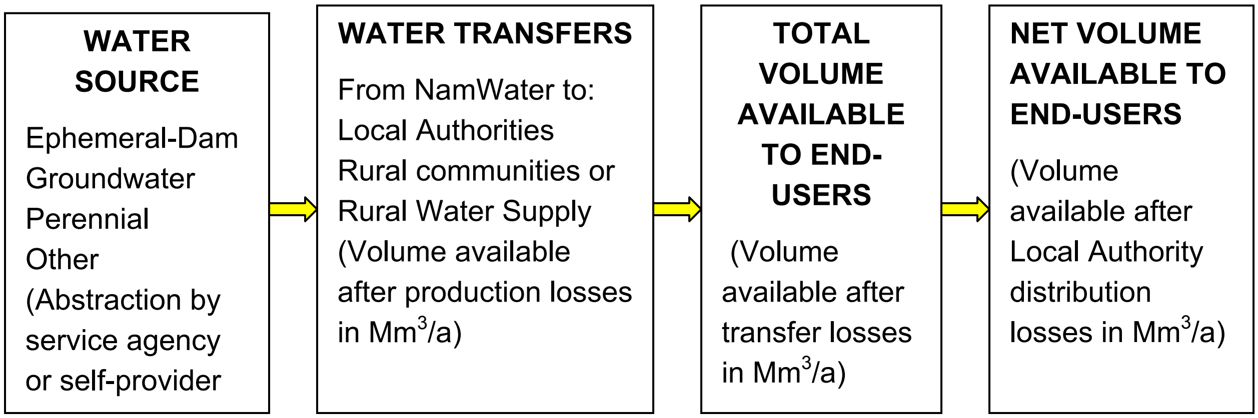

Figure 2.2: Schematic Framework for Water Supply Accounts

2.4.2 Water Use

The accounts for water use record the usage of water by each economic activity ie. agriculture (irrigation & stock farming), fishing, mining, manufacturing, utilities, construction, services (trade, transportation, tourism including national parks etc.) institutions and households. There is also provision for the different ecological uses of water. However, at this stage there is not enough information available to produce meaningful physical accounts for the ecological water requirement.

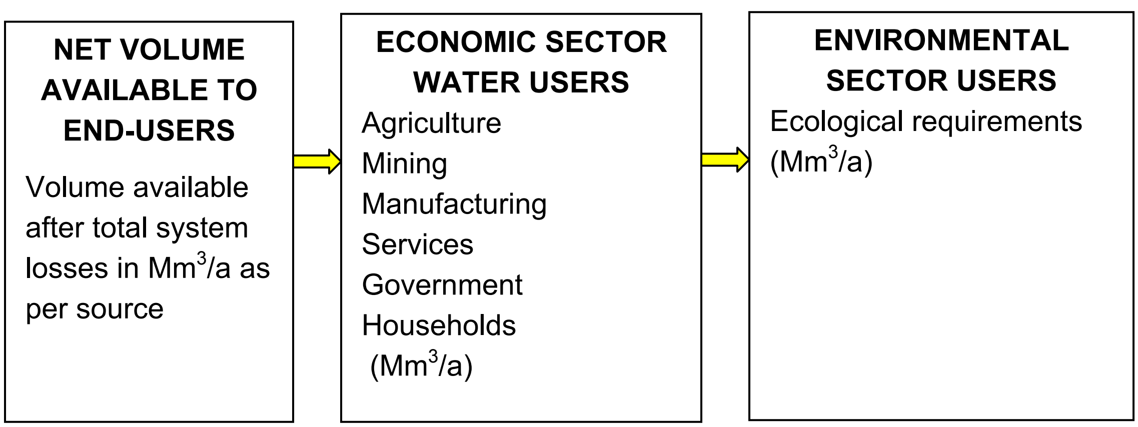

Figure 2.3: Schematic Framework for Water Use Accounts

2.5 Monetary Accounts

The water accounts framework calls for corresponding physical and monetary accounts; the monetary accounts consist of the cost of water delivery, the user-charges levied, and the economic value of water. Estimating the economic value of water is very difficult for most water use and no country has yet done this. Namibia has undertaken case studies to test different valuation techniques, but accounts for the value of water are not constructed here. However, these accounts do, add one more component to the monetary accounts ie accounts for water subsidies where applicable.

This section describes the framework, but also provides some detail on the data sources because this is necessary to explain, in part, the framework design. Chapter 3, however, explains in greater detail the data sources used.

2.5.1 Costs of Supplying Water

The costs and associated subsidies include full financial costs (operating cost, maintenance cost and capital redemption costs) only; no work has been done at this time to estimate scarcity costs or environmental externalities. RWS only has information about total expenditures, and cannot assign costs to specific end-users. However, this hides the variations in costs of supplying water in different regions. There is limited information regarding the cost of water by self-providers. Most of the water is from groundwater and an estimate has been made of the unit cost of abstracting groundwater based on information contained in the DWA Borehole database..

As with the flow accounts the information has been extended to include other suppliers or distributors such as Local Authorities.

NamWater supplies water to end users as well as Local Authorities, Regional Councils and RWS that distribute water to end users. In the case of further distribution by Local Authorities, Regional Councils and RWS a further cost component needs to be added to recover the additional costs for distribution to the end user. The Total Cost of supplying water has two components, a) the NamWater costs of abstraction and transfer to Local Authorities or distributors, and b) the cost of supply and distribution of water to the end user. This would appear to require that the water utilities separate the costs of abstraction, transfer and local reticulation. For NamWater, these costs can be obtained from its records of the full cost recovery tariff that is calculated for each of the different NamWater supply schemes.

For Local Authorities it is a cumbersome process to collect the information from all the different entities, as there is no central database. For local authorities and others, who operate only one water scheme, it is assumed that the cost per cubic metre of water supplied is the same for all customers. Some smaller Local Authorities (villages) were unable to provide the amount from their total expenditures that is allocated to water supply. The cost of purchasing water from NamWater can be obtained for those Municipalities purchasing water from NamWater and a mark-up can be added to reflect the additional costs incurred in reticulation to end-users. Depending on the information available, this approach, of assuming a constant cost per cubic metre supplied, is also used for RWS, even though they operate over a broad area with many different local water supply schemes. It is unlikely that a lot of information will be obtained about the costs of Self-providers. It is possible that in the future, some of the largest self-providers, such as large irrigation schemes and mining companies, may be able to provide cost estimates.

2.5.2 User Charges

Suppliers of water usually levy charges on those who are supplied with water. NamWater charge their customers different water tariffs depending on the scheme that supplies the water and the area concerned. Tariffs are set to achieve full-cost recovery. NamWater supplies sufficient information on the tariffs applied to each customer to construct accounts for water charges levied to all customers.

Local Authorities also charge their customers for water supply, but do not always aim for full-cost recovery especially in small villages. For those Municipalities that provide both individual customer water consumption records and their water tariff schedules, this information can be readily used to construct such accounts. However, this is only available for Swakopmund and Windhoek for the year 2001-02. In future this should be available for the Municipalities whose data is provided by Ae Gams Data, a company that assists local authorities to operate costing systems. Some Municipalities also charge rising block tariffs whereby consumption levels exceeding certain monthly volumes are charged higher unit tariffs.

Self-providers clearly do not pay themselves, nor do they make any payment to government for the right to abstract water.

The framework only details how much water suppliers charge their customers, there is no information on the revenue received by the water supplier. These two components do not equal each other due to the non-payment of water bills by many end-users.

2.5.3 Subsidies to Water Users

There is a system of cross subsidisation within the water sector. NamWater makes a profit on some schemes that is used to subsidise other schemes operated at a loss. Certain local authorities endeavour to make baseline water cheaper to low income groups. This is achieved through rising block tariffs where the tariff for the lower block (normally up to 6 m^3/household/month) is well below the cost recovery price. Self providers of water do not get any subsidy.

The DWA Directorate of Rural Water Supply is responsible for the task of ensuring a sustainable supply of safe water to people and livestock in rural areas. This will be achieved through Community Based Management through Water Point Committees. This is a gradual process over a period of partnership between the government and communities in managing water resources with the aim that in 2007 all water points will be managed and owned by the users. Rural water supply was subsidised 100% until 1997. Since 1998 the subsidy for free diesel was gradually reduced with the aim that communities will eventually carry the full operation and maintenance cost as well as the capital cost. The subsidy to Rural Communities has been reduced over the last few years, as these communities have gradually taken over the responsibility of managing their water resources.

NamWater also supplies water to some rural water supply points. As they operate on full cost recovery principles they experience major problems in recovering costs for water supplied to some users.

2.5.4 Socio-Economic Benefits of Water

Equally important are two additional components of the monetary accounts: the economic *benefits* of water use in each sector, which measure the general contribution of water to socio-economic well-being, and the economic *value* of water in each sector, which isolates the contribution of water to product value from the contribution of other factors of production, such as labour, capital, and other resources (land, minerals, etc.). Water value can be used to assess economic efficiency of the allocation of water. Economic efficiency is based on the concept that water should go to the highest value producer, a concept being adopted for commercial water uses in the new water policies.

Calculation of socio-economic benefits is relatively easy and has a well-developed history in environmental and resource policy analysis. Economic valuation, on the other hand, is extremely difficult because the data are often lacking and quite expensive to collect. Many economic valuation techniques exist and the selection of valuation techniques is largely influenced by data availability. The System of Environmental and Economic Accounts (SEEA) does not at this time provide much guidance on this component of the monetary accounts.

2.5.4.1 Analysis of Socio-economic Benefits

Water consumption for production purposes, such as agriculture and industry, provide economic benefits such as incomes, employment, and foreign exchange earnings. While these benefits do not measure the exclusive contribution of water to economic value, they do measure the broadly-defined socio-economic benefits from the use of water in one sector relative to another sector, or in one region of a country relative to another, or one country relative to another. There are two ways in which this information can be analysed to assist in policy-making. One approach is based on the environmental-economic efficiency, or "eco-efficiency," profiles developed by the OECD and others (OECD, 1993). Eco-efficiency profiles juxtapose, for example, the national shares of water use by each industry with the industry's share of income or employment. This provides an indicator of each industry's environmental burden compared to its economic contribution.

A second indicator is calculated as the ratio of water use to economic contribution, which is most often measured by value added, but can also be measured using output or employment:

$$B_i = \frac{VA_i}{W_i}$$

Where

B	socio-economic benefit of water use in sector i
VA	value added generated by sector i
W	m^3 of water used in sector i

This indicator, value added per cubic metre of water input, has the advantage of summing in a single indicator both the economic benefits and the environmental burden. This makes it possible to compare the economic performance, with respect to water use, of different sectors across countries, the performance of the same sector in a given country over time, or benefits across regions or across countries. Such figures have a long history in environmental economics, especially in energy and pollution analysis, and are used for benchmarking industry performance.

While the socio-economic benefit, B_i, measures the *direct* income generated by water use in a sector, there may be additional benefits, upstream and downstream from the direct user. For example, agricultural production directly generates income and employment, but may also support food processing activities that in turn generate additional income and employment. Models based on hybrid IO tables (mixed unit, monetary and physical tables) are used to measure the total (direct + indirect) impact of water use in a given sector. So far, this kind of analysis has only been carried out for one agricultural area within South Africa, the Crocodile River Catchment (Hassan, et al. 2001).

These socio-economic measures provide an indication of opportunity cost of a given allocation of water by sector. Opportunity cost compares the benefits of using water in one sector to the benefits of the next-best alternative use of water in another sector. In providing scarce water to one industry, for example, there is less available for other industries. For this component of the monetary accounts, opportunity cost is the comparison of the benefits ratio in one sector to other sectors, or the economy-wide average. For instance, water used in agriculture may generate a lower value-added per cubic metre of water input than mining or tourism.

There are a number of drawbacks to this approach. First, opportunity cost assessment assumes that it is possible to easily reallocate water among users. When using water accounts at the national level, this assumption may require transferring water over large distances and is probably most often appropriate for a country such as South Africa, with it extensive water transfer infrastructure. The assumption is less useful for Namibia, where transactions costs of reallocating water may be quite high. In addition, economic benefit measured by sectoral value added is generated by a combination of all the factors of production: labour, capital, and natural resources such as water. A high value-added per sector means that water use in a given sector is valuable, but the value cannot be attributed solely to water. A good example is diamond mining: this activity generates very high value added, but this value-added cannot be attributed to water; rather it results almost entirely from diamonds. Nevertheless, when facing a water scarcity, this simple analysis indicates that, all else equal, water will generate greater income if allocated to diamond mining than if allocated elsewhere in the economy.

2.5.4.2 Economic Valuation

Water supply usually has the characteristics of a natural monopoly and competitive markets for water often do not exist so it is not possible to observe a market-determined price for water. The exceptions to this include, for example, tradable water rights in parts of Australia and the United States and local water vending in cities in some developing countries. If markets for water exist then the marginal value of water can be derived from an estimated demand curve. However, in the absence of water markets, valuation techniques must be used such as hedonic pricing or the production function

In the initial compilation of the water accounts by Lange (1997) there was an analysis of the economic contribution of water to 11 different sectors in the economy. This looked at how much one cubic metre of water used in production contributed to both output and value added in a number of industries considered. This was done by dividing the output and value added figures for each industry by the amount of water used in that particular industry.

Similarly, in this analysis there will be attention given to how water usage contributes to value added and employment in 25 and 17 different industries for these measures respectively.

3 METHODOLOGY AND DATA SOURCES

3.1 INTRODUCTION

There is no comprehensive data source that provides all the necessary data to compile the NRA for Water. Therefore, numerous sources must be utilised in order to create the accounts. This chapter provides the sources of data along with the methodology employed to use this data to produce the NRA.

The accounts were constructed partly on the basis of administrative records from NamWater, Ae Gams Data (company involved in costing systems for local authorities), and some Municipal Authorities with the majority of these records being based on water meter readings. **Table 3.1** lists all the organizations that provide information to compile the Natural Resource Accounts along with the data that they provide. Part A lists the data sources which provide these administrative records for water abstraction, supply and use. However, key sectors were only partly covered by these records or not covered at all. These sectors include Rural Domestic Water Usage, Livestock, Irrigation, Mining and National Parks. For these sectors a wide range of data was used to estimate the water accounts. Part B of **Table 3.1** states the other data sources whose data was used to estimate the water abstraction, supply and use for these.

3.2 DATA FOR PHYSICAL FLOW ACCOUNTS

This section looks at each of the main sources of data and the data that is provided by them. It then highlights the methodology and assumptions that were employed in order to generate the information needed for the accounts. There is also a discussion of the problems with the assumptions made and limitations of the data.

The first part of this section covering points 3.2.1 to 3.2.7 discusses those data providers in Part A of **Table 3.1** that provide administrative records. Then the latter part of the section from points 3.2.8 to 3.2.12 look at the other sources of data which are used to make estimates.

Table 3.1: List of Data Sources with Data Supplied

A: Water Use Administrative Records

Data Source	Data Supplied
NamWater	Individual customers and their monthly consumption and billed amounts Unit costs of water supply for the various NamWater schemes Contents of NamWater operated dams
Windhoek Municipality	Monthly Meter Readings for all Windhoek customers Water tariff rates Own water supply data Total costs of supplying water
Comparex (Swakopmund Municipality)	Monthly meter readings and billed amounts for all Swakopmund Customers
Swakopmund Municipality	Water Tariff Rates
Ae Gams Data	Monthly Consumption for all customers for 11 Municipalities*
Walvis Bay Municipality	Water consumption for fish processing industry and the three townships in the town Water tariff rates Cost of supplying water in the town Water losses
Grootfontein Municipality	Own Groundwater Abstraction
Outjo Municipality	Own Groundwater Abstraction
Usakos Municipality	Own Groundwater Abstraction
Okahandja Municipality	Own Groundwater Abstraction
Omaruru Municipality	Own Groundwater Abstraction Water consumption for four different sectors
Namdeb (Oranjemund Town)	Oranjemund town water consumption Namdeb Mines' water consumption

*Grootfontein, Henties Bay, Karibib, Keetmandshoop, Khorixas, Okahandja, Oshakati, Otjiwarongo, Outjo, Rundu, Tsumeb

B: Other Data Sources

Data Source	Data Supplied
Census Office (National Planning Commission)	Population figures
Veterinary Services	Livestock Census
Department of Water Affairs	Total annual runoff of perennial rivers (Hydrology) Average borehole depth, yield and water level for all boreholes in the Groundwater database (Geohydrology) Operational and Capital Costs for Rural Water Supply (Rural Water Supply) Areas under irrigation for water abstraction permit holders (Law Administration) Orange River Report on water abstraction (Law Administration)
Namibian Agronomic Board	List of farmers irrigating white maize along with area under irrigation for each farmer
Ministry of Mines and Energy	List of Operating Mines Mines production figures
Ministry of Environment and Tourism	List of National Parks and Game Populations
National Planning Commission	GDP Figures
Ministry of Labour	Employment Figures from the Labour force Survey
Nampower	Energy Prices

3.2.1 NamWater

NamWater Accounts for 40.0 % of Freshwater Volume Abstractions and 23.8 % of Freshwater Deliveries to End-Users in 2002.

NamWater have a database of all their customers which number about 5,800 in 2002. For each customer there is information for a number of different elements. These are the Customer Number, ID Number, Titles, Customer Name, Address, City, SP ID (Supply Point ID), Blocked meters, Supply Point, Meter A, Meter B, Material, Category, Type, Communal, Region, Area, Scheme Code, Scheme Name, when the data was created (meaning when the customer details were input in the NamWater records).

The database also includes monthly water tariffs for each financial year starting from May 1997 to April 2002, monthly water sold (volume) for each financial year starting from May

1997 to April 2002 and monthly revenue generated (user-charges) for each financial year starting from May 1997 to April 2002.

Appendix 2 provides a list of the various categories included under each of the main fields in the NamWater database.

Table 3.2 shows the five items of information that have to be presented in the NRA framework along with the corresponding items of data provided by NamWater, which are from the I the information listed in the previous paragraph that come from the NamWater database. The only item of data that is not self-explanatory is for Material. There are three types of Material, these are Treated, Untreated and Irrigation. Treated water is potable water, if it comes from surface water then it has gone through treatment works and been chlorinated. If it comes from groundwater it has generally been only chlorinated, though in some rare instances NamWater do treat groundwater, for instance for the removal of fluoride. The Untreated category is water that has not been treated as described above. Irrigation water is a sub-section of untreated water that is supplied for the irrigation purposes.

Table 3.2: Information from NamWater Database

Component of Water Accounts	NamWater Data
Water Volume	Monthly Water Sold in m^3
Water Source	NamWater Supply Scheme
User's Economic Sector	Customer Name Material Customer Type Customer Category Communal/Non-Communal
Distribution Route	Customer Name
Cost of Supply	Monthly Water Sold in m^3 Full Cost Recovery Unit Cost per NamWater Scheme (N$/$m^3$)
User-Charge Levied	Monthly Water Sold in m^3 Water Tariff (N$/$m^3$)

In order to compile the accounts as described in section 2 each customer must be classified according to which category of End-user, or economic sector, they are in, the source of the water is that they receive, the river basin that they are in and whether the water is delivered to them directly for end-use or to another water supplier for further distribution.

To classify the NamWater customers according to their water source NamWater stated that each scheme delivers water from a given source. The list of these is in **Appendix 3**. Since the data from NamWater reports the scheme from which each customer is supplied, it is straightforward to classify the water source for each customer. In all of the schemes except two the water is from a single source. These two are the Gobabis Purification and Karasburg Purification schemes. NamWater made an estimation that currently for the Gobabis Purification scheme 40 per cent of the water is from groundwater whilst the remaining 60 per cent is from ephemeral sources. This breakdown is more difficult to obtain for the Karasburg Purification scheme. All water is taken from the ground, but the groundwater is largely derived from dams upstream whose water has seeped into the ground. Since NamWater could not provide an estimate for the breakdown it was assumed, to have a similar breakdown as that for the Gobabis Purification scheme. This assumption was not based on any similarities between the schemes but in order to have standard percentage rule that could be applied to both schemes.

In order to classify each customer into an economic sector reference was made to the data that NamWater supplied regarding the customer name, material, customer type, customer category and communal/non-communal. In certain instances assistance was provided by NamWaterstaff to classify a customer’s economic sector. Reference to these customer details allowed the majority of customers to be classified. The exception is that of the Livestock sector. Box 3.1 describes how the customers in the Livestock sector are identified and classified.

Box 3.1 Water Provided by NamWater to the Livestock Sector

In terms of the livestock sector NamWater provided their own way of calculating water supply to the livestock sector. In this they stated that all customers supplied by the Okakarara – Elandspan and Coblenz – Okakarara schemes were involved in the livestock sector along with all customer names or supply points with the words "cattle" or "stock" in them. Then they provided another list of schemes[2] from which they estimate that 50 per cent of the water is used for livestock and the other 50 per cent is for Rural households. However, when the customers supplied by these schemes are inspected more closely it is noted that some such as schools and clinics are not involved in livestock or household water consumption. Therefore, these customers are reclassified accordingly. It was also decided that the reported figures in the water accounts should be consistent with what NamWater reports for their livestock consumption. This was done by altering the 50/50 ratio of the group of those schemes that NamWater assume supply livestock and household consumers equally so that the calculation for livestock consumption in the NRA is the same as the figure that is reported by NamWater. These figures are being matched only for consistency reasons and complete accuracy is not guaranteed.

Each NamWater customer is also classified according to the delivery route of the water. This is necessary as NamWater supplies some end-users directly and also other water suppliers for further distribution. It is especially important in the case of the water supplied by NamWater to Communal Livestock and to Rural Households as water to these two sectors either goes directly to the End-user or via some other water utility. **Table 3.3** gives the four delivery routes along with the percentage of water supplied via each delivery route. The method for classifying this is done on the basis of the customer name. If the customer is named as either a Municipality, Regional, Town or Village Council then it falls in the second delivery route in the table. Likewise, customers named RWS, or Local Water Committees and Water Point Association are coded accordingly. The remaining customers are then assumed to receive their water directly from NamWater for their own use and not for further distribution. One slight anomaly is the case of the Southern Electricity Company which purchases water from NamWater and supplies water to about five settlements in the South of Namibia. This is assumed to fall in the category of Municipal Authorities.

[2] These are Omakango – Omafo, Omafo – Oshikango, Omafo – Omungwelume, Omafo – Eenhana, Ondangwa – Iindangungu, Iindangungu – Omakango, Iindangungu – Oshigambo, Ondangwa – Omutsegwonime (except Ambende), Endola North-East, Omakango – Endola, Omakango – Onambutu and Ondangwa – Omutele

Table 3.3: Delivery Routes of NamWater Supplies and Corresponding Codes

Code	Delivery Route	Percentage
1	NamWater direct to End-users	52.1%
2	NamWater to Municipalities/Regional, Town and Village Councils for further distribution to End-users	41.1%
3	NamWater to Rural Water Supply for further distribution to End-users	4.5%
4	NamWater to Local Water Committees and Water Point Association for further distribution to End-users	2.3%

NamWater could only provide information on the volume of delivered water. They could not provide information on the abstractions of water from different sources. To obtain an estimate of NamWater's abstractions some assumptions are made in terms of the losses of water to NamWater customers. Firstly, NamWater made the assumption that 7 per cent of water is lost in the abstraction, treatment and production process of ephemeral and perennial river water. Furthermore, it is also assumed that an average 3 per cent of water is lost in the distribution of water by NamWater to all customers. This figure for the average losses does not include losses on the two NamWater canals. These are from Kunene to the central northern Regions and from the Kombat/Groofontein/Berg Aukas area to the Omataku Dam. (Central Area of Namibia)

Since all the NamWater customers contained in the database, which is used to generate the accounts, are metered then it would seem that this portion of the accounts represents accurate total volumetric figures. However, meter readings are not 100 per cent reliable. It is noted that over time without calibration meter readings tend to slightly underestimate the flow of water. Also the quality of water can affect readings as deposits build up in the meters. Another possible area of weakness in the data is that there may be less accuracy in terms of the breakdown according to consumption by End-user since this depends on the assumptions made by NamWater and Department of Water Affairs staff in classifying the customers, especially for the communal livestock sector.

3.2.2 Windhoek Municipality

Windhoek Municipality accounts for 0.2 % of Freshwater Volume Abstractions and 3.5 % of Freshwater Deliveries to End-Users

Table 3.4 lists the data provided by the Windhoek Municipality along with the corresponding NRA information that is generated by it.

Table 3.4: Information from Windhoek Municipality

Component of Water Accounts	Windhoek Municipality Data
Water Volume	Monthly Water Meter Readings
Water Source	Table on Water Supply by Source
User's Economic Sector	Customer Name Township Customer Type
Cost of Supply	Total Costs of Supplying Water Monthly Water Meter Readings
User-Charge Levied	Monthly Water Meter Readings Water Tariff Rates

For the purposes of producing the accounts each customer is given a classification for the economic sectorinto which they fall.. This is done by referring to the customer name, customer type and township of each customer. This was done initially by referring to the customer type. **Table 3.5** gives the various categories in customer type that are classified by Windhoek Municipality. The categories such as Domestics, School, etc. match exactly with the classifications used in the accounts. However, for general categories such as Commercial, Business, Industrial, etc. reference to the customer name and township were required to classify them more accurately. In some cases, when the name and township could not provide and exact classification the end-user was categorized in the “Other” categories such as “Other Business” or “Other Services”.

Table 3.5: Categories of Customer Type as Used by Windhoek Municipality

Categories of Customer Type as Used by Windhoek Municipality		
Business	Fire	Parks
Commercial	Hostel	School
Communal	Industrial	Semi-Purified effluent
Domestic	Institution	Tourism

The meter readings are then used to produce consumption figures for each of the customers. Since the Municipality of Windhoek does not read the meters of all of its customers every month a simple subtraction of the April meter reading from the reading taken in the following March could not be used. Therefore, the average daily water consumption figure is calculated by subtracting the meter reading for a point as late in the accounting year as possible from the earliest reading taken in the accounting year. This difference is then divided this by the number of days that separated the meter readings.

However, a problem occurred in that some of the average daily consumption figures calculated produced negative figures. On closer inspection it was discovered that some meters had either been replaced or the water meter had been reset at zero due to reaching the maximum reading during the course of the year under investigation. The methodology employed to resolve this is to find two meter readings which are read from the same scale for those particular customers at different points in the year.

Finally the average daily water consumption was multiplied by the number of days in a year to generate annual consumption volumes for all the customers.

Windhoek Municipality provided data on their annual water abstractions from boreholes, water produced at the recycling plant and annual losses of water in percentage terms.

The limitations of the data and methodology are that some meter readings are not taken for every customer in every month. Therefore for some customers, along with those whose meters had been replaced or reset to zero, their annual consumption figures were based on a limited time period and so seasonal variations in consumption may not be incorporated in their final annual consumption. If some meters have a problem then there is no way of detecting this, which may mean that some of the meter readings are inaccurate for this reason.. Also for some streets the numbers are incomplete which suggests that not all customers were included in the data. The Municipality confirmed that there are some discrepancies with total water billed and total water consumed figures. However, the final consumption figures produced for the city as a whole are in the region of the figures given by the Municipality and NamWater for total water supplied to the city.

The final data figures may also be biased down due to the fact that the data provided by the Municipality on customer meter readings does not include customers supplied with semi-purified water. There are about 100 Windhoek customers, in the activities of sports fields, road building and garden nurseries, which use this source of water.

3.2.3 Swakopmund Municipality

Swakopmund Municipality accounts for 0.8 % of Freshwater Deliveries to End-Users. Comparex is a company that does the water billing for the Municipality of Swakopmund. As a result they have records on around 9,000 customers. The customer information that they are able to provide includes the customer name, customer address, tariff code, town code, zone code, account number and the monthly water consumption as summarised in **Table 3.6**.

In order to classify the customers according to economic sector the water tariff code is referred to. The water tariff codes are in terms of domestic, business, small-holder, departmental and semi-purified water customers. When the customers are broken down in terms of their tariff codes, reference can be made to their name, address and town code to get a better idea of the nature of their economic activity.

The monthly billed amounts for all customers were then summed to get each customer's total annual consumption. Then this was summed according to the economic sector in which the customers hade been classified.

The losses were calculated by comparing the amount received from NamWater and the amount supplied to customers as detailed in the records provided by Comparex.

The limitations of this source of data and methodology are the general limitations of using data from water meters.

Table 3.6: Information from Swakopmund Municipality and Comparex

Component of Water Accounts	Swakopmund Municipality (Comparex Data)
Water Volume	Monthly Water Consumption Volumes in m^3 (Comparex)
Water Source	NamWater Data
User's Economic Sector	Customer Name (Comparex) Water Tariff Code (Comparex) Town code (Comparex) Customer Address (Comparex)
Cost of Supply	Swakopmund Municipality
User-Charge Levied	Monthly Water Consumption (Comparex) Water Tariff Rates (Swakopmund Municipality)

3.2.4 Ae Gams Data

Ae Gams is an company that provides municipal costing systems to a number of Municipalities, Towns and Village Councils (Local Auithorities) which are contained in **Table 3.7**. The data collected from Ae Gams Data accounts for 4.4 % of Freshwater Deliveries to End-Users.

However, due to time constraints to download the data in time, data for only 11 towns was obtained, these are denoted by an asterisk (*) in **Table 3.7**.

Table 3.7: Local Authorities Using the Ae Gams Data Costing System

List of Local Authorities		
Arandis	Katima Mulilo	*Oshakati
Aranos	*Keetmanshoop	*Otjiwarongo
Aroab	*Khorixas	Outapi
Bethanie	Leonardville	*Outjo
Eenhana	Luderitz	Rehoboth
Gochas	*Okahandja	*Rundu
*Grootfontein	Okakarara	*Tsumeb
*Henties Bay	Ondangwa	Usakos
*Karibib	Ongwediva	

Table 3.8 lists the components in the NRA and the different items of data provided by Ae Gams that generate them. Ae Gams provides information on individual customers in terms of the customer name, account number, township, number of sewer and water points and the monthly water consumption. Data on different categories of water tariff, sewer tariff, the type of user are also supplied by Ae Gams. The water and tariff codes provide information on whether the customer is a domestic, business, industrial, school, hospital or church user of water. Likewise the type of user also categorises all the customers according to these groupings.

Table 3.8: Information from Ae Gams Data

Component of Water Accounts	Ae Gams Data
Water Volume	Monthly Water Consumption Volumes in m^3
Water Source	NamWater Data Municipality
User's Economic Sector	Customer Name Water Tariff Code Sewer Tariff Code Type of user Township Number of Sewage and Water Points
Cost of Supply	Not Available
User-Charge Levied	Monthly Water Consumption Water Tariff Rates

As with other information sources with individual customer records, each customer is classified according to the economic sector into which they fall. This is determined mainly by the water tariff and sewerage tariff codes that are applied. Once those customers with a business water tariff code are identified the customer name is referred to in order to determine their economic activity.

Then the monthly bills are summed for all customers for a time period of one year. The water consumption for each economic sector is then the sum of the consumption of all customers involved in that economic activity.

To estimate the losses of water in these towns, the figure for water sales from NamWater to that Municipality (or water abstractions if the Municipality abstracts water itself) is compared to water supplied by that Municipality to its customers for the same period.

One of the limitations of this data source is that Ae Gams can only provide data going back for a 12 monthly period from when the data is requested. This means that there are no figures going back in time for the water consumption for each consumer and therefore for the different economic sectors.

However, the percentage breakdown of water usage for the different economic sectors in one settlement for one year can be obtained from the data. This percentage breakdown can be applied to the water that NamWater supplies the settlement with in other years, after removing losses, to determine the volume of water consumed in the different economic sectors. This assumes that there have been no major changes in the economic structure of the municipalities over the previous five years. It was verified for the ten largest Municipalities that the percentage breakdowns calculated for the 2002/03 year could be applied in other years.

Since the data is based on metered sources it is considered that the information is quite accurate making provision for the problems associated with meter readings as discussed in **Section 3.2.1**. As with the NamWater data, classifying the customers according to economic sector may have involved errors since it would have been time consuming to find out for each customer on a one by one basis what activity they are involved in. However, for each Municipality the ten largest customers were investigated in more detail to confirm that their figures were correct and that they were accurately classified. The data provided by Ae Gams was downloaded from the electronic database from each local authority.

Municipalities whose billing is done through the Ae Gams Costing System but whose data was not supplied, due to the constraints and technical problems, had their consumption figures estimated in the same way as other towns on which there was no individual customer data. This method is described in **Section 3.2.5.**

3.2.5 Municipalities without Individual Customer Records

Municipalities Without Individual Customer Records account for 2.8 % of Freshwater Deliveries to End-Users

For settlements with no individual customer records, or whose records were not made available, the percentage breakdown of a similar settlement in terms of population and geography was applied to the total water available to end-users. Appendix 4 gives an explanation of the assumptions made when applying the percentage breakdown of water consumption between sectors from one settlement to another.

The methodology for obtaining the water consumption by economic sector was first to calculate the water supplied by NamWater for each municipality for the year being investigated. Then any amount of water produced by the Municipality itself was added to the receipts from NamWater.

The losses were then subtracted to give the amount of water available to End-users. The percentage losses figure for each town was obtained in the following way. Firstly, a series of water meter studies done in 2002 (Van der Merwe) reported the percentage losses in a number of local authorities. These percentage loss figures were combined with the figures for losses obtained from the estimates for the Municipalities whose data was supplied by Ae Gams to get the weighted average percentage loss figures for different sized towns. Smaller Municipalities were defined as receiving from NamWater or abstracting a combined amount of less than 500,000 m^3 of water per year. Medium sized Municipalities receive from NamWater or abstract a combined amount of between 500 000 and 2 500 000 m^3 of water per year whilst larger Municipalities had a combined amount of water available of over 2 500 000 m^3. These average losses could then be applied to other Municipalities on which there is no data.

The percentage breakdown for the economic sectors was then applied to the figure of water available for End-users in all years to get the amounts of water used in each economic sector.

3.2.6 Walvis Bay Municipality

Walvis Bay accounts for 1.4 % of Freshwater Deliveries to End-Users

The Municipality of Walvis Bay forms a sub set of those Municipalities which have no individual customer records. This is because it cannot provide data on individual customer records due to confidentiality but it can provide data on water supplied to the Fish Processing Industry. Therefore this can be used directly when completing the NRA framework for the water supplied to Fish Processing by Walvis Bay Municipality.

3.2.7 Municipalities that Abstract their Own Water

Municipalities that Abstract their Own Water account for 4.6 % of Freshwater Volume Abstractions and 1.8 % of Freshwater Deliveries to End-Users (excluding Windhoek)

A number of Municipalities abstract their own water, mainly from groundwater sources. This is either because the Municipality receives no water from NamWater or it abstracts supplies additional to what it receives from NamWater. Grootfontein, Omaruru, Oranjemund, Outjo and Tsumeb are in the former category which abstract all their water for delivery to end-users,whereas Okahandja, Usakos and Windhoek Municipalities abstract water themselves to supplement water received from NamWater.

These Municipalities provide information on their monthly abstractions of water. The exception was Oranjemund which could provide only annual figures for water consumption.

The methodology to allocate the water consumed by End-user has already been explained in **Section 3.2.2** for Windhoek Municipality. Since Ae Gams provide data for Grootfontein, Okahandja, Outjo and Tsumeb the methodology to account for the water consumed by End-users is detailed in **Section 3.2.4**. Finally, for the remaining Municipalities which have no individual customer consumption records, the methodology used for allocating the consumption figures for End-users is explained in **Section 3.2.5.**

3.2.8 Rural Water Supply Data

Rural Water Supply accounts for 7.5 % of Freshwater Volume Abstractions and 9.8 % of Freshwater Deliveries to End-Users

RWS provides water mainly for domestic use and livestock watering with small amounts for other End-users which are assumed to have zero consumption for the purposes of this study. This section discusses the domestic water usage supplied by RWS. The next section discusses Livestock water use, as supplied by RWS and by Self-Suppliers.

RWS does not meter any of its own abstractions of water or deliveries to End-users so there are no records of water use. Therefore, the assumption that rural water consumption is 15 litres per person per day (this figure is the minimum design guideline used by RWS for water schemes) can be used indirectly to estimate water use when applied to population figures.

Table 3.9: Information from Census and Rural Water Supply

Component of Water Accounts	Source of Data Used for Calculation
Water Volume	Population Census (1991 and 2001)
Water Source	Population Census (1991 and 2001)
User's Economic Sector	Not Available. Estimated using method described in text.
Cost of Supply	Rural Water Supply
User-Charge Levied	Not Applicable

Table 3.9 gives the various items of data that come mainly from the Population Census and also from RWS along with the information in the NRA that can be produced as a result. The censuses of 1991 and 2001 provide information on rural population figures according to their main source of water. In 1991 the sources of water were categorized as Piped Water Inside, Piped Water Outside, Public Pipe, Well, Borehole, River/Lake/Canal, Other and Not Stated. The 2001 census provided more categories for the respondents. These were Piped Water Inside, Piped Water Outside, Public Pipe, Borehole, Borehole with Open Tank, Borehole with Tank Covered, River/Stream/Dam, Canal, Well Protected, Well Unprotected and Not Stated.

Some assumptions are made regarding the water utility that supplies the different sources of water as defined in the censuses. After consultations RWS the assumptions in **Table 3.10** were made.

Table 3.10: Mapping of Census Water Source Information with NRA Framework

Population Census 2001: Water Source Category	Population Census 1991: Water Source Category	Entry in NRA Framework
Piped Water Inside	Piped Water Inside	NamWater direct to end-users or via RWS or Rural Communities
Piped Water Outside	Piped Water Outside	
Public Pipe	Public Pipe	
Borehole	Borehole	RWS from own groundwater abstraction
Borehole with Open Tank		
Borehole with Tank Covered		
River/Stream/Dam	River/Lake/Canal	RWS from Perennial source
Canal		RWS from Ephemeral source
Well Protected	Well	RWS from Groundwater
Well Unprotected		
Other	Other	RWS from Ephemeral source
Not Stated	Not Stated	

NamWater is involved in supplying piped water whether inside homes, outside homes or via a public pipe. This may either be direct to the End-users or via the Rural Communities, Municipalities or RWS. This information has already been accounted for in the data supplied by NamWater.

The only source that RWS abstract and supply water from themselves is from boreholes. Therefore the population reporting their main source of water as coming from the various categories of boreholes is assumed to be supplied by RWS.

It is assumed that for the remaining categories of the main source of water the individuals fetch water themselves from the various sources. However, for the purpose of reporting this information in the NRA framework it is included under RWS own abstractions.

With data from the two census years the percentage of the rural population receiving water from the various sources can be calculated. From these calculated figures changes in percentages over the ten-year period between the censuses can be estimated. By assuming a constant rate of change in the percentages supplied by the different sources between years, the annual percentage breakdown of the rural population described by their main source of water, is obtained for the years under investigation. These percentage breakdowns can be multiplied by the total rural population for the year under consideration to get the estimated numbers of rural people supplied by different sources of water.

To get the rural population figures, data on the total populations in the census years were taken and a constant growth rate applied between the census dates to find the total population in each year. The percentage of total population in rural areas was also taken for the two census years and a constant rate of change applied between 1991 and 2001 to get the percentage of total population living in rural areas in the intermediate years. Therefore, to get the figures for rural populations in the years between the censuses the figures for total population were multiplied by the figures calculated for the proportion of people living in rural areas.

A possible problem with the assumptions is that the figures for the population obtaining their water from boreholes in rural areas includes commercial farms and their farm workers. In these cases the water would not be supplied by RWS as they do not supply water in commercial farm areas. However, the number of people on commercial farms is small relative to the total rural population so it is not expected to affect the figures. Furthermore, there are also boreholes in communal areas that are operated by communities or individuals and not by RWS. These would create an upward bias of the figures for water supplied by RWS to Rural Households in communal areas.

3.2.9 Self Providers - Livestock

Livestock consumption accounts for 11.2% of Freshwater Volume Abstractions and 12.0 % of Freshwater Deliveries to End-Users

Section 3.2.1 deals with NamWater and its supplies to the livestock sector. This sector is also supplied by RWS and Self Providers or the farmers themselves. However, there is no direct metering of water used by RWS and Self-Providers.

Table 3.11: Information from Veterinary Services and Rural Water Supply

Component of Water Accounts	Data Source
Water Volume	Stock Population Figures
Water Source	Vet Services RWS
User's Economic Sector	RWS
Cost of Supply	RWS

Table 3.11 summarises data or their sources along with the information they generate in the NRA about Livestock water consumption. The Directorate of Veterinary Services produces an annual stock census. This census provides information on the population figures for a number of animals. The census has information on cattle, sheep, goats, horses, donkeys, pigs, poultry, dogs, camels and ostriches. These are broken down in terms stock census areas. However, these stock census areas do not match any other regional breakdowns used in Namibia, such as the 13 regions or in the case of the NRA

the river basin areas. Furthermore, these census figures do not state how many animals are supplied with water by NamWater, RWS or Sefl-Providers.

The methodology to derive the water consumption figures from the livestock census relied on a number of assumptions. The first assumption concerns the average daily water requirements for each type of animal. These assumptions are obtained from the State Veterinarian except for that of camels which was located on the internet. The general assumption is that an animal requires 10 per cent of its body weight in liquid per day. These assumptions are contained in **Table 3.12.**

Table 3.12: Water Consumption of Livestock

Animal	Water Consumption (litres)		Number of Animals 2001	Total Annual Water Consumption (m^3)
	Daily	Annual		
Cattle	45*	16,425	2,508,570	41,203,262
Sheep	10	3,650	2,369,809	8,649,803
Goats	10	3,650	769,055	6,547,051
Pigs	7	2,555	21,854	55,837
Camels	40	14,600	71	1,037
Donkeys	15	5,475	169,314	926,994
Horses	25	9,125	52,502	479,081
Poultry/ 100	23	8,395	502,356	42,173
Ostriches	11	4,015	59,309	238,126

*Refer to the discussion on the limitations of the data, assumptions and methodology in **Section 3.2.9**

The number of animals is multiplied by their daily water consumption and this is multiplied by the number of days in a year to get an estimate of their annual water consumption

The Directorate of Veterinary Services distinguishes between livestock in communal areas served by RWS, and livestock in commercial areas, where water is provided either by NamWater or by the farmer (Self-Provider).

The RWS gave guidelines regarding the suppliers and sources of water to the various stock census areas. These were that NamWater only supplies water directly to the livestock users in commercial areas and the Government Livestock sector. Additionally, NamWater supplies RWS and the Rural Communities with water for further distribution to livestock users, but this occurs only in Communal areas. The remaining water is assumed to come from Self Providers. RWS also stated that they are the main supplier of water for livestock consumption in the North Central communal areas with lesser quantities coming from oshanas, pans and hand-dug wells. The latter three categories are classified as being Self Providers. In the communal areas it is assumed that RWS accounts for the delivery of two-thirds of the water for livestock consumption the remainder coming from Self-Providers.

The next step was to estimate the breakdown of water consumption based on water suppliers for commercial farm areas. This was done by comparing the total amount of water consumed by livestock in one stock census area, based on the calculation of stock population, multiplied by the average daily water requirements, with the metered NamWater supplies to that approximate area. The difference was taken to be provided by self-suppliers of water.

It is not difficult to get a breakdown of the water sources for Namwater supplies as this could be retrieved from the NamWater data that was described in **Section 3.2.1**. Discussions with RWS reveal that they only abstract from groundwater themselves. Further discussion with RWS and the Directorate of Veterinary Services indicated that their records could provide information for the various water sources available to Self-Providers in each stock census area. The breakdown of water sources for Self-Providers is obtained by dividing the water supplied equally between the various sources available in that area. For commercial farmers supplying their own water the primary source of water is assumed to be mainly from groundwater.

One possible area of weakness of the assumptions and methodology used to generate water consumption figures for livestock, are the assumptions on the average daily water requirements. It was suggested that these assumptions are based on European conditions and may be overestimated when applied to the drier climate of Namibia where such animals may have adapted to consume less water. Also the assumption of 45 litres per animal per day for cattle is an upper limit that is used for planning and design of water infrastructure developments and it is believed that the average consumption figure per animal may be around 30 litres per day. Referring to the Danish Water Accounts, Pedersen and Tronier (2001), it would seem that the assumed daily water requirements for the Namibian NRA are considerably less than those in Denmark. For example the daily water requirement for a dairy cow is 98 litres per cow per day (which is either consumed as water or through water in fodder) and for a pig the annual water consumption assumed in Denmark is 7 m^3 per year compared to the assumed figure in this report of 2.6 m^3 per pig per year. However, there may be additional losses at the point of consumption due to considerable spillage when the animals are drinking.

A further possible limitation of the methodology relates to the breakdown between water suppliers and water source. Since the stock census areas, which are used in the stock census, do not correspond with the regional breakdowns used by NamWater then the methodology employed to estimate the water for livestock consumption supplied by self suppliers, which is taken as the residual after what NamWater has supplied, may not be accurate.

The final area of weakness stems from using assumptions based on experts' judgment not validated by metering of water use. The reason for this is that there have been no relevant studies to confirm or refute such assumptions.

3.2.10 Self-Providers - Irrigation for Crop Production

Irrigation data accounts for 32.6 % of Freshwater Volume Abstractions and 35.3 % of Freshwater Deliveries to End-Users

This section is concerned with irrigation water used for crop production and does not include irrigation on golf courses, parks and other recreation facilities.

NamWater supplies a number of larger irrigation schemes for which there are metered records of water consumption. However, few of the remaining irrigation schemes have metered data and so alternative data sources must be accessed in order to estimate the water consumption in these schemes.

Table 3.13: Information for Irrigation

Component of Water Accounts	Data Source
Water Volume	Area under Irrigation from Permit Returns or Namibian Agronomic Board
Water Source	Law Administration (DWA)
User's Economic Sector	
Cost of Supply	
User-Charge Levied	

The figures for irrigation schemes supplied by NamWater are taken from the NamWater database of metered supplies of water to different customers.

There are a number of data sources for the water consumption in the irrigation sector. After accounting for the NamWater supplies the 2000 report titled "Analysis of Present and Future Water Demand in Namibia" was consulted. This report contains a table which lists the irrigation schemes in Namibia along with the area currently irrigated, the irrigation method, the water source, the river basin and the main crops grown. It also states the assumed consumption per hectare per annum. This information makes it possible to estimate the total volume of water consumed in the irrigation sector for the year under study.

The methodology was to use this table and update it to include new irrigation schemes and to find out how long these new schemes had been operating. It was also necessary to identify the water supplier for each scheme. To update this the Regional Extension Officers from the Directorate of Extension and Engineering Services for the thirteen Regions were contacted to provide the required information.

The Law Administration Division in the DWA has information on farmers that require permits to abstract water for irrigation. These permits are only necessary if a farmer is irrigating an area greater than one hectare in a water control area. The water controlled areas are all public streams, such as the ephemeral and perennial rivers, as well as proclaimed areas including the Karst Aquifer, areas around Windhoek, Gobabis, Mariental, Keetmanshoop and Omaruru and the Stampriet and Maltahohe Artesian Areas. As part of the permit conditions the farmers in control areas must submit monthly returns for the area under irrigation, however, this information is not complete. The Law Administration Division also carry out regular permit studies along the Orange River which provides information on the area under irrigation for all the farmers along that river.

The Namibian Agronomic Board also collects information for certain farmers and their areas under irrigation. The information they hold is for white maize producers and all horticultural producers. However, they only started compiling this information in 2002. Therefore, it is not used extensively in this study but will be consulted more in future compilations of the accounts.

Once the data on the area under irrigation was obtained the Division of Agricultural Engineering was consulted to provide estimates for the consumption per hectare per annum. The factors that are taken into consideration are the location of the irrigation scheme, the crops grown and the irrigation technology employed. As evaporation, wind and soil types further influence the irrigation water requirements, the country was divided in two typical regions with evaporation rates of 2500 to 2900 mm/a (Tsumeb, Okavango Area) and from 3 400 to 3 800mm/a (Hardap, Stampriet and north western areas). Specific crop water requirements were calculated with the CROPWAT programme (Windows) with the modified Penman-Monthief Formula for the different types of crops as summarised in **Table 3.14.**

Table 3.14: Specific Crop Water Requirements in South and Western Parts (3400 to 3800 mm/a Evaporation)

Crop Type	Net Water Requirement(mm/season)	Irrigation System Water Requirement (m^3/a)			
		Flood (65%)	Centre Pivot (85%)	Sprinkler (75%)	Drip & Micro (95%)
Citrus	1 060	16 300	12 460	14.120	11 150
Cotton	1 240	19 100	14 600	16 500	13 100
Lucerne	2 145	33 000	25 200	28 600	22 600
Maize	706	10 900	8 300	9 400	7 400
Sorghum	702	10 800	8 300	9 400	7 400
Vegetables	633	9 700	7 400	8 400	6 700
Wheat	751	11 600	8 800	10 000	7 900

The accepted irrigation efficiencies for the different types irrigation system were accepted as listed in brackets as the percentage below each irrigation application system.

The crop water for the following crops not listed was accepted as listed below after consultation with the Division for Agricultural Engineering:

- Grapes 15 000 m^3/a for micro/drip
- Dates 12 000 m^3/a for micro/drip
- Olives 10 000 m^3/a for micro drip

Table 3.15: Specific Crop Water Requirements in the North and North East (2 500 to 2 900 mm/a Evaporation)

Crop Type	Net Water Requirement (mm/season)	Irrigation System Water Requirement (m^3/a)			
		Flood (65%)	Centre Pivot (85%)	Sprinkler (75%)	Drip & Micro (95%)
Citrus	836	12 880	9 840	11 150	8 820
Cotton	887	13 100	10 440	11 830	9 340
Lucerne	1 630	25 100	19 180	21 730	17 160
Maize	506	7 800	5 950	6 750	5 330
Potato	448	6 900	5 270	5 970	4 720
Sorghum	492	7 600	5 790	6 560	5 180
Vegetables	507	7 800	5 970	6 760	5 340
Wheat	659	10 100	7 750	8 790	6 940

In cases where more than one crop is grown on a farm it was assumed that the crop types was equally distributed on the irrigation area ie if a farmer grows citrus and lucerne the irrigation water requirement was estimated on the basis 50% of the crop was lucerne and 50% citrus. Multi-cropping was accepted for vegetables (2 harvests/a) as well as on the larger irrigation schemes which produce maize (summer crop) and wheat (winter).

Therefore to calculate the total water consumption for the irrigation sector, the area under irrigation is multiplied by the assumed consumption per hectare per annum for each irrigation scheme. The figures are then summed across all irrigation schemes to get the figure for Namibia as a whole.

There are a number of limitations to this approach. The first concerns the data on areas under irrigation as provided by the Law Administration Division. Farmers themselves submit this information and as a result some may under-report the area being irrigated to indicate that they are consuming less water. The second problem with this data source is that the data does not capture information about farmers irrigating outside water controlled areas and farmers irrigating less than one hectare. This therefore may result in a general under estimation of the true figure.

There is also a similar problem with the data from the Namibian Agronomic Board. As stated above they only provide data for white maize and horticultural producers. Therefore this data does not provide any information on producers of other crops such as other cereals and cash crops such as cotton and tobacco. This may provide further reason to believe the reported figures are an underestimation of the true figure. However, data from the Namibian Agronomic Board and the Law Administration Division were compared so that the information presented in these accounts draws upon the two sources to attempt to get the best available estimate of the irrigation sector water consumption.

3.2.11 Self-Providers - Mining

Self-Supply Mining accounts for 2.4 % of Freshwater Volume Abstractions and 0.7 % of Freshwater Deliveries to End-Users

As with the Irrigation sector described in the previous section there are few metered records of water consumption for mining for self-suppliers like Tsumeb, Kombat and Otjihase mines and the diamond mines along the Orange River. The only source of metered data is for the mines supplied by NamWater. For the remaining mines the water consumed has to be estimated using other data sources.

Table 3.16: Information for Mining

Component of Water Accounts	Mining Data
Water Volume	NamWater Analysis of Present and Future Water Demand in Namibia Mine Production Figures (Ministry of Mines and Energy) Namdeb and Ongopolo
Water Source	NamWater and Mining Companies
User's Economic Sector	
Cost of Supply	
User-Charge Levied	

These data sources are also varied. The data for some of the bigger mines comes from the 2000 report titled "Analysis of Present and Future Water Demand in Namibia". The diamond mining company Namdeb provides estimates for their own water consumption in their mines along the Orange River and also for the mining areas that they operate along the coast North of Oranjemund. The NamWater database also provides metered information on the amount of water supplied for mining purposes. The last source of data is the Ministry of Mines and Energy. They can provide information on water consumption for the larger mines and also on production of minerals for each mine in Namibia.

This gives a number of mines with data on their water consumption and also their production of minerals, not all mines had both these pieces of information. The methodology employed to generate figures for the consumption of water in these mines relies on calculating the average amount of water consumed to produce one unit of a certain category of mineral. In each of three categories of minerals, Dimension and Industrial Stones, Semi-Precious Stones and Precious Stones, it is assumed that the water consumption to produce one unit of mineral is the same for each category of stone. (Dimension stone is quarried and crushed using very little water. Very large volumes of water are used in diamond (precious stone) recovery. Semi precious stones are usually small operators using very little water).

Multiplying the water consumption per unit of mineral produced by the units of mineral produced provides an estimate of total water consumption for those mines where only data on their mineral production is available. For mines with no relevant information it was assumed that the water consumption would be the average of other mines in that category.

From reading the methodology used above it appears that there are a number of problems with the data. The first is that the majority of the data does not come from metered sources, only NamWater provides metered data. Therefore, most of the information is based on estimates and assumptions. Furthermore, a number of mines recycle their water which has not been accounted for in this methodology, therefore, the total actual amount of water used at these mines would in fact be higher. For the purpose the accounts the net water input was taken into account. Mine water from slimes dams are normally heavily polluted (except for diamond mining) and cannot be released to the environment for another use

3.2.12 Self-Providers – National Parks

Self-Providers in National Parks account for 0.4 % of Freshwater Volume Abstractions and 0.4 % of Freshwater Deliveries to End-Users

Table 3.17: Information for Wildlife in Parks

Component of Water Accounts	Wildlife in Parks Data
Water Volume	Park Census Figures
Water Source	Park Location
User's Economic Sector	
Cost of Supply	
User-Charge Levied	

The Ministry of Environment and Tourism conducts regular census studies of the population of wild animals in Namibia's National Parks.

A similar methodology is used to calculate the water supplied by National Parks for game as was used for livestock, and described in section 3.2.1, multiplying stock numbers by daily water requirements. The assumptions made are in terms of the average daily water requirement of the various animals counted in the census.

Table 3.18: Daily Water Consumption of Game Animals

Animal	Average Daily Water Consumption (litres)
Elephant	150-300
Hippo	0*
Buffalo	31
Giraffe	40
Eland	23
Roan	10
Sable	9
Hartmann's zebra	12
Burchell's zebra	12
Blue wildebeest	9
Kudu	9
Oryx	9
Hartebeest	5.5
Waterbuck	9
Black-faced impala	2.5
Common impala	2.5
Tsessebe	5
Springbok	1.5
Warthog	3.5
Ostrich	11

Source: www. bigfive.jl.co.za

Further assumptions are made regarding the source of water in each of the game parks. Assumptions regarding the sources of water are made by looking at the area where the game park is located and the local water sources. In the cases where there are two sources of water in that park then equal amounts are assumed to come from each source. In some cases a higher percentage for one source was assumed, based on the relative abundance of the sources in the park. Some of the National Parks were contacted to find out the source of water and the supplier. The Ministry of Environment and Tourism also stated that they operate boreholes in some of the parks.

A possible limitation of this data is that in cases of open parks like the those in the Caprivi Region animals move from one point to another and sometimes even cross borders on a daily basis. Also this ignores the game on private lodges and farms, which would give a downward bias to the overall consumption figures. The estimated water consumption is the total consumption for these animals in National Parks and so also includes the animals' consumption from rainwater. The NRA, however, at this point in time is only concerned with water from production sources and so the inclusion of water consumed by wildlife in National Parks would bias the figures upwards.

3.3 DATA FOR MONETARY ACCOUNTS

This section looks at the data sources and the methodology employed to derive the monetary accounts in terms of the costs of supply, the user-charges and the socio-economic benefits.

3.3.1 Data for Costs of Supply

This looks at the data and methodologies used in generating the costs of supply figures for the different water suppliers. A general limitation is that the costs of the unbilled water are not reported separately and these costs are actually spread across the different Water Utilities and End-users that are supplied by that particular supplier of water.

3.3.1.1 NamWater

To get the costs of supplying water to its customers, NamWater provides information on the Full Cost Recovery Unit Price for each of its approximately 200 water supply schemes. This NamWater policy to recover the full cost of supplying water includes the Capital Costs (based on infrastructure depreciation cost), Operational and Maintenance costs directly associated with water production at that scheme and then some allocation of Administration Costs and Overhead Costs. The Full Cost Recovery Unit Price in 2001/02 ranged from N$ 0.02 to N$ 447.94 per cubic metre. The additional data that NamWater supplies is the database of customer details and their consumption as was described in **Section 3.2.1** above.

The methodology to calculate the cost of supplying each customer is to multiply the volume supplied to the customer by the Full Cost Recovery Unit Price for the particular water supply scheme from which the customer receives water. Since the customers had previously all been categorised according to which economic sector they belonged to, it is therefore possible to get the cost of supplying water to the different economic sectors supplied by NamWater.

Some assumptions are made regarding the schemes from which customers are supplied. This was because the data provided by NamWater on the individual customers provided only the water supply scheme currently supplying the customers. As a result there is no historical record detailing which scheme previously supplied customers. This is important because with the evolution of NamWater the schemes have also evolved, new ones are created and existing ones are reorganized. Therefore, when the Full Cost Recovery Unit Price data is provided for previous years, some scheme names may not appear when comparison is made with the schemes that supply customers currently. As a result NamWater was consulted to determine which schemes would previously have supplied these customers.

Some limitations to this approach are that the actual Full Cost Recovery (FCR) Unit Price may not be allocated to each customer correctly due to the issue described in the previous paragraph. A further weakness is that this Full Cost Recovery Unit Price is calculated using a complicated method of allocating costs to the different water supply schemes. For example, if a scheme encompasses a main source of water and it then supplies water to some customers directly and to some schemes “downstream” then some of its costs are allocated to the costs of “downstream” schemes according to the proportion of water supplied to these “downstream” schemes. Such an “upstream” scheme may therefore have a negative scheme allocation to account for the costs transferred to other “downstream” schemes. Additionally the NRA calculation is based on unit FCR for each scheme multiplied by the consumption, which may differ from the actual total reported NamWater costs.

3.3.1.2 Municipal Authorities

Data was collected from Swakopmund, Walvis Bay and Windhoek Municipalities for their expenditures on supplying water. For a further 14 municipalities information was collected from their Financial Statements for the cost of distribution of water for the 2001/2002 Financial Year. The data provided is the total costs involved in supplying water in their jurisdictions for the period of one financial year. It is assumed that the unit supply-cost for all End-users is the same.

This unit cost is calculated by dividing the total costs of supplying water by the units of water supplied in that town. This unit cost figure is then multiplied by the volume consumed by the various economic sectors to get the cost of supplying water to that particular sector.

A problem with this approach is that the financial year (1 July to 30 June the fallowing year) in local authorities is not the same as the accounting period in the NRA, (1 April to 31 March the following year). As a result the unit cost figures may be slightly inaccurate for one particular year. An additional limitation relates to the method each municipality uses to derive the cost of supplying water. Since some Municipalities may account for capital in a different way from others and some may include certain elements in the costs of supplying water whereas other do not, this makes comparison between local authorities difficult.

3.3.1.3 Rural Water Supply

Rural Water Supply (RWS) provide data on their annual Operational and Development (or Capital) Expenditures. The Operational Expenditures include their payments to NamWater. It is assumed that the unit cost for supply is the same for all users, which is calculated as the Total Costs divided by the total water volume. Information on inflation, which is needed to express the figures in current prices is obtained from the National Planning Commission.

The assumptions made are that 35 per cent of the Development Expenditure is spent on boreholes whilst the remaining 65 per cent is on pipelines. Furthermore the depreciation on boreholes is over ten years whilst for pipelines it is five years.

The methodology to get the cost of supplying water is first to get the annual figures for spending on boreholes and pipelines by applying the percentage of Development Expenditure that is apportioned to each of these components. Then each component is treated as follows. The annual depreciation is calculated on each year's investment. The depreciation in the first year is devalued to take inflation into account then to this is added the depreciation figure for the second year and then this sum is devalued for inflation in the second year. This devalued cumulative depreciation for boreholes is then added to that of pipelines to get the capital costs. This is then added to the Operational costs for that year to get the Total Costs of Supplying water borne by Rural Water Supply.

The main limitation to this methodology is the assumption that all End-users face the same unit costs of supply. This is a big divergence from reality as RWS supply costs vary significantly across the country. A further limitation of this approach is that the method of calculating capital costs may differ from that used by NamWater and other Municipalities which makes comparisons less effective.

3.3.1.4 Self-Providers

The costs of self-providers supplying water from groundwater sources can also be estimated. Groundwater accounts for 40 per cent of the freshwater used by self-providers. The estimation technique relies on data from the Borehole Database in the Geohydrology Division in DWA. The data provided by the database is the average borehole depth, yield and water level for a number of areas in Namibia as well as the number of boreholes in that area. Nampower also provides information on the Unit Cost of electricity for Small Supply Points.

There are a number of assumptions that are made before calculation to estimate the costs of supplying water can be done. Firstly, it is assumed that the boreholes are depreciated over a period of 10 years. Secondly, the cost per metre of borehole is assumed to be N$1,000 in 2001. The Maintenance Costs are assumed to be five per cent of the Capital Costs. The Conversion Constant, which is the energy required to raise one unit of water (one cubic metre) by one unit of vertical distance (metres) adjusted for energy losses in pumps, is assumed to be 0.00389. Finally it is assumed that since the I Borehole Database records mainly boreholes in commercial farmland, the calculations are for water supply to Government and Commercial Livestock and Commercial Irrigation which is then applied to non-commercial farmland and mining activities.

The methodology based on these assumptions required the national average borehole yield and water level to be calculated, weighted according to the number of boreholes in each area. The Capital, Operation and Maintenance Costs are then calculated using the formulae below:

CAPITAL COST

= (Costs per metre of borehole x Borehole depth x Number of boreholes)/Years depreciated over) Depreciation was done in the straight line method.

MAINTENANCE COST

= 5 % of Capital Costs

OPERATION COSTS

= [Total Groundwater Consumed[*]/Average Borehole Yield] x Energy Price x

[Average Water Level x Average Borehole Yield x Conversion Constant]

The total costs of supplying water are then the sum of the three costs components. To get the unit cost of Self-Provider groundwater the figure for total cost of supplying water is divided by the sum of the amount of groundwater supplied by self-providers to the Commercial Irrigation and Commercial and Government Livestock sectors. This unit cost is in constant 2001 terms, since this was the year used for the price of electricity and for each metre of borehole. To convert to current prices the effects of inflation have to be incorporated into the unit cost. This unit cost, in current prices, is then multiplied by the volumes of groundwater used by self suppliers to get the costs involved in supplying themselves with groundwater.

There are quite a few limitations to this methodology. The first, is that not all the boreholes in Namibia have their data recorded on the DWA Borehole Database, which may result in an underestimation of the cost. Secondly, it is assumed that all the borehole data is from commercial farms as well as some boreholes in communal areas It is also likely that some boreholes in the database are those used by the few Municipalities that abstract some of their own water, by mines and by users in non-commercial areas. This would result in an over-estimation of the unit cost.

[*] In the Commercial Irrigation and Commercial Livestock sectors

3.3.2 User Charges

3.3.2.1 NamWater

In the NamWater database along with the amount consumed by each customer there is also an entry for the user-charges levied on that particular customer. Therefore, since the customers are already classified for economic sector and source of water the total user charges levied per economic sector and water source can be derived by adding the figures within the similar categories.

3.3.2.2 Municipalities

The data required to generate the user-charges levied on consumers of the Municipal Authorities comes from either Ae Gams or from the Municipality itself. This data is generally in the form of individual customer consumption volumes and the tariff rates applied in that Municipality.

In order to get the user-charges levied on the individual customers, the tariff rate is multiplied by the volume of water consumed in the simplest form. However, in the case of block tariffs the customers first portion is multiplied by the lowest tariff, then the second portion of water volume consumed is multiplied by the next tariff, etc.

A problem with this methodology is that the user-charges levied in towns with block tariffs are applied for the whole year whereas in reality the block tariffs are applied to the monthly consumption figures. As a result there may be slight discrepancies if a consumer's consumption is highly erratic between months. An additional problem applies to Windhoek whose data did not provide water tariff codes for each customer to which the various water tariffs for the various categories of users could be applied. Therefore there may be some deviations from the actual amounts charged to consumers.

3.3.2.3 Rural Water Supply/Self-Providers

For the user-charges levied on customers supplied by RWS and for Self-Providers it is assumed that this is zero in all cases. This is because RWS provides water with 100% subsidy and that those abstracting water for their own usage do not charge themselves fees for this activity.

3.3.2.4 Rural Communities

The NamWater database also provides the information on the user-charges applied by the Rural Communities.

The methodology to calculate how much the Rural Communities charge their end-users for water supplied is based on the subsidy that the Government gives to these communities. This subsidy has been gradually phased out according to the time scheme in **Table 2.3**. Therefore in the year 2001/02 the amount of user-charges that is levied by the Rural

Communities on their customers is 60 per cent of the total amount billed by NamWater to the Rural Communities. In this case the amount that NamWater charges the Rural Communities is broken down with 60 per cent to be paid by the Rural Communities (which then charge the end-users this amount) and 40 per cent is allocated to RWS(which is effectively the government). It is assumed that the Rural Communities base the charges to end users according to the volume used.

A problem with this method is that the periods used by the Government for phasing out the water supply subsidies to Rural Communities does not match the accounting period used in the compilation of the NRA.

3.3.2.5 Mining

The last set of user-charges levied is for the mine that provides NamWater with water. This information is obtained directly from NamWater.

3.3.3 Socio-Economic Benefits

The National Planning Commission (NPC) provides an annual breakdown of the Value-Added figures for different economic sectors from the National Accounts. The Ministry of Labour produces the Namibia Labour Force Survey every two years. The first was for 1997 and the latest was for 2000. This detail the number of people employed in various economic sectors of the country.

Since the classifications used in the NRA are based on the ISIC, these should match classifications used by the NPC and the Ministry of Labour, who both use this system in their classifications of economic sectors.

To get figures for the socio-economic benefits of water in terms of the amount of value added and employment, the value added and employment figures for a particular economic sector are divided by the amount of water used in that sector. These figures give an indication of the amount of value added and labour employed per cubic metre of water used in a particular sector.

A limitation of this methodology is in interpreting these benefits for some broad categories of economic sector. For example, in the case of irrigation the figures suggest that the value added per cubic metre of water in irrigation is rather low at N$ 0.46 in 2001/02. However, this masks the possibility that some crops may have higher value added figures per cubic metre of water used compared with others.

A limitation of the data available is that the NPC and the Labour Force Surveys do not break down the values for Value Added and Employment as much as is done in the water accounts. Therefore some of the Economic sectors in the NRA have to be combined so as to match the more aggregated categories used in the National Accounts and the Labour Force Survey.

4 AVAILABILITY OF WATER

The System of Environmental and Economic Accounts links the Water Asset Accounts, detailing the availability of water resources, together with the Flow accounts which detail the use of water, the framework for which is discussed in **Section 2**. This section addresses the Water Asset Accounts. These Water Asset Accounts, and therefore the availability, are broken down for the different sources of water and are measured in volume, in this case in m^3.

Water availability needs to be highlighted and linked to water consumption so that policy analysts and decision makers can make more informed evaluations in a number of areas such as the current situation concerning water scarcity.

4.1 EPHEMERAL RIVERS AND DAMS

Except for parts of the Kwando and Okavango Rivers all of the rivers that flow within Namibia's borders are ephemeral and so run only after periods of substantial rain. In order to make use of this water in economic and social activities a number of dams have been constructed to capture this water before it flows away or evaporates. In the case of the Omdel Dam the dam was built so that impounded water seeps underground and artificially recharges the groundwater source.

There are a number of indicators which can provide the availability of water from these dams. These are the capacity, the contents, the 95 % Safe Yield and the annual runoff.

The actual amount of water contained in these dams is one such indicator of the availability of water from this source. **Table 4.1** represents the amount of water in millions of cubic meters that was measured in each of these dams in the first week of April of each year.

Table 4.1: Volume of Water Stored in Dams (Mm^3 as at the First Week in April)

	Content															
Dam	**Apr-88**	**Apr-89**	**Apr-90**	**Apr-91**	**Apr-92**	**Apr-93**	**Apr-94**	**Apr-95**	**Apr-96**	**Apr-97**	**Apr-98**	**Apr-99**	**Apr-00**	**Apr-01**	**Apr-02**	**Apr-03**
Dreihuk	1.63	0.66	0.06		0.23	0.00	2.74	0.63	0.63	1.71	0.44	0.42	2.75	0.64	0.21	0.00
Friedenau	5.67	4.85	6.74	6.56	5.60	5.90	4.97	3.71	4.43	5.88	4.56	5.60	6.93	5.21	5.28	4.56
Hardap	237.00	232.45	144.51	115.90	58.17	83.04	98.35	68.67	82.94	288.60	199.77	179.18	281.27	185.53	261.51	162.06
Naute	85.92	78.44	74.12	78.01	64.80	74.86	72.30	51.23	49.79	90.17	80.30	60.15	84.74	75.15	81.42	55.71
Oanob			2.76	7.25	4.19	26.94	18.80	14.02	10.86	34.29	29.99	26.41	37.31	26.41	25.38	18.05
Olushandja				10.63	14.30	13.24	13.64	14.88	8.56	22.67	24.67	22.67	24.67	23.65	21.54	26.37
Omdel						0.39				11.67	2.49	0.00	17.64	4.38	0.00	0.00
Omatako	23.10	24.82	24.57	34.81	3.88	17.03	42.57	4.78		40.41	5.79	3.00	44.15	4.61	1.15	1.16
Otjivero Main	7.87	6.45	5.25	2.96	2.50	0.24	0.50	0.00	0.16	8.77	7.10	5.72	5.13	5.35	3.12	1.19
Otjivero Silt	6.76	3.60	0.27	2.26	0.00	0.17	0.02	0.00	0.05	4.65	0.49	1.41	3.21	0.14	0.17	0.06
Swakoppoort	67.47	66.37	57.18	44.04	32.50	36.52	31.63	22.43	13.36	48.97	36.92	24.92	44.16	33.10	38.65	24.21
Von Bach	36.67	44.20	25.24	17.44	15.14	10.50	20.22	17.45	5.58	24.63	30.07	20.72	27.17	34.32	25.97	14.27
Avis	0.16	0.02	0.01		0.00	0.01	0.09	0.04	0.09	1.79	1.30	0.98	1.54	0.91	0.69	0.27
Bondels					0.00	0.01	0.71	0.00	0.25	0.39	0.00	0.09	0.11	0.05	0.00	0.00
Daan Viljoen	0.23	0.26	0.19	0.30	0.00	0.22	0.13	0.00	0.00	0.36	0.00	0.00	0.23	0.02	0.19	0.01
Goreangab	3.88	2.49	3.32	2.00	2.70	2.77	4.14	2.51	3.84	4.10	1.29	3.11	3.75	3.37	3.58	1.69
Omatjenne			0.05		0.00	0.20	0.00	0.00		2.24	0.00	0.00	2.59	0.00	0.00	0.00
Tilda Viljoen	0.45	0.65	0.25	1.11	0.27	0.99	0.60	0.00	0.17	1.22	0.96	0.38	0.55	0.32	0.44	0.25
TOTAL	476.8	465.3	344.5	323.3	204.3	273.0	311.4	200.3	180.7	592.5	426.1	354.7	587.9	403.2	469.3	309.9

The figure for the total capacity for dams in Namibia is just over 700 million cubic meters of water. The dams are normally sized to capture approximately three times the average annual run-off. This implies that if these dams were all filled to capacity the availability of water resources from dams would be quite high compared to Namibia's current consumption for economic purposes of 280 million cubic meters in 2001/02. However, Namibia has low rainfall and the little it receives is also very erratic across space and time which means that this figure of 700 million cubic meters of water is very unlikely to be available at one point in time. However, one has to take into consideration that the measurement period of the first week of April is at a time just after the main period of rainfall which occurs in the rainy season from January to March and that a lot of water evaporates (approximately 3 times the safe yield value[3]).

Table 4.2 shows the various dams in Namibia along with the river on which the dam is built together with the capacity of the dams in millions of cubic meters and the long term average availability in millions of cubic meters, denoted as the 95 per cent safe yield. The 95% SAFE yield is a better indicator of the long-term availability of water from a dam. The yield is the amount of water that can be supplied from a reservoir or catchment during a specified time period. The 95 per cent safe yield is the yield that can be expected 95 per cent of the time. The sum of the 95 per cent safe yields for all the dams in Namibia is 92.7 million cubic meters of water per annum as summarised in **Table 4.2**.

Table 4.2: Dam Characteristics

Name of Dam	River Name	Capacity (Mm^3)	95 % Safe Yield (Mm^3/a)
Dreihuk	Hom	15.5	nil
Friedenau	Kuiseb	6.7	0.5
Hardap	Fish	294.6	55.5
Naute	Loewen	83.6	12.0
Oanob	Oanob	34.5	4.2
Olushandja	Etaka	42.3	n/a
Omdel	Omaruru	41.3	5.2*
Omatako	Omatako	43.5	2.0
Otjivero Main	White Nossob	9.8	0.7
Otjivero Silt	White Nossob	7.8	-
Swakoppoort	Swakop	63.5	4.5
Von Bach	Swakop	48.6	6.5
Avis	Avis	2.4	0

[3] DWA

Name of Dam	River Name	Capacity (Mm^3)	95 % Safe Yield (Mm^3/a)
Bondels	Satco	1.1	0
Daan Viljoen	Black Nossob	0.4	0.01
Goreangab	Gammans	4.2	1.4
Omatjenne	Omatjene	5.1	0
Tilda Viljoen	Black Nossob	1.2	0.15
TOTAL		706.1	92.7

* Long-term average recharge

Source: NamWater

The three dam system (Swakoppoort, Von Bach and Omataku) in the Central Area is linked and is operated to improve the efficiency through the transfer of water to lower evaporation losses. As a result of this optimisation the combined yield is 20 Mm^3/a, an increase of approximately 7 Mm^3/a. This indicator of availability states that Namibia can be guaranteed an amount of at least 100 Mm^3 of water in one year from dams in 95 per cent of the years (probability of shortfall of 1 in 20 years). However, one has to proceed with caution as the dams are not interlinked and as is often the case in Namibia there is a shortage of water in one area and a surplus in other areas.

4.2 PERENNIAL RIVERS

Namibia has access to four rivers on its Northern and Southern borders which run year round. These are the Kunene, Okavango, Orange and Zambezi. They are all international rivers that Namibia shares with its co-basin states. The Kwando is a tributary of the Zambezi and cuts through Namibia in the Caprivi strip and forms the border and Botswana in the Eastern part of the Caprivi Region.

An indicator of the availability of water from perennial rivers is the annual runoff.

Runoff is defined in the International Meteorological Vocabulary (1992) as the "part of *precipitation* which flows towards a river on the ground surface (surface runoff)". In consultation with the Division of Hydrology in DWA the term Total Annual Runoff is defined as the total amount of water that flows past a fixed point in a river.

Table 4.3 gives the total annual runoff in the five perennial rivers in Namibia from 1980/82 to 2001/02 where data is available. The data for each period is from the 1st of April to 31st March in the following year.

The figures would suggest that there is a considerable amount of water available from the perennial rivers. However, this ignores two factors that affect the availability of water to Namibia viz the use of water by the other river basin states through which these rivers flow and the ecological requirements of the river basin. At present, there are no estimates of ecological requirements except for the Orange River. Several international rivers are under international management, which have set an annual allocation of water for Namibia.

Table 4.3: Annual Runoff of Perennial Rivers

Year	Total Annual Runoff (Mm^3)					
	Kunene	Kwando	Okavango	Orange	Zambezi	Total
1980/81	n/a	1,732	3,513	n/a	40,153	43,666
1981/82	n/a	923	5,164	n/a	36,290	41,455
1982/83	n/a	837	4,651	n/a	26,048	30,700
1983/84	4,028	870	6,699	n/a	22,532	29,230
1984/85	9,408	880	6,975	n/a	24,528	31,504
1985/86	7,591	913	4,409	n/a	26,666	31,075
1986/87	5,198	929	5,049	n/a	35,559	40,609
1987/88	4,082	787	3,881	n/a	26,419	30,300
1988/89	5,517	1,026	6,225	n/a	38,550	44,774
1989/90	3,221	1,064	4,335	n/a	40,048	44,383
1990/91	5,545	795	4,654	n/a	25,706	30,360
1991/92	5,925	661	5,376	n/a	24,775	30,150
1992/93	4,311	785	4,066	7,824	17,845	29,735
1993/94	2,154	844	3,349	570	38,406	42,325
1994/95	3,676	585	2,403	1,545	17,844	21,792
1995/96	3,711	473	3,405	6,917	15,492	25,815
1996/97	2,435	523	2,928	5,492	15,142	23,562
1997/98	2,847	n/a	4,036	9,622	30,301	43,958
1998/99	4,331	n/a	4,351	3,806	38,229	46,386
1999/ 2000	5,582	650	5,378	4,176	32,126	41,680
2000/01	5,696	n/a	4,383	5,685	37,430	47,498
2001/02	7,637	791[#]	5,954	13,406	37,085	56,444
Long Term Average	4,889	791	5,201	5,810	38,038	49,049

n/a: Data is not available

[#] Long-term Average

Source: Hydrology, Department of Water Affairs

Namibia is a party to five international river basin agreements. These are the Permanent Okavango River Basin Water Commission (OKACOM), the Permanent Water Commission on the Orange River (ORACECOM), the Orange-Senqu River Commission, the Permanent Joint Technical Commission (PJTC) on the Kunene River and the Joint Permanent Technical Commission (PJTC) on water matters of mutual interest between Botswana and Namibia. The PJTC mainly deals with the Kwando-Linyanti-Chobe watercourse system. In these programmes any large new water abstraction development has to be agreed upon by basin states.

These river basin committees negotiated an agreement stipulating how much water each country can abstract from these shared river systems. These allocations provide a better indicator of the amount of water available from perennial rivers in instances.

Table 4.4: International Agreements on Abstraction of Water from Rivers

River	Present Allocation (Mm^3/a)	Mobilised Sources with Installed Capacity (Mm^3/a)	Potential Amount of Water Available (Total Source) (Mm^3/annum)
Kunene	180	90	180
Okavango	0	20	150
Orange	110*	50	275
Zambezi	0	10	500
TOTAL		170	1030

* Proposed Agreement   Source: Water Use and Conservation Theme Report (NWRMR) and DWA

Table 4.4 sets out the amount of water that Namibia is allowed to abstract annually as per agreement for four of the perennial rivers. At present Namibia has only concluded an agreement with Angola, which allows Namibia to abstract up to 180 million m^3 per annum from the Kunene River. Currently negations are taking place between Namibia and South Africa to agree on how much each country is permitted to abstract from the Orange River. At present Namibia has an agreed allocation of 110 million m^3 per annum.

The table also shows the installed capacity which refers to the maximum amount of water that can be abstracted with the abstraction infrastructure currently in place.

The assumed future allocation is that which DWA foresees maximum that may be abstracted once all the anticipated irrigation proposals are undertaken in the long-term.

4.3 GROUNDWATER

The amount of groundwater is dependent on rainfall and on the geohydrological conditions of the area. Most groundwater is stored in favourable geohydrological horizons called aquifers. Groundwater stock/reserve accounts would ideally include annual entries for opening volume, abstraction, recharge, other changes and closing volume. The estimated long-term sustainable yield would be added to the accounts as a memorandum item. Figures for the stock accounts are highly uncertain; only estimated long-term sustainable yield can be provided at this time.

Table 4.5 shows the estimated sustainable yield in millions of cubic meters per annum for a number of the main aquifers in Namibia. The figures come from a variety of studies done in various years. However, due to lack of conclusive studies in some of these areas, the figures should be regarded as preliminary. The category for “Other Groundwater” includes figures mainly for farms which rely on groundwater but are out of the immediate catchments for the main aquifers highlighted in the table.

The figure for stored reserves of an aquifer is much higher that its sustainable yield. The stored reserve is useful for deducing the magnitude of an aquifer and how much water could possibly be banked, if suited for conditions for artificial recharge. A typical example of this phenomenon is the Omdel Aquifer that can be recharged by seepage from the Omdel Dam.

Aquifers normally receive a certain amount of recharge annually. Those that do not receive any recharge are referred to as fossil waters. The rate of recharge of an aquifer is used in determining the sustainable yield of the aquifer. The sustainable yield is the amount of water that can be abstracted from the aquifer on a long-term basis without causing a significant fall of the water table. In instances where the water is either abstracted at a rate greater than the sustainable yield, or from an aquifer which does not receive any recharge, then this is referred to as groundwater mining.

Therefore, when looking at the availability of groundwater it is imperative to look at the sustainable yield and not the stored reserve. This is because the sustainable yield indicates what can be abstracted on a long-term basis whilst the stored reserve may only provide an indication of the magnitude of the aquifer. If over-exploitation of a resource occurs then eventual exhaustion of the groundwater may occur resulting in the unavailability of water for future generations. Regarding the figures in **Table 4.5** the sustainable yield figure can be obtained in a three year study such as that for the Tsumeb aquifers, however, ideally the sustainable figure should be taken from continuous long term monitoring of the aquifer.

Table 4.5: Estimated Sustainable Yield of Aquifers in Namibia

Aquifer	Estimated Sustainable Yield (Mm^3/annum)
Grootfontein Karst	14.6
Otjiwarongo	3.2
Khorixas	2.2
Omaruru	2.5
Nei-Neis	0.6
Omdel	8.2
Karibib	0.183
Usakos	0.28
Kuiseb	5
Osona	1.25
Rehoboth	2.0
Tsumeb Aquifers (Including Abenab)	18
Stampriet Artesian Basin	8
Windhoek	1.73
Other Groundwater	81.7
Total	150.0

Source: Geohydrology, Department of Water Affairs.

Note: The estimated sustainable yield for the Koichab Pan that supplies Luderitz, the off-bank aquifer that supplies Orangemund, the well-explored aquifer that supplies Gobabis or the Artesian aquifer at Maltahohe is not included in the table above.

4.4 OTHER WATER

The availability of other water sources is mainly that of recycled water and waste water. The Municipality of Windhoek has completed a new water reclamation plant which receives treated residential effluent from the City and treats it to potable quality. The maximum capacity of the plant is 21,000 cubic meters per day of recycled water which would mean 7.5 million cubic meters of water per year. However, the recycling plant is likely to operate at 70% capacity due to the required mixing ratio between recycled and fresh water of 35 per cent and also the fact that reaching full operational capacity will take time due to the limited raw water available for reclamation.

Some municipalities like Windhoek, Walvis Bay, Swakopmund and Otjiwarongo also reuse purified effluent to irrigate sports fields, cemeteries and parks and in some cases even for crop production (Grootfontein).

4.5 TOTAL WATER AVAILABILITY

With the discussion in the previous sections of this chapter on the availability of water from the different sources it is of interest to summarise these to give an indication of the annual amount of water available in Namibia.

Table 4.6 summarises the total water availability from the different sources with the current installed capacity. This gives Namibia a current availability of water of 423 million m^3 per annum. However, if all potential water sources were developed then the amount of water available would be 1 615 million m^3 per annum. This is given in the potential amount of water available column.

Table 4.6: Total Water Availability

Water Source	Mobilised Sources with Installed Capacity (Mm^3/annum)	Potential Amount of Water Available (Total Source) (Mm^3/annum)
Dams and Ephemeral Rivers	100	200
Perennial Rivers	170	1105
Groundwater	150	300
Other Water (Recycled)	7.5	10
TOTAL	422.5	1 615

Source: DWA The higher identified volumes from Perennial River are subject to negotiation with river basin states including the construction of additional infrastructure such as the dam at Vioolsdrif.

5 PHYSICAL WATER ACCOUNTS

Assessment of the physical accounts provides information on the national trends in water supply and use, water use by each economic sector, and water distribution by Namwater, municipalities and self-suppliers. **Chapter 6** considers the monetary component of the water accounts: the costs of supply, tariffs charged and the socio-economic benefits of water use in different sectors. Although the water accounts include both freshwater and seawater, the discussion will focus mainly on freshwater (including recycled water) because freshwater management is the main challenge for water management and only mines and fishing use substantial amounts of seawater at this time. Furthermore, it was not possible to obtain a reasonable estimate of the ecological water requirements, known as environmental flows, so this component is excluded in accounts. In **Section 5.5** is a discussion on the environmental water requirements.

This chapter considers:

- national trends in water supply and use;
- water distributed by NamWater , municipalities and self suppliers;
- losses and unaccounted for water.
- water use by different economic sectors of the economy;

5.1 NATIONAL TRENDS IN WATER SUPPLY AND USE

The abstraction of freshwater and production of recycled water[4] (hereafter, the term freshwater includes recycled water unless otherwise stated) have increased from 276 Mm^3 in 1997/98 to 318 Mm^3 in 2001/02. Water use has grown slightly faster, from 236 Mm^3 to 275 Mm^3 over the same period. Losses have also increased from 40 to 43 Mm^3 (**Table 5.1**), but as a share of water use, losses declined from 14.6% to 13.6%.

The use of water has grown faster than population, so that average annual per capita water use has increased from 147 m^3 per person to 153 m^3 per person. The increased consumption implies a lower water use efficiency which is discussed in more detail in **Chapter 6.**

[4] Recycled water was defined and discussed in Chapter 2 (Methodology) and Chapter 3 (Data sources) of this report. The water accounts do not, at this time, distinguish different qualities of recycled water.

Table 5.1: Water Supply, Use and Water Productivity, 1997 To 2001

	1997/98	1998/99	1999/2000	2000/01	2001/02
Freshwater supply and use (Mm^3/a)					
Freshwater supply	276	272	295	311	318
Freshwater use	235	240	254	266	275
Losses & unaccounted for water	40	32	41	45	43
Population (million)	1.6	1.7	1.7	1.8	1.8
Per capita water use (m^3/person/a)	147	142	146	149	153

Declining water productivity is not necessarily a problem, if the economy and water use has grown by employing underutilised water resources, such as underutilised water (and land) along perennial rivers. Long-term, water availability[5] in Namibia has been estimated at 660 Mm^3/annum, roughly double present levels of abstraction (Christelis and Struckmeier, 2001). However, from a long-term perspective, such trends should be viewed with caution, because of the danger of 'locking into' inefficient uses of water through investment and infrastructure development that cannot easily be changed in the future when competition for scarce water increases. This is especially true for fossil groundwater.

Furthermore, although national water use does not exceed national water availability, water resources and demand are not evenly distributed across the country. Namibia's water resources are unevenly distributed over the country and there are no perennial rivers within the borders of Namibia. Consequently, regional water shortages may emerge long before a national shortage is apparent. A good example is the Central Area of Namibia and the Namib Region where the local demand is higher than the available local resources, which will require expensive supply augmentation schemes or even desalination.

Water use and supply should be evaluated on a regional basis to reflect pressures on water use and differing economic opportunities to utilize water resources in different geographical locations. While national trends are useful, water accounts compiled at river basin or water scheme level are necessary for water management. This is discussed in more detail in **Section 5.4.**

Water supply and use can be viewed from two perspectives: natural source and institutional source. In the **Appendix A3** water accounts are cross-tabulated by both natural source and institutional source and in the next two subsections, trends are reviewed separately for each component.

[5] Water availability was not precisely defined in the source document.

5.2 WATER SUPPLY BY NATURAL SOURCE

Natural sources include four freshwater sources (groundwater, perennial rivers, ephemeral rivers, recycled water) and seawater. Most discussions of water supply focus on freshwater, but in some countries seawater is also an important water resource for industrial applications. For example, seawater, mainly used for cooling in electricity production, accounted for 80% of total water use in Denmark in 1994. Seawater is important not because it is a scarce resource—on the contrary, there is virtually no limit to the seawater available—but because it substitutes for scarce freshwater. In Namibia, a fairly large amount of seawater (68 million cubic metres annually) is used in diamond mining, equivalent to nearly 21% of total freshwater supply in 2001/02 (**Table 5.2**). Seawater is also used in some fish processing activities, but this use of seawater is not included in the water accounts because data are not available at this time. The following discussion of water supply will exclude seawater in order to focus on the more challenging issue of freshwater management.

Groundwater has been the single largest natural source of water in all years, accounting for an average of about 40% of freshwater; perennial rivers and ephemeral rivers each provide roughly 30% of freshwater (**Figure 5.2, Table 5.2**). The relative shares of groundwater, perennial river water and ephemeral river water vary, depending in part on rainfall and inflows into dams. The share of perennial river water, however, appears to be increasing steadily, reflecting the growth of irrigated agriculture along the perennial rivers. Recycled water, although locally important, has not provided more than 1% of freshwater in any year.

Table 5.2: Supply, Use and Losses by Natural Source of Water

	1997/98	1998/99	1999/2000	2000/2001	2001/2002
Supply: Abstraction and Re-use	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a
Ephemeral-dam	83.8	69.9	80.4	88.2	96.6
Groundwater	112.5	113.4	116.3	124.1	121.8
Perennial	77.0	85.9	96.5	95.3	98.4
Recycled water	2.8	2.6	2.1	3.0	1.3
Seawater	68.8	68.8	68.8	68.8	68.8
Total	344.9	340.6	364.1	379.4	386.9
Total Freshwater: abstraction & re-use	276.1	271.8	295.3	310.6	318.1

	1997/98	1998/99	1999/2000	2000/2001	2001/2002
Use of Water	**Mm^3/a**	**Mm^3/a**	**Mm^3/a**	**Mm^3/a**	**Mm^3/a**
Ephemeral-dam	71.0	61.6	66.7	73.7	82.9
Groundwater	96.3	98.5	101.1	107.7	104.7
Perennial	66.2	77.1	84.4	81.6	85.9
Recycled water	2.3	2.2	1.7	2.6	1.3
Seawater	61.9	61.9	61.9	61.9	61.9
Total	297.7	301.3	315.8	327.5	336.6
Total Freshwater	235.8	239.5	253.9	265.6	274.7
Estimated System Losses	**Mm^3/a**	**Mm^3/a**	**Mm^3/a**	**Mm^3/a**	**Mm^3/a**
Ephemeral-dam	12.8	8.3	13.8	14.5	13.7
Groundwater	16.2	14.9	15.2	16.4	17.1
Perennial	10.8	8.8	12.1	13.7	12.6
Recycled water	0.5	0.4	0.4	0.4	0.1
Seawater	6.9	6.9	6.9	6.9	6.9
Total	47.2	39.2	48.3	51.9	50.4
Total Freshwater	40.3	32.3	41.5	45.0	43.4

Note: Supply = Use + Losses. Derived from Tables in the Appendix

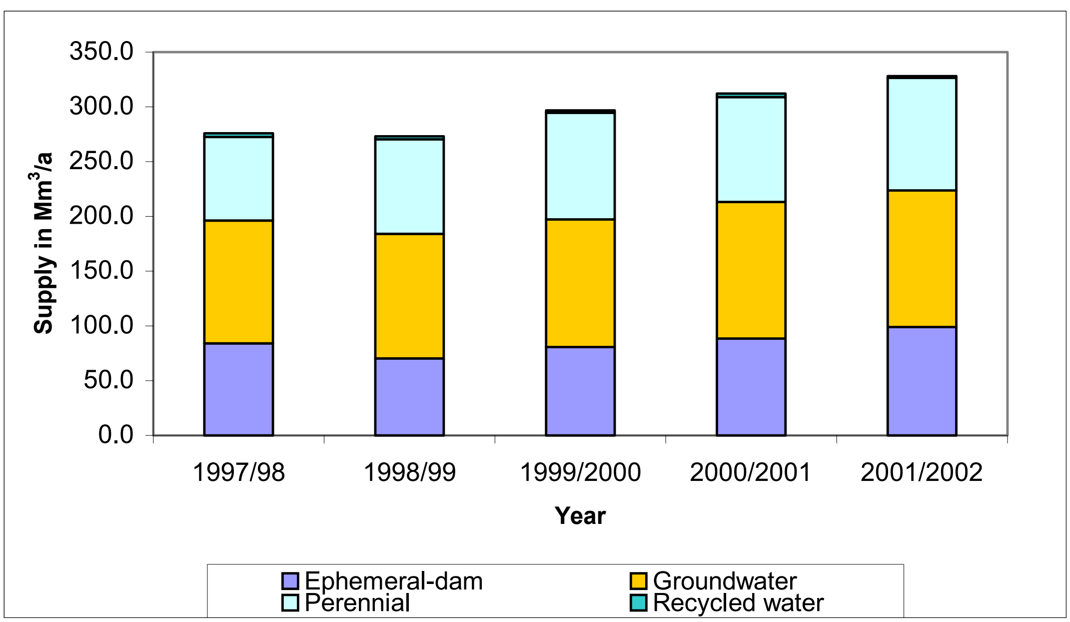

Figure 5.1: Distribution of Freshwater Supply by Natural Source, 1997/98 to 2001/02

5.3 WATER SUPPLY BY INSTITUTION

5.3.1 Water Supply by NamWater

In 1997/98 NamWater was the largest supplier of freshwater, accounting for 43% of all freshwater supply, followed closely by agricultural self-suppliers accounting for 40%. By 2001/02, the situation had reversed; agricultural self-providers surpassed NamWater to become the largest suppliers of water, accounting for 45% of all freshwater abstractions as summarised in **Table 5.2**.

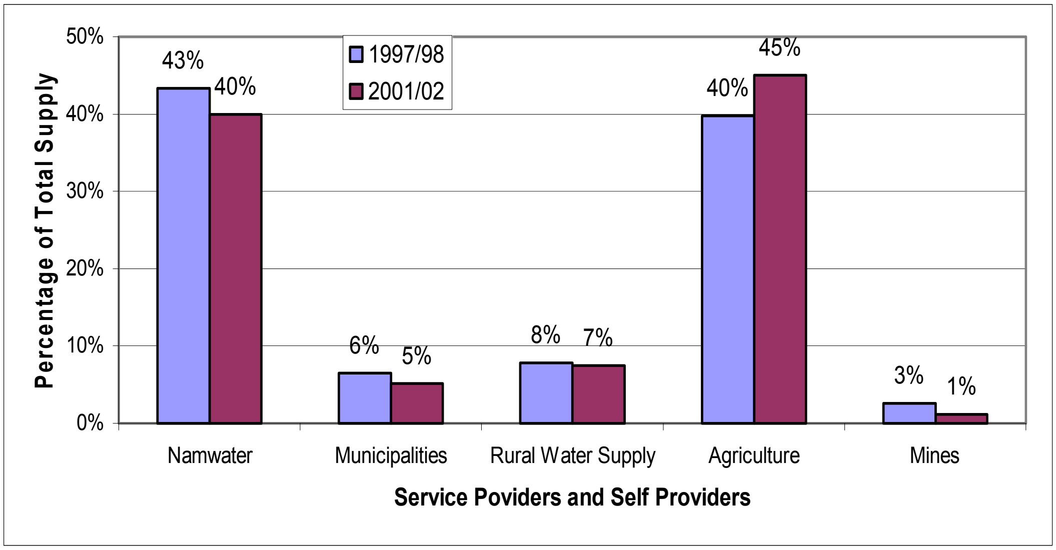

Figure 5.2: Share of Total Freshwater Supply Abstracted By institution*, 1997/98 and 2001/02

The water accounts present the entire pathway for water supply, from the institution that first abstracts water, through transfers to other institutions, which eventually deliver water to the end-user. Regarding the supply of water by institution, the accounts distinguish three stages:

- primary abstraction of water and recovery of waste water for reuse
- transfers of primary water from one supplier to another before delivery to end-user
- water distribution to end-users.

In addition, losses are incurred at each stage.

Using NamWater as an example (see **Table 5.3**),

Primary abstraction by NamWater in 2001/02 was 130.5 million m^3. Net transfers from NamWater to other water supplying institutions totalled 52.3 million m^3. "Net" transfers = purchases/transfer in *minus* sales/transfers out. NamWater purchased roughly 5 million m^3 from Mining but sold 57 million m^3 to Municipalities, RWS and Rural communities, for a Net Transfer of –52.3 million m^3. The Net transfer is entered as a negative number to show that NamWater has 52.3 million m^3 less to deliver to end-users

Water distributed to end-users totalled 66.7 million m^3, which includes agriculture, mining, and domestic end-users

Total losses amounted to 11.6 million m^3.

Agricultural self-providers use all the water they abstract themselves. The relative importance of irrigation and livestock farmers is discussed in the section on sectoral water use.

NamWater on the other hand, supplies about half the water it abstracts directly to end-users, and delivers the other half to other water authorities, mainly municipalities and rural water authorities, who then distribute this water to end-users.

Table 5.3: Supply, Use and Losses of Freshwater by Institution

Primary Abstraction & Reuse	1997/98 (Mm^3/a)	1998/99 (Mm^3/a)	1999/2000 (Mm^3/a)	2000/2001 (Mm^3/a)	2001/2002 (Mm^3/a)
Namwater	118.9	105.8	119.7	121.2	130.5*
Municipalities	17.7	12.0	17.0	18.0	16.7
Rural Water Supply	21.5	22.0	21.7	26.0	24.3
Rural Communities	0.0	0.0	0.0	0.0	0.0
SP-Agriculture	110.7	124.8	129.6	138.4	137.3
SP-Mines	7.3	7.3	7.3	7.0	9.1
Total	276.1	271.8	295.3	310.6	318.1
Net transfers to other suppliers*					
Namwater	-44.6	-48.6	-47.3	-50.2	-52.3
Municipalities	43.4	47.8	44.7	47.7	49.3
Rural Water Supply	5.1	4.8	6.2	5.3	5.4
Rural Communities	1.3	1.3	1.7	2.3	2.8
SP-Agriculture	0.0	0.0	0.0	0.0	0.0
SP-Mines	-5.1	-5.3	-5.3	-5.1	-5.1
Total	0	0	0	0	0

* Includes approximately 7 Mm^3 abstracted by Ongopolo Mining from Kombat Mine pumped into the Canal (Eastern Water Carrier)

Total available supply: primary abstraction + reuse + net transfers					
Namwater	74.3	57.2	72.4	71.0	71.3
Municipalities	61.0	59.8	61.7	65.7	66.0
Rural Water Supply	26.7	26.8	28.0	31.3	29.7
Rural Communities	1.3	1.3	1.7	2.3	2.8
SP-Agriculture	110.7	124.8	129.6	138.4	146.0
SP-Mines	2.1	2.0	2.0	1.9	2.3
Total	276.1	271.8	295.3	310.6	318.1
Deliveries to End Users, after Transfers and Losses					
Namwater**	64.0	48.4	62.0	60.4	69.8
Municipalities	44.9	49.8	45.6	49.3	51.0
Rural Water Supply	24.6	26.3	26.6	27.9	27.4
Rural Communities	1.0	1.0	1.3	1.8	2.1
SP-Agriculture	99.4	112.4	116.6	124.6	132.3
SP-Mines	1.9	1.8	1.8	1.7	2.1
Total	235.8	239.5	253.9	265.6	274.7
Losses and Unaccounted for Water					
Namwater	10.3	8.8	10.4	10.6	11.5
Municipalities	16.2	10.0	16.1	16.4	15.0
Rural Water Supply	2.1	0.5	1.4	3.4	2.4
Rural Communities	0.3	0.3	0.4	0.6	0.7
SP-Agriculture	10.9	12.5	13.0	13.8	14.7
SP-Mines	0.2	0.2	0.2	0.2	0.2
Total	40.3	32.3	41.5	45.0	43.4

* Net transfers = purchases/transfer in *minus* sales/transfers out. Water sold or supplied to another institution is entered as a negative number for the supplier—indicating less water available for the supplier to distribute to end-users. Water purchased or received from another institution is entered as a positive number for the recipient, indicating additional water available for the recipient to distribute to end-users. Since all transfers must be both given and received, the total net figure will be zero.

In terms of deliveries to end users—after taking into account transfers among utilities and losses—agricultural self-providers are the largest group in all years, followed by Namwater, municipalities, and RWS.

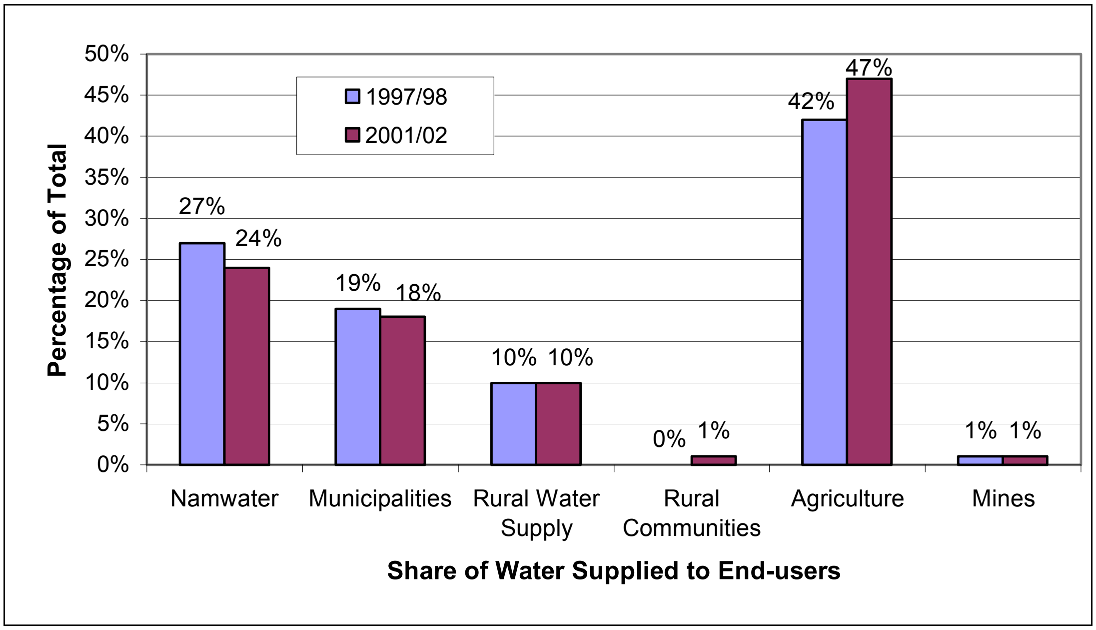

Figure 5.3: Share of Freshwater Supplied to End-users by Institution,

Note: **Figure 5.3** differs from **Figure 5.2** by the amount of net transfers received by an institution for delivery to end-users and losses.

Figure 5.4 takes volumes from the full water accounts to show the natural sources drawn on by the two largest suppliers, NamWater and Agricultural self-providers. Together, NamWater and Agriculture account for virtually all water collected in dams, roughly 85% and 15% respectively. These shares have not changed much from 1997/98 to 2001/02.

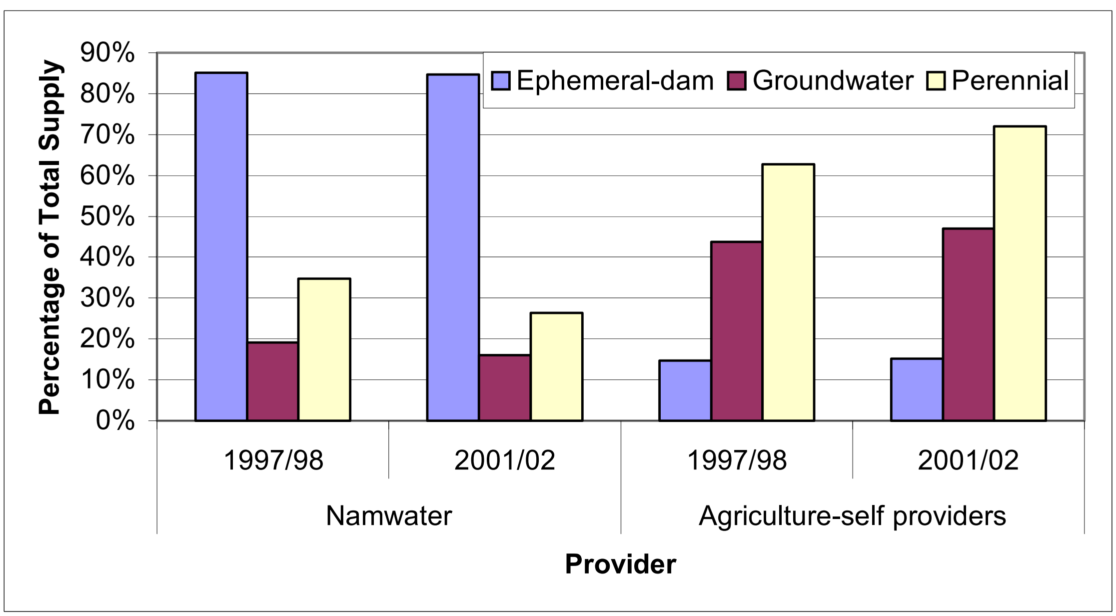

Figure 5.4: Freshwater Supply by Source Abstracted by NamWater and Agricultural Self-providers

There has been a change in the utilization of other water resources: as the importance of Agricultural self-providers has grown relative to Namwater, it has accounted for an increasing share of total abstractions from both groundwater and perennial river water resources. Agricultural self-providers increased their share of total withdrawals from perennial rivers from 63% to 72% in 2001/02.

From trends at the national level, one would conclude that the growing importance of Agricultural self-providers warrants closer monitoring, especially in sensitive groundwater areas. As discussed earlier in this report, although there is a legal requirement for monthly reporting of abstractions, this is not enforced and many farms do not have adequate water metering devices. Even where NamWater suppliers agriculturalists, as at Hardap, water meters are often not working. Given the overwhelming importance of agricultural water use, more accurate information would surely help improve water management.

5.3.2 Municipal Water Distribution

Data were collected for 45 municipalities and towns. Most towns obtain water for local reticulation from Namwater; only a few towns abstract their own water. Towns that report abstracting water themselves—Grootfontein, Okahandja, Omarura, Oranjemund, Outjo, Tsumeb, Usakos, Windhoek—rely on groundwater. Recycling is limited to the towns of Windhoek, Oranjemuind, and Grootfontein[6]. **Table 5.4** reports total water supply, total use, the share used by households, and the share of unaccounted for water and losses. The towns are listed according to their rank in total water supply in 2001/02; for some municipalities, this ranking differs from 1997/98 water use, but the later year is used, as the data are more detailed. Detailed billing information about water use and losses was available for all years only for a few municipalities—Windhoek, Oranjemund, Walvis Bay, and Grootfontein. These four towns accounted for more than half of all municipal water. For other towns, as explained in earlier sections, the rate of loss and the distribution of remaining water among end-users were obtained only for 2001/02; it was assumed to have been the same in earlier years.

Table 5.4: Water supply, use and losses by municipalities, 1997/98 and 2001/02

Local Authority	Supply: abstraction + net transfers, m^3		Losses as % of supply		Household Use as Percent of Supply		Other uses as % of supply	
	1997/98	2001/02	1997/98	2001/02	1997/98	2001/02	1997/98	2001/02
Windhoek	16,973,551	19,586,332	18%	13%	48%	51%	34%	36%
Oranjemund	5,758,791	6,576,317	33%	31%	40%	38%	27%	30%
Walvis Bay	3,164,677	4,508,100	16%	11%	39%	42%	45%	47%
Grootfontein	2,936,523	3,533,110	18%	15%	42%	36%	40%	49%

[6] Swakopmund, Otjiwarongo and Walvis Bay also recycle some water, but figures for these towns were not obtained for the water accounts.

Local Authority	Supply: abstraction + net transfers, m^3		Losses as % of supply		Household Use as Percent of Supply		Other uses as % of supply	
	1997/98	2001/02	1997/98	2001/02	1997/98	2001/02	1997/98	2001/02
Tsumeb	3,146,572	3,262,300		33%		24%		43%
Swakopmund	2,612,229	2,758,532		18%		46%		36%
Katima Mulilo	2,270,980	2,400,019		38%		36%		26%
Rundu	2,166,851	2,028,912		61%		23%		16%
Keetmanshoop	1,712,558	1,729,691		49%		21%		30%
Rehoboth	2,058,260	1,706,165		40%		25%		35%
Okahandja	1,512,489	1,574,250		3%		44%		53%
Otjiwarongo	1,479,820	1,374,092		1%		39%		60%
Oshakati	826,449	1,275,568		24%		24%		52%
Outjo	664,421	1,010,805		33%		35%		33%
Luderitz	886,629	936,870		14%		41%		45%
Ongwediva	1,013,597	782,379		33%		23%		45%
Omaruru	1,025,035	748,931		7%		45%		48%
Ondangwa	871,833	744,049		37%		21%		42%
Gobabis	655,265	691,185		9%		38%		53%
Mariental	620,521	683,144		33%		28%		39%
Khorixas	939,176	602,103		17%		24%		60%
Opuwo	584,183	598,192		81%		5%		14%
Arandis	509,816	448,029		42%		46%		12%
Otavi	403,787	380,947		49%		26%		25%
Henties Bay	371,246	374,317		27%		59%		14%
Uis	261,456	372,040		85%		8%		7%
Gibeon	325,842	368,637		75%		14%		11%
Okakarara	279,827	317,422		30%		36%		34%
Usakos	302,893	317,316		49%		40%		11%
Karibib	349,158	314,037		21%		62%		17%
Karasburg	223,991	237,739		49%		28%		23%
Aranos	230,519	194,046		49%		28%		23%
Maltahohe	129,757	118,516		49%		28%		23%

Local Authority	Supply: abstraction + net transfers, m^3		Losses as % of supply		Household Use as Percent of Supply		Other uses as % of supply	
	1997/98	2001/02	1997/98	2001/02	1997/98	2001/02	1997/98	2001/02
Bethanie	120,801	110,443		49%		28%		23%
Witvlei	87,154	93,454		49%		28%		23%
Kalkrand	77,418	77,095		35%		35%		30%
Koes	70,435	75,390		49%		28%		23%
Kamanjab	74,565	67,926		65%		10%		25%
Stampriet	53,839	66,423		68%		17%		15%
Tses	57,931	65,444		77%		13%		10%
Aroab	64,786	59,728		49%		28%		23%
Gochas	62,863	56,244		49%		28%		23%
Leonardville	59,752	54,807		49%		28%		23%
Berseba	40,135	47,503		53%		26%		21%
Others	2,332,863	2,349,553		49%		51%		0%
All towns	60,371,244	65,678,102	27%	25%	38%	39%	34%	36%

Notes: A blank entry means figures are not available.

Detailed information about losses and the use of water by different economic sectors was only available for 4 towns in all years; for other towns, figures for the distribution of water among economic sectors were obtained for 2001/2002. The same distribution was assumed for all previous years.

Households are the single largest user of municipal water, accounting for 39% in 2001/02, compared to 36% for all other uses; the remaining 25% is losses and unaccounted for water, which are discussed in the next section. These shares have remained fairly stable over time—partly by assumption for many towns (roughly half the water supply), but also for towns that provided billing information for all years.

Municipal water use grew 9% from 1997/98 to 2001/02, but the growth varied considerably among towns. Among the large water consuming towns (those using 1 million m^3 or more), the fastest growth in water use occurred in Walvis Bay (42%) and Oshakati (54%), and Outjo (52%). But reported water use actually declined in some towns—Rundu (-6%), Otjiwarongo (-7%), Rehoboth (-17%)—and even greater declines were reported for some of the smaller water consuming towns like Ongwediva, Omaruru, and Ondangwa. It is not clear whether this is due to a reduction in losses in those towns, declining population, or some other factor, such as a change in economic activity, water conservation activities, or possibly a reduction in supply from NamWater due to non-payment of water bills.

Table 5.5 shows the towns for which population figures were available for 1997 and 2001—information was not available for all the towns in the water accounts; per capita water supply was calculated by dividing the water supply from **Table 5.4** by the population figures in **Table 5.5.** The towns are listed according to their per capita water supply in 2001, which ranges from a low in Oshakati of 45 m^3 per person annually to a high in Oranjemund of 1477 m^3 per person annually. Per capita water supply declined in most towns between 1997 and 2001, including the majority of towns which used more than 1 million m^3 in 2001, but in five of these towns per capita water supply increased: Grootfontein, Tsumeb, Okahandja, Oshakati, and Outjo.

Of the 18 towns where the volume of water use decreased between 1997 and 2001, information about population in both years was available for 10 of them, and indicated that only in 4 small towns did population actually decline, usually by a very small amount. In all 10 towns, per capita water use declined significantly (**Table 5.5**), indicating that factors other than just population decline are affecting water use. The main reason for reduction in per capita use is the creation of informal settlements at most of the urban centres that provides water services from standpipes. Another reason may be a reduction in water demand as a result of price increases (price elasticity of demand).

Table 5.5: Per Capita Water Supply in Major Towns, 1997/98 and 2001/02

Town	Population		Per capita water use		
	1997	2001	1997/98 (m^3/a)	2001/02 (m^3/a)	Increase/ Decrease (m^3/a)
Oshakati	21,603	28,255	38	45	+7
Gobabis	8,340	13,856	79	50	-29
Rundu	19,366	36,964	112	55	-57
Karasburg	4,602	4,075	49	58	+10
Ondangwa	7,926	10,900	110	68	-42
Mariental	7,581	9,836	82	69	-12
Otjiwarongo	15,921	19,614	93	70	-23
Luderitz	7,700	13,295	115	70	-45
Ongwediva	6,197	10,742	164	73	-91
Rehoboth	21,439	21,308	96	80	-16
Windhoek	147,056	233,529	115	84	-32
Karibib	3,067	3,726	114	84	-30
Okakarara	3,725	3,296	75	96	21
Otavi	3,506	3,813	115	100	-15

Town	Population		Per capita water use		
	1997	2001	1997/98 (m^3/a)	2001/02 (m^3/a)	Increase/ Decrease (m^3/a)
Khorixas	7,358	5,890	128	102	-25
Walvis Bay	NA	43,611	NA	103	NA
Katima Mulilo	13,377	22,134	170	108	-61
Usakos	3,548	2,926	85	108	23
Keetmanshoop	15,032	15,778	114	110	-4
Okahandja	11,040	14,039	137	112	-25
Arandis	4,303	3,974	118	113	-6
Henties Bay	1,612	3,285	230	114	-116
Swakopmund	17,681	23,808	148	116	-32
Opuwo	4,234	5,101	138	117	-21
Omaruru	4,851	4,761	211	157	-54
Outjo	4,535	6,013	147	168	22
Tsumeb	16,211	14,929	194	219	24
Grootfontein	12,829	14,249	229	248	19
Oranjemund	NA	4,451	NA	1,477	NA

Source: Calculated from figures in **Table 5.4** divided by population from CBS 2001 Census of Population. Population figures for 1997 interpolated between 1991 and 2001 census figures.

5.3.3 Losses and Unaccounted for Water

All providers suffer significant losses of water between the point of initial abstraction, through treatment and distribution to the end user. Losses occur for several reasons: leakages within the system, water lost during treatment, illegal use of water from the system, or poor monitoring and meter reading. Losses due to system leakage are not directly attributable to the use of water by any specific economic sector. Unaccounted for water due to illegal or poor monitoring may have an economic use, but there is not sufficient information to assign it to any particular sector. Although unaccounted for water cannot be attributed to specific economic activities, it is important to monitor this figure because it represents a drain on scarce resources as well as a potential source of additional supply—often at a relatively low cost.

The calculation of losses/unaccounted for water was described earlier in this report. In some instances, losses can be calculated from administrative records as the difference between supply and the amount delivered (billed) to end-users; in other instances, losses can be estimated on the basis of technical assessment. In assessing losses, it is not always straightforward to determine what is being compared. Namwater, for example, incurs considerable losses in primary abstraction and treatment and additional losses in delivery to end-users. Other water institutions do not engage in much, if any, primary abstraction, and incur losses only in delivery to end-users.

NamWater's losses are estimated from loss parameters at each stage in the supply chain as described earlier, which are assumed to be the same for all years (**Table 5.6**). The only difference from year-to-year is due to the share of groundwater in primary abstraction—it is assumed that there is no loss in production from groundwater, only from ephemeral and perennial river water. Hence, the loss rate in 1997/98 is only 4% because of a higher share of groundwater abstracted compared to 2001/02. These loss rates are exemplary, but it is not clear if these rates apply equally to all water schemes.

Table 5.6: Losses Experienced by NamWater, 1997/98 and 2001/02

Description	1997/98	2001/02
Primary abstraction (Mm^3)	118.9	130.5
% consumed in production	4%	6%
% lost in transfers to other suppliers	1%	1%
Supply for end-users (after losses in treatment and transfers, (Mm^3)	65.9	68.7
% lost in delivery to end users	3%	3%

For other suppliers, no information was available about losses, so a fixed rate was used for all years, as explained in an earlier section of this report:

- 8% losses for Rural Water Supply
- 25% losses for Rural Communities
- 10% for Self-providers in agriculture and mining

Loss rates for municipalities were calculated from administrative records, and these bear closer scrutiny. Reported in **Table 5.4** above, the loss rates in 2001/02 varied enormously among towns, from an implausibly low 1% in Otjiwarongo to an extraordinarily high 81% for Opuwo and 85% for Uis. For the four towns that provided detailed records for earlier years, loss rates have fallen over time, with especially big improvements for Windhoek and Walvis Bay (**Table 5.7**).

Table 5.7: Losses and Unaccounted for Water as Percent of Total Supply for Selected Towns, 1997/98 and 2001/02

Town	1997/98	2001/02
Windhoek	18%	13%
Oranjemund	33%	31%
Walvis Bay	16%	11%
Grootfontein	18%	15%

Note: records for years prior to 2001/02 are not available for other towns.

Within Namibia's water supply system, loss rates can be calculated with some degree of certainty only for NamWater and the municipalities, which account for less than half of primary abstraction. As a potential source of effective supply, reduction of losses is likely to be a high priority for water authorities; more comprehensive monitoring of losses by all providers would certainly be a valuable tool for water management. Using the data currently available, one can readily identify towns with problematic delivery and billing systems that could benefit from immediate attention, notably those with reported loss and unaccounted for water exceeding 20% of supply. These towns account for 37% of total municipal water supply (**Table 5.8**).

Table 5.8: Towns with Non-revenue Water of 20% or Higher in 2001/02

Towns	Loss and unaccounted for water as percent of water supply	Share of total municipal water
Katima Mulilo, Ondangwa, Kalkrand, Tsumeb, Mariental, Ongwediva, Outjo, Oranjemund, Okakarara, Henties Bay, Oshakati, Karibib	20%-39%	21%
Berseeba, Maltahohe, Bethanie, Gochas, Witvlei, Usakos, Aranos, Karasburg, Otavi, Koes, Leonardville, Aroab, Keetmanshoop, Arandis, Rehoboth, all other towns	40%-59%	11%
Uis, Opuwo, Tses, Gibeon, Stampriet, Kamanjab, Rundu	60% or more	5%

This issue will be addressed in the section that deals with future work on the water accounts.

5.4 WATER USE BY ECONOMIC SECTOR

Agriculture is the major user of water in most countries and Namibia is no exception to this global trend: 75% of water use in 2001/02 was for agriculture, about 23% in the communal sector and 52% in commercial agriculture (**Table 5.9**). Water for crop irrigation dominates, accounting for 54% (commercial & communal) of total water use; livestock watering accounts for 21%. Within the commercial sector, irrigation uses much more water than livestock, but in communal areas, water use is roughly the same for crop and livestock farming. In communal areas, irrigation water is used mainly for commercially oriented farming, not subsistence farming.

Table 5.9: Water Use by Detailed Economic Sector in 1997/98 and 2001/02

Economic Sector	Water use, Mm^3		Percent Distribution	
	1997/98	2001/02	1997/98	2001/02
AGRICULTURE	**169.33**	**202.03**	**71.8%**	**73.6%**
Commercial agriculture	**109.59**	**134.95**	**46.5%**	**49.1%**
Commercial Crop Irrigation	85.84	108.63	36.4%	39.6%
Commercial Livestock	23.75	26.32	10.1%	9.6%
Communal agriculture	**59.74**	**67.08**	**25.3%**	**24.4%**
Communal Crop Irrigation	32.43	35.56	13.8%	12.9%
Communal Livestock	27.31	31.52	11.6%	11.5%
FISHING	**0.03**	**0.69**	**0.0%**	**0.3%**
MINING	**8.73**	**9.13**	**3.7%**	**3.3%**
Diamond mining	1.01	0.94	0.4%	0.3%
Other mining & quarrying	7.73	8.19	3.3%	3.0%
MANUFACTURING	**5.96**	**6.64**	**2.5%**	**2.4%**
Total for Food Processing	**2.98**	**3.61**	**1.3%**	**1.3%**
Meat processing	1.20	1.38	0.5%	0.5%
Fish processing	0.67	0.91	0.3%	0.3%
Beverages	0.94	1.12	0.4%	0.4%
Grain milling & other food processing	0.17	0.20	0.1%	0.1%
Textiles	0.18	0.13	0.1%	0.0%
Other Manufacturing	2.79	2.91	1.2%	1.1%
UTILITIES	**0.20**	**0.23**	**0.1%**	**0.1%**
CONSTRUCTION	**0.20**	**0.28**	**0.1%**	**0.1%**
SERVICES	**7.01**	**7.92**	**3.0%**	**2.9%**
Trade	1.70	1.95	0.7%	0.7%
Hotels & Restaurants	1.75	1.81	0.7%	0.7%
Transportation	0.37	0.43	0.2%	0.2%
Communication	0.06	0.06	0.0%	0.0%
Financial & Business services	0.60	0.71	0.3%	0.3%

Economic Sector	Water use, Mm^3		Percent Distribution	
	1997/98	2001/02	1997/98	2001/02
Social services	2.53	2.97	1.1%	1.1%
GOVERNMENT	**14.21**	**14.15**	**6.0%**	**5.2%**
HOUSEHOLDS	**30.15**	**33.60**	**12.8%**	**12.2%**
Rural Households	8.48	9.15	3.6%	3.3%
Urban households	21.68	24.46	9.2%	8.9%
TOTAL	**235.82**	**274.67**	**100%**	**100%**

Note: The use of sea water in Fishing & Diamond mining sectors are excluded from the accounts. For other mines the reuse of water from slimes dams was excluded.

Figures for land under irrigation and water use are available for 1995/96 to 2002/03, a longer period of time than the water accounts. Using figures for this longer time period allows us to see more clearly the longer-term trends (**Table 5.11)**

Table 5.10: Land Under Irrigation and Water Use 1995/96 to 2002/03

Year	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01	2001/02	2002/03
Area in ha	6,673	6,497	7,041	8,054	8,183	9,185	9,630	9,847
Consumption (Mm^3/a)	109.9	107.6	118.2	118.0	130.0	135.0	144.22	158.5

Over these 7 years (1995/96 to 2002/2003), land under irrigation grew by 48% from 6,673 hectares to 9,847 hectares in 2002. Water use for irrigation increased with 44.5%, from 110 million m^3 to 159 million m^3 in 2002. The lower increase in consumption may be a combination of a combination of the following factors:

- Increased use of water-saving irrigation methods on existing and new irrigated land
- Replacement of water–intensive crops by less water-intensive crops
- Expansion of irrigation in areas that, due to climatic conditions, may require less water delivered for a given crop
- Further analysis of the water accounts for irrigation will reveal the relative importance of each of these factors.

Irrigation water is not measured and is calculated on areas based on an estimated water demand in improvement of approximately 2.2% falls outside the accuracy level op the data on irrigation areas as well as assumptions for crop water requirements.

Table 5.11: Livestock Numbers by and Increase Between 1998 and 2002

Type Animal	1998	2002	Total % Growth
Cattle	2192359	2329553	6%
Sheep	2086434	2764253	32%
Goats	1710190	2110092	23%
Horses	53325	47220	-11%
Donkeys	162973	134305	-18%
Pigs	14706	47805	225%
Poultry	403937	883950	119%
Ostriches	52393	62976	20%
Camels	50	88	76%

Note: Negative= decrease

Mining, one of the major sectors of the Namibian economy, is not a significant user of water, accounting for only 3.3% of water use in 2001/02, lower both in percentage and in absolute terms compared to 1997/98. This trend reflects, in part, the extensive use of seawater as diamond mining has moved increasingly to offshore mining sites. Three mining operations together account for 73% of mining water use in 2001/02: Navachab (12%), Rosh Pinah (16%), Ongopolo and Kombat (45%). It is expected that this will change significant after completion of the Skorpion Mine near Rosh Pinah.

Water use appears to have grown fastest in Fishing, but understanding this growth requires a closer look at the fishing industry. Fishing is dominated by marine capture fishing, and fresh water use for this type of fishing is negligible, limited to office use. In the past few years aquaculture has developed near Hardap Dam and is now a major user of water. Ponds for aquaculture have also been established in the northeast, but no figures on water use are currently available. Economically, freshwater aquaculture is still quite small compared to marine fishing, but it is highly water intensive, like crop irrigation. Freshwater aquaculture has been identified as a sector with high-growth potential so monitoring water use should be a priority. Most of the implemented schemes requires a daily input of 10 to 15% fresh water input relative to the storage in the pond. The overflow is normally used for small-scale irrigation schemes provided that the effluent is suitable for irrigation. Reuse of water within requires expensive filtration systems and is only applied in small-scale operations.

Water use in manufacturing has increased, mainly in the food processing industries, but from a very low base. It appears that water use for textiles has declined from 1997/98 to 2001/02; however, since that time several large, new textile companies have been established in Windhoek. The increased water use by the textile industry should appear in more recent water accounts. Although food processing and textile industries do not consume a large amount of water in the national context, they are important to monitor because 1) they are likely to be significant water consumers of regional water resources, (pressure that will not show up in national water accounts) and 2) they have been targeted as high-growth sectors for Namibia's development so their water needs are likely to grow more rapidly than other sectors in the future.

Water use by construction appears low—construction is often a water intensive industry and water consumption is higher in the Botswana and South African water accounts—but has increased significantly. It has been suggested that construction companies outside major towns often abstract their own water at rivers and from groundwater sources. There is no record of the water use, and no method for estimating it at this time. Services use a considerable amount of water, especially social services. Social services include many schools and recreational facilities that may be using a lot of water for field irrigation. Surprisingly, water use by government has declined slightly; a review of the more detailed accounts in the appendix reveals that this can be attributed to the decline in government agricultural activities. In the past, the major component of government water use was water for irrigation and livestock farms operated by government; much of this activity has declined.

Following agriculture, domestic use by households constitutes the second largest user of water. Household water use appears to be rising only slightly faster than the rate of population growth. Daily per capita water has not changed very much for either urban or rural households between 1997/98 and 2001/02 (**Figure 5.5**). Urban households consume much more than rural households, on average, 113 litres per day compared to 21 litres per day for rural households, so that increased urbanization will result in higher domestic use of water.

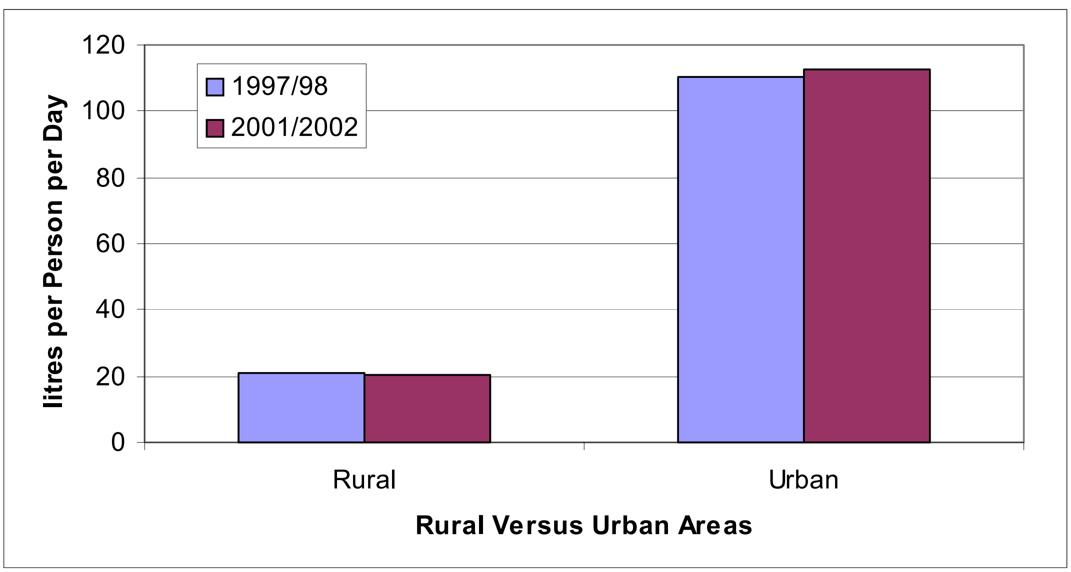

Figure 5.5: Daily Water Consumption by Rural and Urban Households, 1997/98 and 2001/02

5.5 BREAKDOWN OF WATER USE IN RIVER BASIN AREAS

This section covers the water demand in the main identified river basin areas in Namibia. There are 23 identified hydrological river basins in Namibia that covers most of the regions. In the Namib Desert there are some areas that does not fall within a specific catchment. The Water Demand Study completed by WCE (2000) for the NWRMR was done on river catchment areas. This information was updated from the base year 1999 to 2001/2002 for the breakdown of water use for each hydrological river basin. The river basins are indicated in **Figure 5.6**.

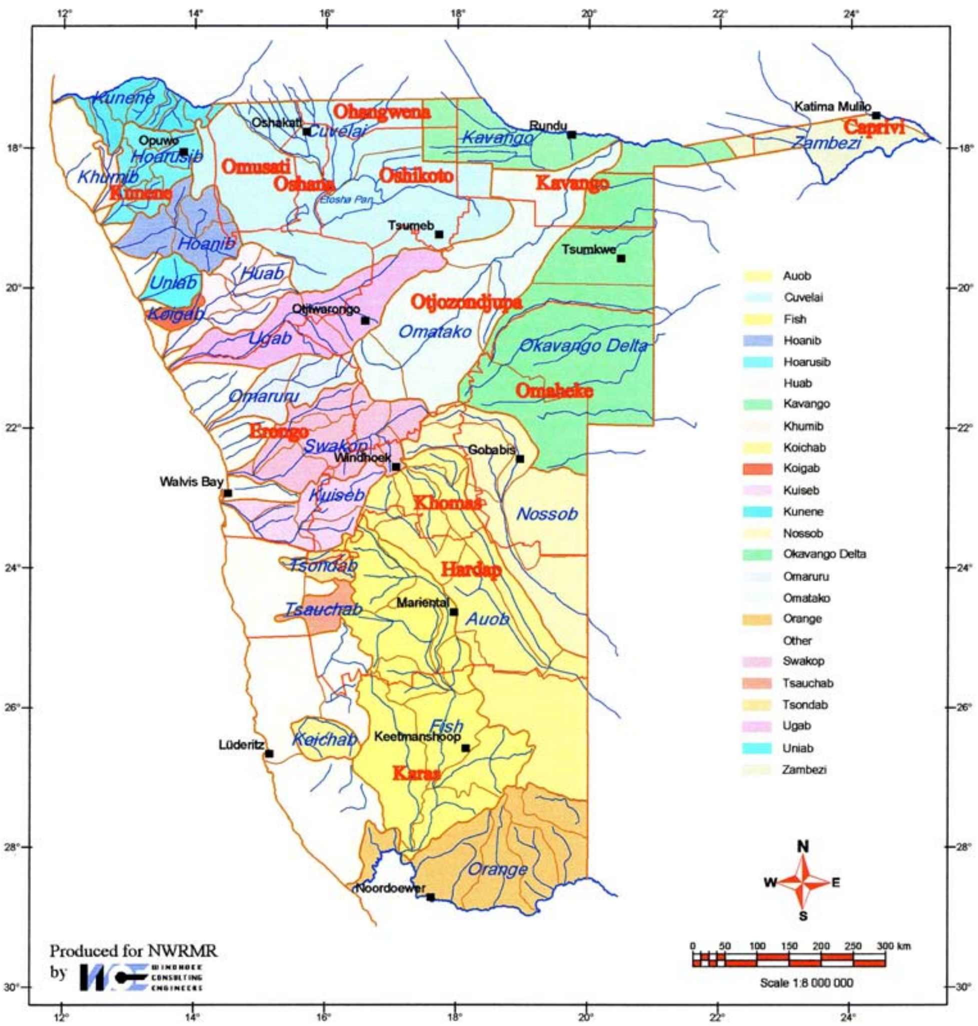

Figure 5.6: River Basins of Namibia

Irrigation water requirements for 2001/02 reveal that four catchments account for roughly 89% of land area and water use for irrigation (**Figure 5.7**). Two of these catchments, the Fish River and the Orange River in the south, account for 54% of land under irrigation and 61% of water use. Water use and land area irrigated are related, but can vary due to factors such as crops irrigated, irrigation method, and climatic conditions.

Among the four river catchments that dominate irrigation farming, irrigation in the Cuvelai and Kavango expanded slightly faster than the national average; irrigation in the Fish River did not expand much at all, while irrigation along the Orange River expanded at nearly double the national rate. Regarding water use, the three fastest growing catchments were Hoanib, Omatako, and Zambezi. For the Hoanib and Omatako, water use expanded much faster than land area under irrigation. Given water scarcity, this is a development that bears closer scrutiny to determine which of the factors mentioned above is responsible for such a rapid increase in water use.

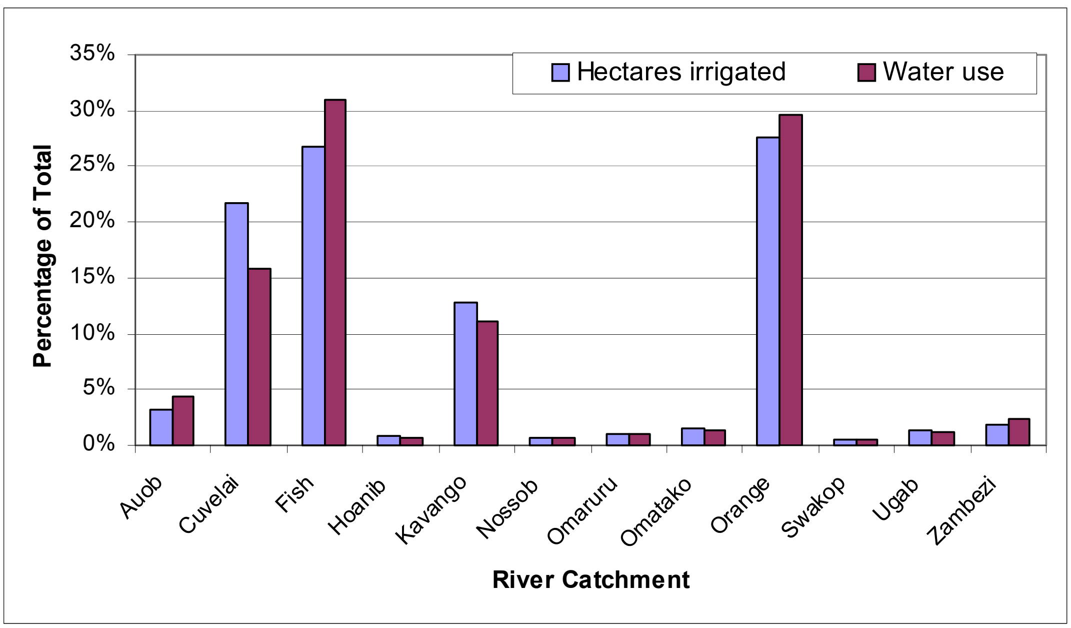

Figure 5.7: Distribution of Irrigated Agriculture by River Catchment for 2001/2002

Note: Cuvelai includes water transfers from the Kunene River

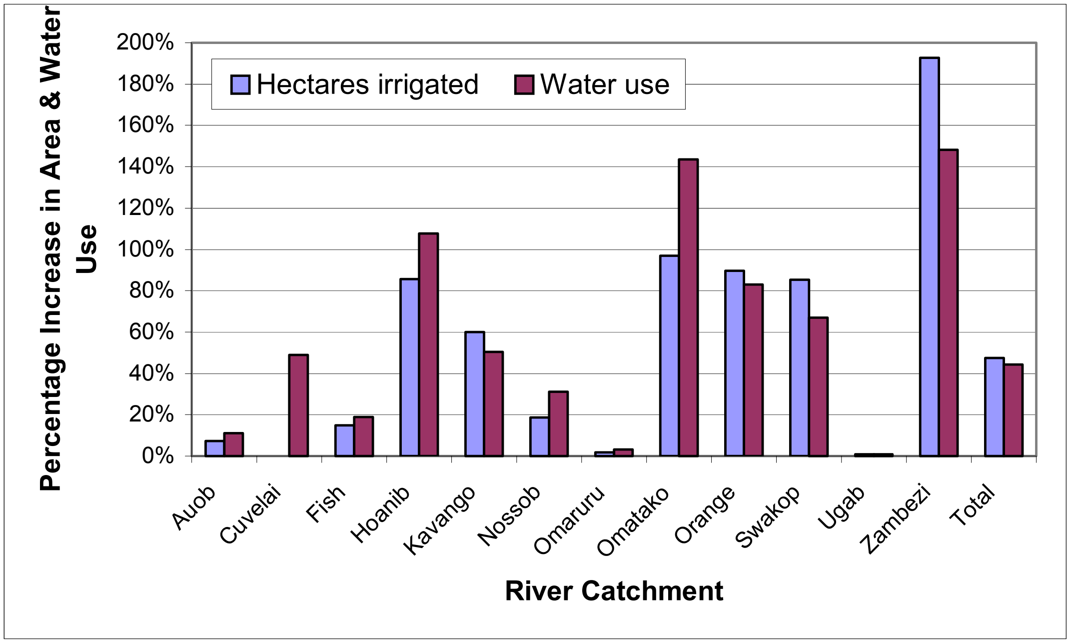

Figure 5.8: Growth of Irrigation by River Catchment: Percent increase in Hectares under Irrigation and in Water Use Between 1995 and 2002

Note: Cuvelai includes water transferred from the Kunene river.

The summary of the irrigation areas and water requirements are summarised in **Table 5.12**.

Table 5.12: Land Under Irrigation and Water Use by River Basin, 1995/96 to 2002/03

Land Under Irrigation (hectares)								
Catchment	**1995/96**	**1996/97**	**1997/98**	**1998/99**	**1999/2000**	**2000/01**	**2001/02**	**2002/03**
Auob	278	334	305	272	272	289	301	299
Cuvelai	1,365	1,356	1,366	1,675	1,610	2,079	2,091	2,138
Fish	2,275	2,276	2,276	2,276	2,276	2,576	2,576	2,613
Hoanib	55	55	55	55	85	86	87	102
Kavango	877	877	877	877	877	1,053	1,228	1,404
Nossob	60	69	69	70	66	64	69	71
Omaruru	92	95	115	101	111	110	102	93
Omatako	86	86	101	119	119	152	152	170
Orange	1,353	1,119	1,634	2,363	2,531	2,538	2,664	2,568
Swakop	44	41	56	58	49	50	51	81
Ugab	127	127	127	127	127	128	128	128
Zambezi	62	62	62	62	62	62	182	182
Total	6,673	6,497	7,041	8,054	8,183	9,185	9,630	9,847

Water use for Irrigation (Mm^3/a)								
Catchment	**1995/96**	**1996/97**	**1997/98**	**1998/99**	**1999/2000**	**2000/01**	**2001/02**	**2002/03**
Auob	6.0	7.3	6.7	5.9	6.0	6.4	6.7	6.6
Cuvelai	19.0	19.0	15.7	18.9	19.9	23.7	23.8	28.4
Fish	40.9	40.9	41.1	28.6	38.3	40.9	46.9	48.7
Hoanib	0.5	0.5	0.7	0.6	0.9	0.9	1.0	1.1
Kavango	12.6	12.6	12.6	12.6	12.6	14.8	16.9	19.0
Nossob	0.8	1.1	1.1	1.1	1.0	0.9	1.1	1.1
Omaruru	1.3	1.4	1.8	1.5	1.7	1.7	1.6	1.4
Omatako	1.0	1.0	1.1	1.5	1.5	2.2	2.2	2.4
Orange	23.6	19.9	28.1	39.9	42.6	42.7	44.8	43.2
Swakop	0.7	0.7	0.8	0.9	0.7	0.8	0.8	1.2
Ugab	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Zambezi	1.5	1.5	1.5	1.5	1.5	1.5	3.6	3.6
Total	109.9	107.6	112.9	114.9	128.4	138.3	151.1	158.5

Note: Cuvelai includes water transferred from the Kunene River.

WCE (2000) developed a spreadsheet as part of the NWRMR to allocate stock numbers from the information collected from Veterinary Services to river basins. The 9800 inspection points in the veterinary districts were plotted on a map on a map of Namibia according to their veterinary district, and then overlaid with a map of the 24 basins. The 24 basins were divided into 56 polygons, each polygon being part of a basin and a veterinary area. With this approach, it was relatively easy to assign different parts of one particular veterinary inspection district to the catchment basins overlaying them. The surface areas of each polygon were calculated and divided by the surface area of the veterinary area of which it is a part. The same spreadsheet with updated stock numbers was used to determine the water requirements.

Furthermore mines and urban areas were allocated for the respective river basins as summarised in total water requirements in **Table 5.13.** It was not possible to do a further breakdown according to source as well as user group (industry fishing, services etc) for each river basin. Rural water supply (using approximately 5% of the water) was also omitted from **Table 5.13.** The potential resource are indicated per basin include groundwater, water from ephemeral rivers and assumed future allocations from perennial rivers subject to development of further infrastructure and international negotiations (Table 4.4). The WCE 9200) estimates were further applied for the basins. The estimated losses of 44.5 Mm^3/a is not included in the demand figures for each river basin. Rural water demand for domestic use estimated at approximately 5 Mm^3 was not allocated to a specific river basin due to a lack of detailed information for each catchment.

Table 5.13: Total Water Requirements and Source per River Basin

Basin	Water Demand (m^3/a)						Remarks
	Irrigation	**Stock**	**Mining**	**Urban**	**Total Water Demand (Mm^3)**	**Resource Potential (Mm^3/a)**	**Notes:** Figures from surface water sources should be regarded as best estimates based on 95% yields from existing and potential dams in ephemeral rivers. Figures of international rivers are based on reasonable future allocations subject to the agreement with basin states. The estimates of groundwater within catchments can only be regarded as a rough indication and requires detailed investigations and verification. The volume of available groundwater in Namibia is unknown. Environmental water requirements are not quantified or taken into account for any catchment.
Auob	5,612,946	691,832	3,544	1,963,950	8.272	17.5	Surface water potential very limited and no figure available Groundwater potential of part of Stampriet Aquifer
Cuvelai	19,146,194	18,337,547	2,796,636	6,182,719	46.463	22.0 GW[1] 20.0 GW 22.5 KR	Surface water potential in Cuvelai Basin only at low reliability. Treaty guaranteed availability of water from Calueque = 189 Mm^3/a which is supplied from the Kunene River
Fish	46,885,607	6,533,448		3,344,853	56.764	150	The 95 % safe yield from existing large dams [Hardap + Naute] = 66 Mm^3/a highest 95 % safe yield from The theoretical combination of existing and non-existing dams is approximately 164.3 Mm^3/a presumably safe yield of some combination of existing and non-existing dams
Hoanib	727,119	1,749,272			2.476	4.4	The 95 % safe yield from proposed dam at Sesfontein = 3.6 Mm^3/a. The highest 95% safe yield from theoretical main+silt dam combination at Khowarib = 4.4 Mm^3/a
Hoarusib	0	1,876,946	40	598,192	2.475	15.2	The 95% safe yield of proposed dam in the Upper Puros is 15.2 Mm^3/a.
Huab	549,040	1,044,512		825,013	2.419	2.5	Estimate of the available resource.
Okavango	21,845,800	3,368,296		2,028,912	27.243	10.0 GW 270	There is no treaty on available water. Allocation subject to approval by basin states.

Basin	Water Demand (m^3/a)						Remarks
	Irrigation	Stock	Mining	Urban	Total Water Demand (Mm^3)	Resource Potential (Mm^3/a)	**Notes:** Figures from surface water sources should be regarded as best estimates based on 95% yields from existing and potential dams in ephemeral rivers. Figures of international rivers are based on reasonable future allocations subject to the agreement with basin states. The estimates of groundwater within catchments can only be regarded as a rough indication and requires detailed investigations and verification. The volume of available groundwater in Namibia is unknown. Environmental water requirements are not quantified or taken into account for any catchment.
Khumib		106,914			0.107	0.10	No surface water potential
Koichab		9,480	8,253	956,894	0.975	1.19	No surface water potential only groundwater potential
Koigab		27,820			0.028		No surface water potential
Kuiseb	12,100	1,267,660	2,574	4,508,100	5.79	8	Safe yield from potential dams in the Kuiseb River varies from 8.7 to 10.1 Mm3/a.
Kunene	0	1,935,399	3,055	122,610	2.061	180 10.0 GW	Treaty guaranteed availability of water from Calueque = 180 Mm^3/a which is supplied from the Kunene River
Nossob	1,529,460	7,329,199		1,033,492	9.892	15	Safe yields of surface water dams are below 1 Mm^3/a
Okavango Delta	0	4,849,138	874	140,179	4.99	20	No surface water potential only groundwater potential.
Omaruru	1,616,329	831,555	1,000	1,169,818	3.619	12	The 95% safe yield of a dam in the middle Omaruru is estimated from 6.6 to 11.7 Mm^3/a. Groundwater potential is unknown.
Omatako	2,004,463	7,465,749	5,000	4,724,624	4.2	15.0 GW 14.6 GW3	The 95% safe yield of the Omataku Dam is estimated at 0 to 2 Mm^3/a.
Orange	37,996,700	2,646,085	2,375,296	6,903,718	49.922	275	Estimated potential water demand subject to agreement with South Africa and construction of a Dam at Vioolsdrif. According to the treaty only 9 Mm^3/a is allocated to Namibia.

Basin	Water Demand (m^3/a)						Remarks
	Irrigation	Stock	Mining	Urban	Total Water Demand (Mm^3)	Resource Potential (Mm^3/a)	**Notes:** Figures from surface water sources should be regarded as best estimates based on 95% yields from existing and potential dams in ephemeral rivers. Figures of international rivers are based on reasonable future allocations subject to the agreement with basin states. The estimates of groundwater within catchments can only be regarded as a rough indication and requires detailed investigations and verification. The volume of available groundwater in Namibia is unknown. Environmental water requirements are not quantified or taken into account for any catchment.
Swakop	861,555	2,068,492	2,193,414	25,084,828	30.208	11 17.5 GW	Approximate 95% safe yield of Von Bach and Swakoppoort Dams 11 Mm^3/a
Tsauchab		548,131			0.548		No surface water potential
Tsondab		435,581			0.436		No surface water potential
Ugab	2,382,800	2,375,695	1,743,689	1,763,792	8.266	12	The 95% safe yield of proposed dam in the middle Ugab varies from 5 to 9 Mm3/a. Only groundwater sources are used.
Uniab		76,698			0.077		No surface water potential
Zambezi	3,052,030	3,590,560		2,557,729	9.2	500	No treaty guaranteed availability of water. Subject to negotiation with countries in the catchment
Other	0	1,240,922		338,500	1.579		No surface water potential
Total	**144,222,142**	**57,526,277**	**9,133,375**	**64,247,923**	**275.13**		

Notes: GW=Ground Water GW[1]=Both groundwater and water from excavation type dams in the Cuvelai Basin GW[2]= Tsumeb Aquifer GW[3] = Groundwater from Tsumeb and Karst 1, 2 & 3. aquifers KR = Kunene River

It was not possible to provide a breakdown of the system capacity or yield per catchment due to the format of existing information of installed infrastructure. The total mobilised resources as summarised in **Table 4.6** is was estimated at 422.5 Mm^3/a

5.6 ENVIRONMENTAL WATER REQUIREMENTS

The rational for recognising environmental water needs as a part of water resources management is essentially that Namibia's Constitution provides for the sustainable use of all natural resources. Article 95 (l), states that: 'the state shall actively promote and maintain the welfare of people by adopting policies aimed at maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilisation of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future".

The principle of sustainable use has been carried through into recent legislation. The Water Resources Management Act, (Act 24 of 2004) was founded on the Second National Development Plan and the National Water Policy White Paper (Government Gazette, 2004), both of which promoted environmental sustainability. One of the "Basic Principles" identified in the National Water Policy is the "Principle of Ecosystem Values and Sustainability" which states that the "management of water resources needs to harmonise human and environmental requirements, recognising the role of water in supporting the ecosystem". One of the strategies given, in the policy, to ensure environmental and economic sustainability reads: "Ensure that in-stream flows are adequate, both in terms of quality and quantity to sustain the ecosystem. The Water Policy also states: "The legislation will provide for determining an environmental water reserve for freshwater sources before they can be used to supply other demands than domestic and subsistence livestock watering".

These principles are taken up in the new Water Resources Management Act so that, for example, one of the fundamental principles of water resource management (Part 3.(d)) is that of 'harmonisation of human needs with environmental ecosystems and species that depend upon them, while recognising that those ecosystems must be protected to the maximum extent;' and the next principle of management in the Act, is to adopt; 'integrated planning and management of surface and underground water resources, in ways which incorporate the planning process, economic, environmental and social dimensions'. Further, a function of the Minister responsible for water (Part II 5.(g)) is 'to ensure that water resources management operates in accordance with the principles of environmental sustainability'.

These principals are that the functions and products of the environment, (in this case water resources and their associated aquatic ecosystems) should be maintained so that they can be used indefinitely.

According to the State of Environment report for Water (The Water and Environment Team 1999) the "goods" or "resources" provided by wetlands include water, soil, sediment and nutrients, plants and animals, conservation and tourism, value, navigation and energy, aesthetics and various social values. The "services" provided by wetlands include primary production, flood attenuation, aquifer recharge, water quality improvement and transport (for example of sediment, nutrients, animals and seeds).

5.6.1 Relationship between Water Resources and Aquatic Ecosystems

Water resources are defined in the Act as including:- a river or spring, the base flow of an ephemeral river at the time of no visible surface flow, a natural channel, an estuary, wetland, lake or dam, an aquifer and the sea and meteoric water or any other collection of water declared to be a watercourse, by the Minister.

Many people continue to think of water as just a commodity, contained in rivers and groundwater or stored in dams, used as drinking water, for irrigation or for industrial processes. In fact, the water itself is only one part of a large and complex ecosystem. It is this larger ecosystem which provides not only the commodity, water, but also many other services and benefits. : (Department of Water Affairs and Forestry 1999)

Aquatic ecosystems or the aquatic environment comprise the physical water bodies together with their physical, chemical and biodiversity characteristics. (Biodiversity includes species diversity (what species there are), as well as their productivity and ecological functions).
A water resource such as a river includes various aquatic ecosystems such as the main channel, flood plains and banks each of which has a range of species, such as fish and vegetation, dependent on the flow of water. The water resource also has ecosystem functions such as sediment and nutrient transport. The water itself is just one part of the water resource. Healthy sustainable surface water resources depend on well-functioning aquatic and wetland ecosystems.

The management for sustainable water resources requires an understanding of the extent of the resources, how the water is used to maintain aquatic ecosystems and their associated biodiversity and productivity and how the resources function and change with time. .

As "renewable natural resources", water resources have a degree of resilience to the pressures and demands of human use. Such resilience allows water resources to be used continuously as long as the demands are not too great. The ecological integrity, which gives a water resource its resilience, is an essential component of the value of the resource.

If a water resource is over-used or degraded too far, (ie too much water is taken out, too much waste is put in) or the ecosystem is modified too greatly by over-use, erosion, sedimentation or habitat degradation, then the water resource ecosystem looses resilience and begins to break down. The water resource is no longer being used sustainably. (Department of Water Affairs and Forestry 1999).

Water resource developments, such as dams, inter-basin water transfers and water abstractions, affect flow regimes, water chemistry, sediment and temperature characteristics and hence the ecology of water resources. These changes affect the people dependant on a range of associated resources. Downstream impacts can be reduced by manipulating flows (eg maintenance water releases from dams) or by regulation of abstractions or both.

5.6.2 Environmental Water Requirements.

Water resource management, on a basin by basin basis, as provided for in Namibia's new Water Act, will require the assessment of ecological water requirements as part of individual catchment water-use determinations, as well as to ensure sustainable wetland resource use. The discipline of determining ecological water requirements (EWR) (also called the environmental water reserve), environmental water allocations, in-stream flow requirements (IFR) or environmental flow requirements (EFR) looks at how much water a wetland or riverine environment requires to attain or be maintained in a particular desired state.

The desired state is commonly chosen to maintain or enhance important goods and services provided by the wetland. For instance, to maintain a downstream aquifer, floodplain or estuary to provide habitat for a particular fish species or water of a certain depth for navigation.

The methods used to determine EWR and the measurement of wetland ecosystem health are still evolving, eg of perennial rivers (King Tharme and Brown, 1999; King, Tharme and de Villiers, 2001). Most are based on understanding the biophysical, social and economic nature of rivers. Biophysical data on the hydrology, hydraulics, aquatic ecology, geomorphology and water quality are usually needed. Social data would include subsistence, health and cultural needs data and economic data would include resource economics and various development option valuations. There are now a range of methods used to determine environmental water needs of perennial rivers.

An excellent review of the rational of environmental flows and the current methods for environmental flow assessment used in southern Africa, with case studies, is given by Brown, King and Tharme, (2002). They also give a table, giving the EWR methods in the following categories, with an assessment of their advantages, disadvantages and data needs.

5.6.2.1 The Orange River Case Study

The minimum environmental water demand, both in terms of quantity and quality, in the Orange River was exceeded long ago. However, efforts to protect the Orange River estuary, which is ranked as the sixth most important coastal wetland in Southern Africa, have resulted in estimates for the environmental water demand required to protect the wetland resources of the Orange River Mouth (WCE, 2000).

The environmental water demand was quantified for two situations named. "ideal conditions" and "absolute minimum conditions"

Under the ideal conditions scenario, the minimum water requirement was calculated at 244 Mm^3/annum made up of:- 20 Mm^3/month (7,65m^3/s) for October to July inclusive, a low flow of 4 Mm^3/month (1,9m^3/s) during August and a freshwater flush of 40 Mm^3 (19,1m^3/s) in September. It is not clear what is meant by "ideal" conditions, but it is proposed that these criteria be met 95% of the time.

Under the absolute minimum conditions scenario the water requirement to maintain the estuary is reduced to a total of 100Mm^3/a, consisting of 6Mm^3/month (2,87m^3/s) for October to July inclusive, followed by two flush months of 20Mm^3/month to be met 99,5% of the time.

Although this represented a useful quantitative assessment of the environmental demand it was not certain that the annual inundation of the salt marsh at the mouth would be achieved. This was seen as an absolute requirement to maintain the biological value of the estuary wetlands. It was recommended that it should be seen as the collective responsibility of all basin states, despite the fact that the saltwater marsh is on the South African side of the border. In other words the allocation of water for environmental reasons was seen as the joint responsibility of both countries.

5.6.2.2 Ephemeral rivers.

To date, no internationally accepted methods exist for assessing EWR's of ephemeral river systems. Although work is being done, for instance in Australia, Israel and the US.

Ephemeral rivers have many unique characteristics compared to perennial systems. Namibia must develop methods suited to the country's conditions and circumstances taking the following variables into account:

- Water flow and aquifer recharge is often sporadic.
- Flow interval increases downstream.
- Flow volume decreases downstream.
- There are gradients of soil moisture and water table depth within the channel.
- Accumulations of detritus, nutrients and sediment along previous flood-lines.
- Distinct sandy, nutrient and biodiversity poor channels.
- Large riparian trees on floodplains, channel banks and even within downstream channels.
- Pioneering terrestrial plants (often weeds) are common.
- Aquatic species are confined to isolated spots or short wet sections for most of the time.
- Aquatic species biodiversity is low, but terrestrial species biodiversity is high along the river course.
- Ephemeral rivers form resource-rich corridors compared to surrounding land.

Although there is presently no recognized methodology to assess environmental water requirements of ephemeral rivers in Namibia, there has been an attempt to determine and supply adequate environmental water releases from the Oanob Dam (Du Plessis, 1994). The idea was to maintain the camel thorn, *Acacia erioloba*, woodland in the floodplain immediately below the dam, near Rehoboth. This research project was one of the first government initiatives in Namibia to assess environmental water needs. However, there is no clear management policy resulting from the project.

5.6.3 Value of Environmental Water.

A way of assessing the environmental opportunity costs of water abstraction, is to think of each cubic meter of water, as having a changing potential value for supporting a proportion of the productivity of the entire river system downstream, as it flows down the length of a river (this could be modelled in theory). High up in the catchment a particular cubic metre of water has a high potential value for providing fish habitat, transporting nutrients and sediment, tourism focal points such as water falls, generating electricity etc as it travels down the river. Near the river mouth the potential value of the same cubic metre of water for supporting natural resources is very much less. It is clear that the loss of natural resource productivity, due to abstraction of water, will depend on where in the catchment the water is removed. Downstream aquifers and recharge-enhancing dams in the lower river, such as at Omdel Dam on the Omaruru River are ideal from an environmental viewpoint.

5.6.4 Activities and Projects in Namibia to Determine Environmental Water Requirement in Ephemeral Rivers

The activities as summarised below:

- **Environmental water need assessment methodology development programme, for Namibian ephemeral rivers:** This project is part of NDP II water. To date some initial consultative meetings and a national workshop on setting up the programme have taken place. The programme still needs official approval and support so as to obtain international funding and project input. The programme proposal contained the following details of Namibian projects being conducted to further EWR determination.

- **Flood recharge of alluvial aquifers in drylands environment (WADE):** Central to determining environmental water requirements is the quantification of “floodwater recharge” of aquifers, to accurately assess the quantity and quality of floodwaters as a water resource. This is where the WADE project will contribute to EWR determinations. The WADE project aims to assess long-term (decades to centuries) water resources in selected semiarid to hyperarid ephemeral river basins by determining long-term transmission losses from floods and quantifying floodwater recharge into alluvial aquifers. An innovative approach will be applied based on three principal research themes. Palaeoflood hydrology will be used to determine long-term flood magnitude and frequency in order to quantify the frequency of recharging flood events. Surface and sub-surface hydrology will be monitored in order to quantify transmission losses through the riverbed into the alluvial aquifers. The combination of these two methodologies will be able to quantify long-term aquifer recharge through flooding. The final research theme focuses on the socio-economic issues related to the use of alluvial aquifer groundwater within the study catchments. The research will be undertaken in 4 research basins, twinning catchments in Spain and Israel with study catchments in Namibia (Kuiseb catchment) and South Africa. (MAWRD IFR proposal, 2003)

- **Subsurface water and riparian tree interactions**: This study will look at the interaction between flood events, groundwater and woody riparian vegetation to improve understanding of these relationships. The specific objectives are to:
    1. Monitor dynamics between groundwater and vadose zone in one vegetated and one unvegetated area
    2. Evaluate quantitatively the relation between flood events and groundwater recharge
    3. Compare evapotranspiration rates and water abstraction zones of three tree species over time
    4. Compare access to water between juvenile and mature trees of three species over time
- **Regeneration process and recruitment of *Faidherbia albida* and *Acacia erioloba* in western ephemeral rivers of Namibia**: *Faidherbia albida* and *Acacia erioloba* are key resources for indigenous farmers, livestock and wildlife in the Kuiseb Basin River. Both species are experiencing increasing pressure through water extraction, human use and livestock grazing. These two species could be used in identifying ecological requirements for the Kuiseb River. Currently there are two studies looking at regeneration and recruitment of both *F. albida* and *A. erioloba.* The study will examine the interaction between flood events, groundwater and woody riparian vegetation in ephemeral rivers, principally the Kuiseb River.

5.6.5 Conclusion on Environmental Water Requirements

In the WCE Report (2000) the following statement was made for the environmental water demand: “Environmental demand, although not quantified for any basin, can be assumed to be the single biggest consumer of water. It is necessary to implement the necessary investigations and research to evaluate environmental demand on a basin by basin basis. It seems likely that any increase in consumption by man, will result in a reduction in environmental consumption (when environment is taken in the fullest sense of the word). The question that has to be answered is what is the minimum environmental demand required by the environment, or conversely what is the maximum environmental demand that can be tolerated by man and the economy?” This needs to be done not only on a basin by basin basis, but also on a spatial basis within the basin.

From the discussion in **Section 5.6.2** it is clear that there is insufficient information at this stage to include it in the 2001/2002 NRA accounts. The framework makes provision to included for environmental water requirements into future exercises as soon as information is available.

6 ECONOMIC ANALYSIS OF NAMIBIAN WATER ACCOUNTS

The purpose of water accounting is to increase knowledge concerning the interaction between water and human activity, providing a tool for improved water management. Population, the structure and level of economic activity, urbanization and increasing standards of living, land cover and land use changes all influence the availability of water and the use of water. Hence, a tool that links water supply and use with these factors is valuable for water management.

Water accounts provide:

- A broader assessment of the consequences of economic growth and population growth for water use and availability
- The contribution of sectors to particular environmental problems, such as overexploitation of groundwater, water pollution, or loss of biodiversity
- The sectoral implications of policy measures: policies include those *directly* affecting water, such as water pricing, abstraction regulations, and infrastructure development, as well as those *indirectly* affecting water such as agricultural development schemes, hydroelectric power development and urban concentration

This chapter describes the water accounts over the period 1997/98 to 2001/02, and provides a brief analysis linking the water accounts to population and economic activities. Comparability problems do not allow comparison with earlier water accounts for 1993 and 1996 at this time, but they will be included in future work, providing a set of water accounts that will span nearly 10 years. Most of the examples in the body of this chapter present only the figures for 1997/98 and 2001/02 in order to make the presentation more concise. Full water accounts for all years are provided in the appendix.

6.1 COSTS OF WATER SUPPLY AND USER CHARGES

An overview of the costs of water is provided in **Table 6.1**; more detailed discussion will follow. Comprehensive information is only available for 2001, and not for all institutions and types of water. For example, only the cost of groundwater was estimated for agricultural self-providers, so the figure in the water accounts for the cost of supply to agriculture is missing the cost of self-provided surface water. The same applies to Mining. The significance of the missing cost information is discussed later in this sector.

Costs of supply are separated into two components: costs of primary abstraction and cost of the water that is ultimately provided to end-users by each agency. The difference is the amount received or supplied to other institutions. NamWater, in 2001-02 for example, abstracted 130.5 million m^3 of water, but transferred much of that to other institutions, leaving it with only 68.7 million m^3 of water to deliver directly to end-users. NamWater's average cost of water abstraction in that year was N$2.01/$m^3$, but the cost varied considerably depending on the source. Ephemeral water cost an average of N$1.25/$m^3$, while the average cost of groundwater was N$3.86/$m^3$. The unit cost of groundwater or ephemeral water also varies across different regions of the country, reflecting the varying hydrological conditions and the different water schemes in place.

The NamWater costs (abstraction, water treatment and transfer costs) and tariffs of water for 2001/2002 are summarised in **Table 6.** Full cost recovery (FCR) includes an amount of N$ 44.74 million for depreciation of infrastructure. The unit cost of sources (groundwater and ephemeral) varies across different regions of the country, reflecting the varying hydrological conditions and the different water schemes in place.

Table 6.1: Tariffs and Full Cost Recovery for the NamWater Regions

NamWater Area	Regions	Tariff	FCR
Okavango	Kavango and Caprivi	2.26	1.53
Kunene	Kunene Omusati	3.08	5.23
Cuvelai	Omasati, Ohangwena, Oshona and parts of Oshokoto	3.84	3.82
Waterberg	Part of Otjondjupa	2.89	3.44
Brandberg	Parts of Oshokoto, Otjondjupa and Kunene	2.79	2.87
Khomas	Khomas and parts of Erongo	3.07	2.74
Namib	Erongo and part of Kunene	2.51	2.15
Omaheke	Omaheke	3.6	9.19
Hardap	Hardap	2.81	4.07
Karas	Karas	2.82	3.18
Total average Tariff and Costs		2.89	2.79

The FCR included depreciation costs to an amount of N$ 44.74 million/a

Once the transfers to other institutions are accounted for, the remaining water that NamWater distributes itself has an average cost of N$1.23/$m^3$, which is considerably less than the average cost of water it abstracted. The average cost of water obtained from each source also differs from the average at the point of abstraction. This difference results from the varying unit costs between water schemes. For example, perennial water is abstracted from 56 water schemes (**Appendix A 3**); the average cost over all 56 water schemes is N$2.97/$m^3$. However, the average unit cost of water NamWater delivers to end-users is lower, N$1.83/$m^3$, because more of the water is drawn from less expensive water schemes. The perennial water transferred to other institutions comes from more expensive water schemes. It should be noted that this result does not reflect any policy decision, as such, merely the geographic location of water supply and demand.

Table 6.2: Costs of Water Abstraction and Supply to End-users, 2001/02

Authority responsible for abstraction	Abstraction			Water provided to end-users, net of transfers		
	N$ million	Volume, Mm^3	N$/$m^3$	N$ million	Volume, Mm^3	N$/$m^3$
NamWater						
All sources	261.85	130.52	2.01	84.39	68.72	1.23
Ephemeral-Dam	104.63	83.53	1.25	38.96	52.14	0.75
Groundwater	76.83	19.92	3.86	25.01	5.41	4.62
Perennial	80.39	27.08	2.97	20.42	11.17	1.83
Rural Water Supply						
All sources	83.59	24.34	3.43	107.87	29.73	3.63
Ephemeral-Dam	0.59	0.17	3.59	0.93	0.19	4.78
Groundwater	66.32	23.55	2.82	70.16	24.07	2.91
Perennial	16.68	0.63	26.67	36.78	5.46	6.74
Rural Communities						
All sources	No primary abstraction			9.46	2.76	3.42
Ephemeral-Dam				0	0	NA
Groundwater				6.29	2.25	2.79
Perennial				3.17	0.51	6.16
SP-Agriculture						
Groundwater	243.04	58.20	4.18	243.04	58.20	4.18
The following providers are not fully represented in the table above because the total costs recorded in the water accounts do not include all self-provided water: Municipalities; SP-Agriculture; SP-Mines						

NA: Not applicable

RWS abstracts much of the water it distributes itself at a cost of N$3.43/m^3, but it also obtains a small amount from NamWater which raises its unit costs to N$3.63/m^3. Groundwater is not only the main source of water for RWS but also the cheapest. Rural Communities do not abstract water themselves[7] and obtain their water from NamWater. The unit cost of the water they obtain, N$3.42/m^3, is higher than the average unit cost for water abstracted by NamWater, N$2.01/m^3, indicating that it is obtained from water schemes that are very expensive to operate. An estimate was made of the cost incurred by Agricultural self-providers to abstract groundwater (See Chapters 2 and 3), based on the number of operating boreholes, average capacity, water requirements and pumping time. The estimated average cost for 2001-02 is N$4.18/m^3, which is on the high side, but well within the range of water abstraction costs.

Full-cost recovery is not yet fully implemented for all users, and there may be considerable cross-subsidisation of water. The extent of cross-subsidisation will be explored further in the next section, which looks at water costs and tariffs by economic sector. Accounts compiled at the water scheme level would reveal the extent of full-cost recovery. Furthermore, as discussed in earlier chapters, the figure for user charges represents *billed* revenues, not *collected* revenues. There is a serious problem of non-payment by several municipalities so that collected revenues are less than billed charges. However, data that distinguish billed from collected charges are not yet available.

In the past, NamWater's user charges did not cover all costs; but a policy of full-cost recovery was gradually implemented in the 1990s. The effect of this policy can be seen in the difference between costs of supply and water charges: in 1999, costs still exceeded billed charges by N$43 million and both other water utilities and end-users were subsidized. But after 2000/2001 and 2001/2002, user charges were N$ 13 million N$11 million more than covered supply costs. These national figures do not represent the cost-tariff relationship for every water scheme.

A critical issue in water management is payment for water. With incomplete information about costs and user charges, a comprehensive analysis cannot be provided. Nevertheless,

This is a considerable increase in cost recovery from 1993, when only self-providers covered all the costs of supply. At that time, NamWater also subsidized water use to some extent and continued to do so until 1999, when subsidies were 20% of NamWater's supply costs (**Table 6.3**).

[7] Of course, rural communities do collect payment for water themselves, but there is no information about the volume, time-cost or other aspects of this source of water.

Table 6.3: Water subsidies, 2001/02

Responsible for Abstraction	Water subsidy as % of supply costs	Share of total freshwater supplied to end-users
NamWater	no subsidy— water charges are 4% greater than supply costs	24%
Municipalities	NA	18%
Rural Water Supply	100%	10%
Rural communities	35%	1%
Self-providers	no subsidy	48%
Total	Cannot be calculated at this time	100%

Sources: **Table 6.2**

There is concern that groundwater in some areas is being overexploited. This concern warrants more detailed analysis of costs and user charges for groundwater because subsidies will encourage excessive use. **Table 6.2** presents national figures for groundwater subsidies by supplier. A little more than half (53%) of the groundwater receives no subsidy, that which is abstracted by self-providers and NamWater. However, 20% of groundwater, which is supplied by RWS, is completely subsidised. Municipalities provide another 25% of groundwater to end-users, but the extent of the water subsidy cannot be determined at this time.

6.1.1 NamWater Deliveries to End-Users

Table 6.4 shows deliveries of water to end-users by NamWater, the user charges and supply costs of water and subsidies, if any, by economic sector. Although data for user charges prior to 1999 are available, data for costs are not, so only 1999-2000 and 2001-2002 are shown. A word of caution in interpreting the tables: NamWater is attempting to implement full-cost recovery pricing, but this is difficult to accomplish unless water demand is stable and predictable. In addition, NamWater uses accounting methods that may result in large charges in a single year, sometimes without smoothing over time. It is also not clear exactly how capital and depreciation are accounted for. Consequently, a longer time series of supply costs and user charges may be required to assess trends for specific sectors.

Table 6.4: Groundwater Subsidies in 2001-02

Responsible for Abstraction	Volume, (Mm^3)	Share of total groundwater supplied to end-users	Subsidy as % of supply cost
NamWater	5	4%	0%
RWS	24	20%	100%
Self-providers	59	49%	0%
Municipalities	31	25%	NA
Rural communities	2	2%	35%
Total	122	100%	NA

NA: not available

As already shown in **Table 6.2**, NamWater does not recover its full supply costs from deliveries to end-users. Subsidies amounted to 20% of supply costs in 1999 and 34% in 2001. Even after 2000 when on an institution-wide basis full-cost recovery was achieved, the total charges to end-users did not cover costs. The end-user subsidy was offset by user charges to other water suppliers (municipalities and RWS) that were higher than costs, an issue which we will return to after further discussion of user charges and costs to end-users.

Agriculture accounts for more than half the total water NamWater provides to end-users. In 1999, supply costs were greater than user charges to most agricultural users, especially commercial irrigation. By 2001 sales to commercial irrigation appeared to more than cover supply costs, but the charges to commercial livestock farmers and for communal irrigation did not cover costs.

Regarding commercial irrigation, the figures for user charges to commercial irrigation are somewhat misleading from a water management perspective. Full cost recovery is often promoted for fiscal sustainability, but especially to promote water conservation and efficient water use in water scarce environments. Where water is heavily subsidized, there is little incentive for a farmer to take appropriate water-saving measures such as investment in water efficient irrigation equipment, switching to higher-value crops or crops that require less water.

Table 6.5: NamWater Supply to End-users: User Charges, Supply Costs and Subsidies by Economic Sector, 1999/2000 and 2001/2002

Economic Sector	1999-2000				2001-2002			
	Volume, (1000 m^3)	User charges/ 1000m^3 (N$)	Supply cost/ 1000m^3 (N$)	Subsidy: (charges – cost)/ 1000m^3 (N$)	Volume, (1000m^3)	User charges/ 1000m^3 (N$)	Supply cost/ 1000m^3 (N$)	Subsidy: (charges – cost)/ 1000m^3 (N$)
Commercial agriculture								
Commercial Irrigation	38,302	1,792	4,010	-2,218	46,977	1,770	1,045	725
Commercial Livestock	366	512	649	- 137	283	953	1,813	-860
Communal agriculture								
Communal Irrigation	9,330	445	188	257	5,358	632	1,059	-426
Communal Livestock	102	297	462	- 166	266	1,095	949	146
Fishing	619	31	37	- 6	691	33	14	18
Mining								
Diamond Mining	1	3	2	1	2	6	3	4
Other Mining	5,030	16,683	10,673	6,010	4,960	21,487	32,574	-11,087
Manufacturing								
Meat Processing	525	1,611	1,112	499	489	2,335	1,814	522
Fish Processing	0	0	0	0	0	2	2	0
Beverages	127	327	87	240	141	436	42	394
Other food processing	3	9	11	- 3	2	10	58	-48
Textiles	103	263	209	54	107	403	282	121

Economic Sector	1999-2000				2001-2002			
	Volume, (1000 m^3)	User charges/ 1000m^3 (N$)	Supply cost/ 1000m^3 (N$)	Subsidy: (charges – cost)/ 1000m^3 (N$)	Volume, (1000m^3)	User charges/ 1000m^3 (N$)	Supply cost/ 1000m^3 (N$)	Subsidy: (charges – cost)/ 1000m^3 (N$)
Other Manufacturing	1,243	2,169	1,393	776	1,234	3,647	2,685	962
Utilities	178	182	256	- 74	21	88	109	-21
Construction	186	541	1,411	- 870	112	416	664	-248
Trade	70	186	283	- 96	136	575	717	-142
Hotels & Restaurants	922	1,869	2,562	- 694	942	3,120	3,550	-430
Transportation	264	590	848	- 258	220	782	1,288	-507
Communication	1	2	1	1	1	4	2	2
Financial Intermediation	9	20	19	2	6	22	26	-4
Real estate and Business services	10	21	21	1	24	82	1,053	-971
Social services	2,090	5,113	11,052	-5,939	2,246	8,893	15,408	-6,515
Government	1,662	3,998	5,189	-1,192	1,602	6,203	7,256	-1,053
Households								
Rural, Non-Communal	270	539	2,911	-2,372	285	830	7,096	-6,266
Rural, Communal	579	1,699	5,217	-3,518	553	2,142	4,885	-2,743
Urban Households	Not provided directly by NamWater							
Total	61,993	38,903	48,605	-9,702	66,659	55,966	84,392	-28,426

Source: Appendix tables

Table 6.6: NamWater Supply to Other Institutions: User Charges, Supply Costs and Subsidies 2001-2002

Customer	1999-2000					2001-2002				
	Volume. Mm^3	Cost of supply, Million N$	User Charge, Million N$	User Charge – Costs		Volume. Mm^3	Cost of supply, Million N$	User charge, Million N$	User Charge - Costs	
				Million N$	N$/$m^3$				Million N$	N$/$m^3$
Municipal Authorities	44.7	121.3	108.0	-13.3	-0.30	49.3	145.7	183.0	37.3	0.76
Rural Communities	1.7	4.6	0.9	-3.7	-2.18	2.8	9.5	6.1	-3.3	-1.21
Rural Water Supply	6.2	37.6	21.7	-16.0	-2.55	5.4	24.3	29.3	5.0	0.92
Total/Average	52.6	163.5	130.6	-32.9	-0.63	57.4	179.4	218.4	39.0	0.68

Although the accounting methods employed by NamWater indicate that irrigation was supplied at full cost recovery in 2001-02, this is misleading because NamWater has calculated the incremental cost only, depreciation and operating costs required for domestic supplies are therefore not included in the cost of irrigation water. As in many instances the volumes of irrigation water supplied far exceed the volumes of domestic supply, which creates a massive cross-subsidy to irrigation. In addition, NamWater does not supply farmers directly, as the water accounts seem to indicate, but to a government agency, which then distributes the water to farmers. It is possible that further subsidy to farmers is provided by this agency. There is no information about this possible subsidy at this time (pers.comm., M. Harris, 2004).

Regarding commercial livestock, small volumes of water are provided to a few commercial farmers at rates lower than bulk supply charges, in cases where NamWater activities have affected their farming operations. However, the volumes supplied at reduced rates are limited by contract, and consumption in excess of this amount is charged for at commercial rates. The effect of this on the national water accounts is negligible (pers.com. M. Harris, 2004).

Mining also appeared to switch from paying tariffs substantially in excess of cost in 1999 to receiving large subsidies by 2001. The reason for the apparent subsidy to Mining in 2001 has not yet been established. Supply costs in 2001 increased by a factor of three over the previous year. It is possible that this additional cost represented a large maintenance cost that occurs at intervals of five or more years and is financed by 'over recovery' in years where such large operating costs are not incurred. This aspect deserves further investigation and commentary by the Finance Department of NamWater.

Social services, mainly schools and hospitals, received the largest water subsidy, followed by rural households and government. In 1999, Other mining & quarrying paid much more than the supply cost of water, but this situation was reversed in 2001, when Other mining & quarrying became the biggest recipient of subsidies, followed by Social services and Rural households.

How does NamWater finance the subsidy to end-users while meeting its obligations as a commercial operation to cover all its costs? **Table 6.5** demonstrates considerable cross-subsidisation among end-users, but it is not sufficient to cover all the subsidies to end-users. The rest of the subsidy, N$28.4 million in 2001, must come from the other water supplying institutions: Municipalities, RWSand Rural communities. **Tables 6.2** and **6.6** show that in 1999 all purchasers from NamWater were subsidized (by government payments to NamWater). By 2001 NamWater had to finance itself, which it did by charging the 2 major water distribution institutions (Local Authorities and RWS) considerably more than the cost of supply.

Deliveries to Rural communities, which account for less than 5% of NamWater's water deliveries to other water supply institutions, were still subsidized in 2001 by N$3.3 million, which amounted to an average of N$1.21/$m^3$ of water. Deliveries to Municipalities, which account for 86% of water deliveries, generated N$37.3 million of revenues in excess of costs; this amounts to 96% of the total excess revenue charges (N$39.3 million) used to subsidise end-users. While Municipalities constitute the largest source of excess revenue, on a unit basis, RWS is paying an even higher 'tax': Municipalities paid an average excess revenue charge of N$0.76/$m^3$ of water, while RWS paid an average excess revenue charge of N$0.92/$m^3$ of water.

Water prices can affect water usage—subsidies may encourage increased water usage (or at least do not discourage it), while taxes (prices in excess of supply cost) may discourage increased water usage or at least do not encourage it. There has been no comprehensive assessment of water pricing and its impact on the Namibian economy. Does the system of subsidies and taxes support the objectives of the Water Act, Vision 2030, or the National Development Plans, or does it undermine these objectives?

The Namibian Water Resources Management Review commissioned a study on water pricing, but there was simply not enough information to do a comprehensive study. The pricing of bulk water supply by NamWater is subject to extensive review and must be approved by government each year. However, there is no national policy on water pricing by Local Authorities, who provide most of the water to the urban population, manufacturing and service industries. Each Municipality sets its own water pricing policy (see discussion of Municipalities in the next section).

A thorough assessment of water pricing, subsidies/taxes and their economic impact are beyond the scope of this report, although the water accounts provide a good indication of where to start such an assessment. A first step in such an assessment would be to compare the water subsidy/tax with the water productivity in each sector. In **Table 6.8**, the sectoral water subsidies and taxes for water provided directly by NamWater are compared to one measure of socio-economic contribution of water: the national income (value-added) generated by each sector. The two sets of data are not entirely comparable: the NamWater data on water subsidies applies only to part of the economy while the sectoral value-added was calculated from national data, including value-added generated from other water sources. It would be better to compare subsidies from NamWater to water productivity only in those companies using water from NamWater. The economic data are not available for such an analysis but serve as a first approximation.

Table 6.7: NamWater Subsidies by Sector and Water Productivity by Sector for 2001-2002

ECONOMIC SECTOR	NamWater: water supply and subsidy			National Water Productivity N$ Value Added / m^3 water used
	Volume, thousand m^3	User charges – Cost Subsidy = negative number Surplus= positive number		
		Thousand N$	N$/m^3	
AGRICULTURE	**52,883**	**-415**	**-0.01**	**4.54**
Commercial agriculture	**47,260**	**-135**	**0.00**	**4.61**
Commercial Irrigation	46,977	725[8]	0.02	0.55
Commercial Livestock	283	-860	-3.04	18.44
Communal agriculture	**5,624**	**-280**	**-0.05**	**4.41**
Communal Irrigation	5,358	-426	-0.08	-0.49
Communal Livestock	266	146	0.55	9.92
FISHING	**691**	**18**	**0.03**	**939.04**
MINING	**4,962**	**-11,083**	**-2.23**	**127.20**
Diamond Mining	2	4	2.26	891.14
Other Mining & Quarrying	4,960	-11,087	-2.24	39.58
MANUFACTURING	**1,973**	**1,951**	**0.99**	**260.62**
Food processing	**632**	**868**	**1.37**	**314.31**
Meat Processing	489	522	1.07	77.70
Fish Processing	0	0	-0.04	218.38
Beverages	141	394	2.81	451.48
Other food processing	2	-48	-20.09	1 645.87
Textiles	107	121	1.12	194.67
Other Manufacturing	1,234	962	0.78	153.19
UTILITIES	**21**	**-21**	**-0.98**	**998.46**
CONSTRUCTION	**112**	**-248**	**-2.21**	**1 850.68**
SERVICES	**3,575**	**- 8,566**	**-2.40**	**551.92**
Trade	136	-142	-1.04	775.70

[8] At Hardap Dam an amount of -N$ 990 784 was given as Scheme Allocation. This was more than the total depreciation of N$ 911 685 on whole scheme giving a surplus of N$ 704 000 on irrigation.

ECONOMIC SECTOR	NamWater: water supply and subsidy			National Water Productivity N$ Value Added / m^3 water used
	Volume, thousand m^3	User charges – Cost Subsidy = negative number Surplus= positive number		
		Thousand N$	N$/$m^3$	
Hotels & Restaurants	942	-430	-0.46	164.81
Transportation	220	-507	-2.31	1 771.61
Communication	1	2	1.63	7 816.60
Business services	30	-975	-32.50	1 681.43
Social services	2,246	-6,515	-2.90	45.19
GOVERNMENT	**1,602**	**-1,053**	**-0.66**	**234.16**
GDP/m^3 water, all uses	**66,659**	**-28,426**	**-0.43**	**57.23**
GDP/m^3 water, excluding agriculture				**203.76**

Note: households are omitted because they do not generate value-added.

The comparison in **Table 6.8** provides a useful indication of the relationship between subsidies/taxes and water productivity. In 2001, the largest amount of subsidy was received by Other mining, but its water productivity, N$52.72/$m^3$ water, was lower than the average for the economy, N$56.21. Other major recipients of subsidies from NamWater were in the service sectors, which had substantially higher national water productivity than the economy-wide average.

6.1.2 Municipalities

Windhoek is the only city which provided information and for which complete water accounts can be constructed. Windhoek's water usage is typical for a large city: no agricultural activity, and mining is limited to the head offices of rural mining operations; much of Namibia's manufacturing is located in Windhoek as well as a large share of its service industries. As the nation's capital, Windhoek also has the largest population.

Windhoek has a sophisticated water pricing structure of volumetric block tariffs and cross-subsidisation. Overall, Windhoek's water revenues exceed supply costs by about 11% of costs, with an average user charge per m^3 of N$7.34 and costs of N$6.59, but not all sectors pay the full cost of water (**Table 6.9**). Households pay 23% more than the cost of their water and this surplus subsidises some Manufacturing and Service industries. Low-income households are also subsidized, but the water accounts do not distinguish different categories of households at this time. Not all industries receive subsidies: subsidies are received by some of the most water-intensive industries including Food processing (Meat processing and Beverages but not other sectors), Trade, Hotels & restaurants, Business services, Social services (especially Schools and Hospitals) and Government.

Table 6.8: Water Use, Supply Cost and User Charges in Windhoek, 2001-02

Economic Sector	Volume, m^3	User charges, N$	Supply cost, N$	User charges –Cost, N$
Mining	8,871	59,306	58,494	812
Manufacturing				
Food processing	1,121,757	7,238,213	7,396,935	- 158,723
Other manufacturing	83,771	595,207	552,393	42,814
Utilities	88,184	552,124	581,491	- 29,368
Construction	49,140	324,076	324,030	47
Trade	405,172	2,653,944	2,671,728	- 17,784
Hotels & Restaurants	170,972	1,080,496	1,127,399	- 46,903
Transportation	97,679	653,540	644,104	9,435
Communications	10,900	73,594	71,873	1,721
Financial services	259,521	1,721,370	1,711,300	10,070
Real Estate and Business services	651,941	4,259,233	4,298,940	- 39,707
Community, social and other services	2,780,187	16,845,757	18,332,726	- 1,486,968
Government	1,354,976	8,467,005	8,934,802	- 467,797
Households (total)	10,029,688	81,148,629	66,136,389	15,012,241
Total	17,112,759	125,672,495	112,842,605	12,829,889
Average user charge, cost and subsidy, N$ per m^3		7.34	6.59	0.75

Note: The above figures are based actual expenditure to operate and maintain the water system including own production sources. The user charges reflect the billed accounts.

There is no detailed information available on the outstanding arrears on the water account only. According the Financial Statements of the City of Windhoek the outstanding debtors amounted to N$ 281.7 million for 2001/2002 and N$ 313.7 million for the 2002/2003 financial years. According to the Budget Services and Financial Statements Division of the City of Windhoek approximately 80 to 85% of this amount was with respect to service accounts including water services.

There is very little detailed data for the costs and user charges levied by municipalities available from the participating local authorities. The required information is normally summarised in the Financial Statements of the relevant Local Authority. In many cases local authorities are not up to date with the processing of their annual statements and the information is not readily available. The information as summarised in **Table 6.7** was recently (May 2005) obtained from the Audit Reports from the Office of the Auditor General. In some cases the volume of water billed was reported while in others it was not. This information is needed to provide an indication of cost recovery of the respective water accounts of some of the local authorities.

Table 6.9: Income and Expenditure on Water Supply in Municipal Areas for 2001/2002

Local Authority	Income (N$)	Expenditure (N$)	Surplus/Deficit (N$)	Surplus/Deficit Percentage
Grootfontein	4 243 699	2 278 472	1 965 216	86.3%
Henties Bay	2 231 206	1 262 942	968 264	76.7%
Karibib	1 637 421	2 14 878	(377 447)	-1.8%
Keetmanshoop	7 696 078	7 118 746	577 332	8.1%
Lüderitz	6 513 595	4 999 732	1 513 858	30.3%
Okahandja	5 775 398	5 317 938	457 460	8.6%
Omaruru	1 467 676	697 369	770 307	110.5%
Ondangwa	5 698 800	4 779 595	919 205	19.2%
Tsumeb	2 209 921	1 695 541	514 380	30.3%
Ongwediva	4 081 129	5 021 060	(939 931)	-18.7%
Oshakati	8 252 042	7 325 971	926 071	12.6%
Otjiwarongo	7 573 487	7 249 213	324 274	4.5%
Outjo	1 611 731	916 574	695 157	75.8%
Rehoboth	8 316 096	6 188 964	2 127 132	34.4%

From the information in **Table 6.7** it is clear that most of the local authorities aim to make a surplus on their water account. The self-providers make very high surpluses with Omaruru (110%) Grootfontein (86%), Outjo (76%) and Tsumeb (30%) amongst the highest 6. Henties Bay (76%), Rehoboth (34.4%) and Luderitz (30.3%) are the highest 3 of the Local Authorities that get water from NamWater. The figures in **Table 6.8** do not reflect the payment level of these accounts nor the outstanding arrears on the accounts. In a recent survey (2005) of a few local authorities it was determined that payment levels vary from 40 to 85% of the monthly accounts processed. With the installation of pre-payment water meters in some towns in 2004, income collected in many towns decreased to levels of approximately 10 to 15% of the real water consumption as a result of faulty pre-payment water meters.

There is no uniform national policy regarding end-use water tariffs in Namibia. In many of the villages the water is sold well below the NamWater tariff. In many cases the cost allocated to the rendering of water services is not clearly stated nor accounted for.

Most local authorities have volumetric pricing and may set different tariffs for domestic and commercial users. Rising block tariffs (whereby the unit tariff increases as the volume of water used increases) are applied by Windhoek, Swakopmund, Walvis Bay, Otjiwarongo, Tsumeb and Okahandja.

An important aspect of the water pricing policy at the municipal level is the effective collection of revenue. A number of towns are in arrears to NamWater for their bulk water purchases, due to failure to collect payments from local users. At this point in time, there is insufficient data to explore this issue for 2001/2002. It is suggested that as part of the updating of the accounts for 2003/2004, a more detailed investigation be done. The estimated figure for debt owed to local authorities in February 2005 indicated that the figure is for outstanding service accounts is well above N$ 400 million.

In future, it should be possible to create water accounts for all municipalities as their billing systems become fully computerized. At this point it is not possible to estimate whether or how water use could be subsidized in other municipalities except for Windhoek.

6.1.3 Self-Providers in Agriculture and Mining: Missing Data

As mentioned in earlier chapters and at the beginning of this section, some costs have not been estimated. There is no information about the costs of abstraction incurred by self-providers, so estimates were made, based on technical factors. The estimates were only made for groundwater abstraction, based on numbers of working boreholes, average depth, pumping capacity, etc. (see Chapter 3). However, the cost of abstraction by self-providers from other sources—perennial rivers, dams, and seawater—has not been estimated at all. **Table 6.10** indicates that these other sources of water account for a large share of self-providers' water, as well as national water supply.

Groundwater accounts for 40% of the volume of water abstracted by agriculture, and only 8% of water abstracted by mining, so the costs of the remaining 60% (agriculture) and 92% (mining) of water abstraction are not accounted for. How important are these omissions? As a share of national water volume, the 'missing' water accounts for 39% of all water abstracted in Namibia in 2001-02 (22% from agriculture and 17% from mining). However, in terms of water management, self-providers pay the full financial cost of abstraction, so there is no subsidy that encourages over-exploitation of resources.

Table 6.10: Abstraction by Self-providers in 2001-02

Source of Abstraction	Share of Sector's Water Abstracted	Sectors' Share of National Supply, Including Seawater
Self-providers, Agriculture		
Ephemeral-dam	10%	4%
Groundwater	40%	15%
Perennial	50%	19%
Recycled water		
Total	100%	37%
Total water volume abstracted	147 Mm^3	
Self-providers, Mines		
Ephemeral-dam	*	*
Groundwater	8%	2%
Perennial	1%	*
Recycled water	0	0
Seawater	90%	17%
Total	100%	19%
Total water volume abstracted	76 Mm^3	

* Estimated at less than 1% except for recycling of mine water from slimes dams

6.1.4 Costs and User Charges

Water accounts should be prepared not just in physical units but also in various types of monetary units as well: the cost of providing water to each sector, the tariff that is charged for water, and the subsidy, if any. The accounts for supply costs and revenues charged are not as complete as the water volume accounts. NamWater was able to provide complete information about amounts charged for all years, but information about costs only from 1999 onward. Costs incurred by RWS were also available only from 1999; no revenues are reported because RWS did not levy charges in 2001/2002.

The municipalities were not able to provide much information. Information supplied by the smaller municipalities for supply costs was available only for 2001/02 and even these were not complete. Only three municipalities were able to provide cost figures, Windhoek, Walvis Bay and Swakopmund. Information from other local authorities was compiled from the audits done by the Auditor General (Collected in ay 2005) and the information is not sufficient to do detailed cost accounts. Accounts for revenues charged have been constructed for all years from 1997 to 2001, but are not complete, particularly for earlier years. Supply costs for self-providers were estimated for all years but only for groundwater abstraction, not for abstraction from perennial rivers or dams (see Chapters 2 and 3 on methodology and data sources).

6.1.5 Affordability of Water Services

It known that the income distribution in Namibia is skewed. No information on income levels is available from the 2001 National Population Census. The Namibia Household Income and Expenditure Survey (1993/94) concluded that the arithmetical mean of the Household Income was N$ 17 198/a and the median annual value was N$ 6 161. The mean and median of the per capita income was N$ 3 031 and N$ 933 per annum, respectively. The mean values are high compared to the median, which illustrates the high income levels of a small percentage of the population ie. 5.3% of the population have more than 50% of the total income of private households. There is also a major difference between rural and urban income as well as between Windhoek, Swakopmund Walvis Bay and the other smaller towns.

The real bulk price of water increased well above the rate of inflation. Water is in general, affordable to commercial and industrial undertakings and to the middle and high income groups for domestic consumption. The cost of water to industry is normally small in comparison to their overall cost structure. Cost recovery from these groups is not seen as a problem.

Affordability is a major problem for low-income families. In two recent surveys done by WCE in Windhoek (2001) and Tsumeb (2002) informal settlements, the following conclusions were made:

- In the Otjomuise area (upgrading of services) approximately 80% of the households could afford to pay N$ 58.20/month (if it is accepted that a household should not pay more than 15% of its monthly income on land and services).
- The total average income per household in Soweto (Tsumeb) is N$ 754.35 per month. Male headed households have an average income of N$ 999.24 per month while female headed households average an income of N$ 634.55 per month. However a large proportion (64%) of the population has an income of between N$ 0.00 and N$ 400.00 per month. Only 16% of the households in Soweto have a positive Primary Household Subsistence Level (PHSL). In other words 84% of the formal households make a living below the poverty line.

The total cost of land and services in urban areas is made up of occupational rent (or mortgage repayments), water and sewer basic, water consumption, refuse removal and a general rates and taxes.

A guideline for water related services for low-income groups in urban areas is taken as 3% to 5% of their income. (water and sewer services). It was determined in Windhoek and Rehoboth that 32% and 27% respectively of the residential consumers use less than 15 m^3 water per month. Due to the income elasticity of demand most of these consumers using less than 15m^3/month could be regarded as low-income staying in low-income areas especially, in Windhoek.

The historic information for 2001/2002 is not regarded as relevant to 2005 and **Table 6.11** was compiled based on 2003/2004 and 2004/2005 tariffs (water and sewer services) for a family of 5 with different monthly water consumption in three different urban areas, based on their respective tariff systems.

Table 6.11: Comparison of Monthly Cost for Water Services for Low Income Households

	Windhoek		Rehoboth		Tsumeb	
Consumption (m^3/month)	**2003/2004 (N$/month)**	**2004/2005 (N$/month)**	**2003/2004 (N$/month)**	**2004/2005 (N$/month)**	**2003/2004 (N$/month)**	**2004/2005 (N$/month)**
3	63.07	66.27	18.07	21.46	78.15	85.96
6	75.61	80.52	62.64	47.92	79.82	87.80
9	96.37	104.25	67.21	74.38	88.82	97.70
15	138.10	151.71	116.35	127.30	106.82	117.50
20	180.54	199.05	188.80	206.40	128.77	141.65

Note: The amounts in **Table 6.11** represent the total monthly account for both water and sewerage services for a residential plot. The cost of other services (electricity, refuse removal and rates and taxes) are not included in the Table and amounts in many urban areas to more than N$ 200/month which put services out of reach of the poorer part of the community. Some towns provide standpipes and communal and/or dry toilets in settlement areas, which imply lower monthly costs to families staying in such areas.

The results in the table illustrate that low-income families or pensioners with an income of less than N$ 600/month cannot afford to use 6 m^3/month, which is regarded as baseline water for a urban family of 5 with full water services. There is not enough information available to do similar calculations for rural areas. The situation may be the same or even worse. The non-payment of accounts leads to a vicious circle, where both NamWater and local authorities need to increase their tariffs to compensate for non-payment of accounts. This practice makes services more unaffordable to the poor in Namibia. These facts illustrate the importance of a proper investigation and policy guideline to set equitable end-use tariffs for all consumers.

In a project funded by the Swedish International Development Cooperation Agency providing management assistance to Rehoboth Town Council the following results were achieved:

- Income from service accounts and repayment on outstanding debt by consumers was N$ 1.9 million more than the total billed accounts for services for the 2003/2004 financial year. Similar results were also achieved for the 2004/2005 financial year in Rehoboth.
- Outstanding debt to NamWater was reduced from N$ 6.2 million in March 2002 to N$ 2.6 million in March 2004
- With improved cash flow Rehoboth was put in the position to embark on capital project amounting to N$7.1 million in the 1994/95 Financial Year.

- Involvement of the community in the decision-making process of tariff setting and credit control, improved customer responsibility resulting in a better payment record for services rendered

6.2 WATER PRODUCTIVITY

Water productivity—a measure of the dollars of GDP generated per m^3 of water used—has declined slightly from N$ 59.5 in 1997 to N$56.2 in 2001. The decline is mainly attributable to agriculture and the rapid expansion of irrigated crop farming, which will be discussed in greater detail in Section 5.1.3. Agricultural water productivity has declined from N$5.5/$m^3$ to N$4.2/$m^3$ as summarised in Table 6.14. However, if agriculture is excluded and only the trends in non-agricultural sectors are considered, water productivity has increased over time, from N$194.2/$m^3$ to N$209.3/$m^3$ from 1997/98 to 2001/2002.

Table 6.12: Water Supply, Use and Water Productivity, 1997 to 2001

	1997/98	1998/99	1999/2000	2000/01	2001/02
Freshwater supply and use (Mm^3)					
Freshwater supply	276	272	295	311	318
Freshwater use	236	240	254	266	275
Losses & unaccounted for water	40	32	41	45	43
Population (million)	**1.6**	**1.7**	**1.7**	**1.8**	**1.8**
Per capita water use (m^3/person/ a)	141	142	146	149	148
Water Productivity (N$GDP per m^3 water used, GDP in constant 1995 prices)					
GDP (N$ million)	N$13,778	N$14,406	N$14,896	N$15,382	N$15,720
All sectors: $GDP per m^3 water	N$58.4	N$60.2	N$58.7	N$57.9	N$57.2
Agricultural productivity: N$ Agr GDP/m^3 Agr water use	N$5.4	N$5.6	N$5.5	N$5.2	N$4.5
Non-agricultural productivity: N$ Non-agr GDP/m^3 non-agr water use	N$193.3	N$185.3	N$207.6	N$209.5	N$203.8

Sources: Water: **Table 2.2**; Population from CBS, interpolated between 1991 and 2001; GDP from CBS, adjusted for the year used for water accounts rather than the calendar year used by CBS.

Figure 6.1 summarises these trends showing the index of the growth in freshwater use, per capita freshwater use, and water productivity both for the economy as a whole, and separately for the non-agricultural sectors. The index of growth of freshwater use has gone from 1.00 in 1997 to roughly 1.20 in 2001, meaning that total water use has grown roughly 20% over the 5-year period (increasing annually by 4.7%). Per capita water use has increased by 8% over the five year period, an annual increase of 1.6%. As discussed above, water productivity for the economy as a whole has declined, but if we look at the non-agricultural sectors separately, we see there have been gains in water productivity.

Figures at the national level, such as these presented in **Figure 6.1**, provide a short-term indicator of macro-economic efficiency of water use, and declining water productivity (N$GDP/$m^3$ water) is usually interpreted as an undesirable trend. However, such indicators are subject to several caveats)

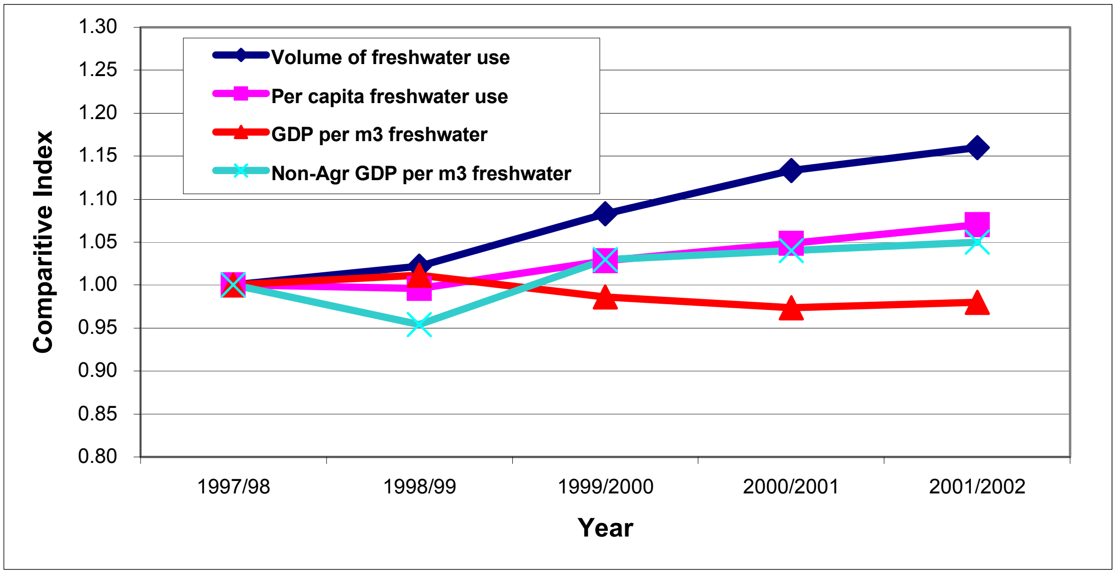

Figure 6.1: Index of the Growth of Water Use, per Capita Water Use and Water Productivity, 1997/98 to 2001/02 (1997/98) = 1.00

Indicators of water use and productivity are useful only when assessed against the available supply. Declining water productivity is not necessarily a problem, if the economy and water use has grown by employing underutilized water resources, such as underutilized water and land along perennial rivers. Long-term, water availability[9] in Namibia has been estimated at 660 Million m^3 per year, roughly double present levels of abstraction (Christelis and Struckmeier, 2001,). However, from a long-term perspective, such trends should be viewed with caution, because of the danger of 'locking into' inefficient uses of water through investment and infrastructure development that cannot easily be changed in the future when competition for scarce water increases. This is especially true for fossil groundwater.

6.3 Water Productivity and Economic Benefits of Water Use by Sector

In a water-scarce country, the provision of water must always be considered in terms of the socio-economic benefits a particular user contributes. It is not easy to measure a precise economic value for water, but there are two commonly used indicators of the socio-economic benefits from water use: national income and employment in each sector relative to the water it uses. National income is measured as value-added, a sector's contribution to GDP. In many countries, "environmental-economic profiles" are constructed that compare the percentage use of water by a sector to its percentage contribution to national

[9] Water availability was not precisely defined in the source document.

income and employment. Environmental-economic profiles can be quite useful in comparing the allocation of water across sectors, and in "benchmarking" company or industry performance. Benchmarking tells an industry whether it is improving its water efficiency over time, how it compares to other industries, how it compares to the same industry in other countries, and can be used by individual companies to see how they compare to the average performance for their industry.

Table 6.12 presents the socio-economic profile for water in 1997/98 and 2001/02. Of the major sectors, Agriculture, using 75% of all water in 2001/02, contributed only 7% of national income (value-added) and 24% of employment. The socio-economic contribution of Agriculture—in terms of income and employment—appears to be the lowest of all sectors relative to the share of water it uses. This sort of imbalance between water demand and socio-economic benefit is seen in many countries, due to the nature of agriculture as a water-intensive activity. However, the employment figures understate the social importance of agriculture because many people who rely on subsistence agriculture have no alternative source of livelihood. Commercial agriculture also supports a sizable downstream food processing industry, which generates additional income and employment. Furthermore, in some parts of the country, agriculture may represent the highest value local use of water, where other economic activities are not feasible. For example, Mining generates more income than agriculture, relative to the water it uses, but opportunities for Mining are limited by the availability of profitably exploitable reserves. Regional water accounts would provide a more realistic tool for assessing options for water management and allocation.

Mining makes a strong economic contribution in terms of income (9%) relative to its water use (2%), but not employment (1%). All of the remaining sectors account for higher shares of income and employment compared to their shares of water used. The socio-economic contribution is especially high for services.

Table 6.13: Percent Contribution by Major Economic Sector to GDP, Employment and Water Use 1997/98 and 2001/02

Economic Sector	1997/98		2001/02		
	% of GDP	% of water use	% of GDP	% of water use	% of employment
Agriculture	7%	72%	6%	74%	24%
Commercial agriculture	4%	47%	4%	49%	7%
Communal agriculture	3%	25%	2%	24%	17%
Fishing	4%	*	4%	*	2%
Mining	8%	4%	7%	3%	1%
Manufacturing	11%	3%	11%	2%	5%
Total for Food processing	8%	1%	7%	1%	2%
Other Manufacturing	3%	1%	4%	1%	4%
Utilities + Construction	4%	*	5%	*	7%

Economic Sector	1997/98		2001/02		
	% of GDP	% of water use	% of GDP	% of water use	% of employment
Services	26%	3%	27%	3%	45%
Trade, hotels & restaurants	11%	1%	11%	1%	13%
Transport & communication	6%	*	8%	*	4%
Finance & business services	7%	*	8%	*	11%
Social services	1%	1%	1%	1%	17%
Government	22%	6%	21%	5%	15%
Total	82%	87%	82%	88%	100%

*less than 1% Note: Percentage of GDP in constant 1995 prices. The above table excludes the contribution from owner occupied houses and taxes less subsidies.

Water use does not sum to 100% because of water use by households.

Source: Water data from appendix tables; GDP from Central Bureau of Statistics, and employment data from Ministry of Labour, Labour Force Survey 2000

It is difficult to use all the figures in **Table 6.12** to compare the performance of industries over time, so another indicator is often used: water productivity. Water productivity is the ratio of the value added from each sector divided by the water use in each sector. For this comparison, the value-added for both years is given in the same year's prices, 1995 prices, in order to adjust for inflation, which would otherwise bias the comparison in favour of 2001/02. Overall, the economy is producing less national income for a given amount of water in 2001/02 than in 1997/98: the value fell from N$59 to N$56 per cubic metre of water used (**Table 6.13**).

As mentioned at the beginning of this chapter, a decline in water productivity is usually not taken as a positive development. Improvements in water productivity are achieved by forces operating at different levels of the economy. At the level of the company or farm, companies can take measures to conserve water, producing the same quantity of output, but with less water. At the sectoral level, water productivity is improved as many companies or farms introduce water-conserving measures, or switch to products that are either higher-value (grapes instead of maize) and/or less water intensive (maize instead of lucerne). At the macro-economic level, water efficiency is achieved by directing production toward those economic activities that generate higher value-added per cubic meter of water used—for example, manufacturing and services instead of agriculture. This improvement in water productivity is the result of structural change in the economy. Over time, water efficiency can be improved in all ways: farmers and companies within each industry need to conserve water and the national development strategy should promote less water-intensive industries.

Table 6.14: Freshwater Contribution to National Income by Economic Sector in 1997/98 and 2001/02

Economic Sector	GDP (N$ million) and N$ Value-added per m^3 of water used (constant 1995 prices)			
	GDP (N$ Million)		Value Added (N$/$m^3$)	
	1997/98	2001/2002	1997/98	2001/2002
AGRICULTURE	**922**	**918**	**5.44**	**4.54**
Commercial agriculture [(a)]	**512**	**623**	**4.67**	**4.61**
Commercial Crops	50	59	0.58	0.55
Commercial Livestock	404	485	16.99	18.44
Communal agriculture	**410**	**296**	**6.87**	**4.41**
Communal Crops	-22	-17	-0.69	-0.49
Communal Livestock	432	313	15.84	9.92
FISHING	**490**	**649**	**14 353.02**	**939.04**
MINING	**1 138**	**1 162**	**130.30**	**127.20**
Diamond Mining	785	838	779.19	891.14
Other Mining & Quarrying	353	324	45.72	39.58
MANUFACTURING	**1 477**	**1 697**	**255.69**	**260.62**
Total for Food processing	**1 051**	**1 133**	**351.75**	**314.31**
Meat Processing	94	108	77.91	77.70
Fish Processing on shore	286	199	423.75	218.38
Beverages	298	504	316.01	451.48
Other food processing	374	323	2 209.32	1 645.87
Other manufacturing	427	566	153.12	194.67
Textiles	15	20	82.52	153.19
UTILITIES	**216**	**229**	**1 077.84**	**998.46**
CONSTRUCTION	**381**	**510**	**1 921.43**	**1 850.68**
TOTAL FOR SERVICES	**3 623**	**4 373**	**516.93**	**551.92**
Trade	1 270	1 513	745.71	775.70
Hotels & Restaurants	262	298	149.79	164.81
Transportation	638	753	1 731.16	1 771.61
Post and Communications	299	477	4 992.49	7 816.60
Financial, Business services and Real Estate	1032	1198	1 717.19	1 681.43
Social services	122	134	48.25	45.19
GOVERNMENT	**3 000**	**3 313**	**211.05**	**234.16**

Economic Sector	GDP (N$ million) and N$ Value-added per m^3 of water used (constant 1995 prices)			
	GDP (N$ Million)		Value Added (N$/$m^3$)	
	1997/98	2001/2002	1997/98	2001/2002
ECONOMY-WIDE AVERAGE:				
GDP/m^3 water, all uses	**13 778 [(b)]**	**15 720 [(b)]**	**58.42**	**57.23**
GDP/m^3 water, excluding agriculture	**12 857**	**14 802**	**193.30**	**203.76**

Notes: (a) Amounts of N$ 59 million and N$ 78 Million for 1997/98 and 2001/2002 respectively was generated through own construction, other animal products and forestry within the commercial agriculture sector. It was not possible to allocate specific water consumption to these activities. (b) In the total GDP figures amounts of N$ 648 million and N$ 718 million and N$ 1 745 million and N$ 1 994 million were added for Owner Occupied Dwellings and Taxes less Subsidies on Products respectively for 1997/98 and 2001/2002. For 1997/98 the GDP figures for the 1997 calendar year were used and for 2001/2002 the 2001 calendar year. It was not possible to allocate specific water use to these activities.

Source: Water data from sources described in the text; value-added data from the Central Bureau of Statistics, adjusted for the water accounts' year.

6.3.1 Water Productivity in Agriculture

Agriculture is particularly important in determining water productivity because it accounts for 72% of all water use. In Agriculture, the economic contribution of water per cubic metre of water declined between 1997/98 and 2001/02 from N$5.44 to N$ 4.54. This change can be ascribed to two factors: a decline in the value of Communal Agriculture (from N$ 6.87 to N$ 4.41 per cubic metre) and an increase in the share of irrigated crop production in agricultural output, both commercial and communal. The decline in Communal Agriculture resulted mainly from a large decline in the number of livestock, which is represented in the national accounts as a loss of inventories but it is considered likely that this figure will recover in the future. This increased the share of irrigation in Communal Agriculture (negative contribution to GDP as result of subsidies), which has lower water productivity (negative) in comparison with livestock.

Within Commercial agriculture, water productivity increased for both subsectors: crops and livestock. If the relative shares of crop irrigation and livestock had remained the same, average productivity of Commercial agriculture as a whole would have risen. However, water productivity for Commercial agriculture fell because the share of irrigation in agricultural water use increased substantially over livestock watering. Even after improvement, irrigation water productivity is still so much lower than livestock water productivity that the rising share of irrigation served to reduce average water productivity for Commercial agriculture.

The discussion on irrigation that follows was summarised from a recent study done in South Africa (Louw, 2003) on the development potential along the Orange River. The following information was collected in a survey of 168 selected farms along the river. The river was divided in six river stretches with different crop types produced within the specific area. The predominant crops for the selected river stretches are summarised in **Table 6.15**.

Table 6.15: Summary of River Reaches and Percentage Predominant Crops for Each Irrigation Area Surveyed

Region/ Farms	Grapes Table	Grapes Dry	Grapes Juice	Grapes Wine	Lucerne	Other
Augrabries Blouputs (AugBlou) (16 farms)	67.2%	27.5%	0.3%	2.5%	2.3%	
Kakamas (46 farms)	26.0%	43.0%	2.0%	11.0%	-	2%
Upington Keimoes (UpKeim) (15 farms)	27.0%	36.0%	2.0%	15.0%	16.0%	4.0%
Crop types	**Maize**	**Wheat**	**Lucerne**	**Vegetables**	**Grapes**	**Other**
Boegoeberg (Boegoe) (39 farms)	11%	18%	9%	27% T	6% T 28% D 8% J	5% (cotton)
Prieska De Aar (PD) (34 farms)	46%	50%	2%	1%		1%
Vanderkloof/Hopetown (VdKl-HT) (29 farms)	43%	46%	4%	3%		4%

Note: T=table d=dry j=juice w=wine

Table 6.16 represents some of the gross margins of existing crops in the region. For the purpose of analysis, it was assumed that the gross margins for all the regions are the same and that other factors (e.g. farms size, economies of scale) are responsible for differences in financial results. It is clear that the gross margin per m^3 water requirement are substantially higher for table grapes followed by red wine and dry grapes. Readers should be aware that from a water allocation policy (for regional economic planning) point of view this is the wrong criteria to be used, since gross margin analysis gives only an indication of the economic contribution of crops in an irrigation region. It is of paramount importance that the forward and backward economic linkages (that may be substantial) of irrigation crops to the rest of the economy should also be considered. This can only be determined through a well-developed and calibrated SAM for specific regions.

Table 6.16: Gross Margin/Ha/m^3 Estimates

Crop	Yield (ton/ha)	Price/ unit	Gross income	Production costs	Gross margin	Water required (m^3/ha)	GM per m^3 (R)
Red wine	15	1200	18000	8254	9745	1472	6.6
White wine	25	600	15000	8453	6546	1472	4.4
Juice grapes	24	460	11040	7653	3386	1472	2.3
Dry grapes	25	850	21250	12221	9028	1472	6.1
Table grapes	15	8300	124500	79901	44598	1350	33.0
Lucern	18	500	9000	5652	3347	1477	2.3
Wheat	5	1400	7000	4363	2636	527	5.0
Maize	7	1300	9100	5380	3720	880	4.2
Oats	5	1300	6500	4062	2437	880	2.8
Cotton	3	2800	8400	5674	2725	1125	2.4

GM= Gross margin

Table 6.17 represents some economic parameters for the various regions and indicates the Gross Income (GI), Direct Allocateable Costs (DAC) and Net Disposable Income (NDI). The reader should note that depreciation is not accounted for in the calculations below, since the survey did not collect adequate information for accurate depreciation calculations.

Table 6.17: Economic Indicators

Item	VDKL-HT	PD	Boegoe	Upkeim	Kakamas	AugBlou
Long-term crops (ha)	546	430	1324	994	2003	1046
Short-term crops (ha)	10252	15907	669	20	49	0
Total irrigated (ha)	**10798**	**16337**	**1993**	**1014**	**2051**	**1046**
Capital investment per ha irrigated (R)	**47782**	**48475**	**55395**	**143772**	**161549**	**205605**
Gross income (R/ha)	12255	11978	17002	38168	41657	91034
DAC (R/ha)	7279	6389	9905	24044	24553	44199
Total gross margin (R/ha)	4976	5589	7097	14124	17104	46834
Overheads (R/ha)	2946	3330	3787	6633	7400	24793
NDI (R/ ha)	**2030**	**2259**	**3310**	**7491**	**9703**	**22042**
Water use (m^3 ha)	11000	10000	15000	15000	15000	15000
NDI (R/m^3)	**0.18**	**0.23**	**0.22**	**0.50**	**0.65**	**1.47**

It is clear that the capital investment per ha irrigated is approximately the same in the Vanderkloof and Douglas Prieska (PD) regions where the same crops are produced. The capital investment per ha increases substantially as the area under long-term crops in general and table grapes specific, increases. Also, the NDI per ha are more or less the same for the Vanderkloof and PD regions (same crops). The NDI per ha increases slightly as the area under long-term crops increases and substantially in the Augrabies Boegoeberg region where 67% of the area are utilised for table grape production. Also, the NDI per volume of water used are more than double in the Upington-Keimoes region compared to the upstream parts of the River. In the Augrabies Blouputs region the NDI per ha is almost three times higher than in the Upington-Keimoes region.

It was also determined that the labourer requirement per ha increases substantially from Vanderkloof to Augrabies Blouputs. Both seasonal and permanent labour requirements increase and are summarised in **Table 6.18**.

Table 6.18: Employment Comparison between the Different Regions

Item	VDKL-HT	PD	Boegoe	Upkeim	Kakamas	AugBlou
Number of permanent labourers	337	302	339	444	896	904
Seasonal - permanent equivalent labourers (240 days)	437	180	666	1025	1565	1292
Total labour (casual plus permanent)	774	482	1005	1469	2461	2196
Labourers per ha irrigated	0.07	0.03	0.50	1.45	1.20	2.10

In evaluating water use in primary economic activities such as Agriculture, it is useful to consider the entire 'value-chain,' ie. is the 'upstream' and 'downstream' activities, which are linked as suppliers of inputs to, or users/processors of output from the primary activity. In the case of Agriculture, the most important linkage is the 'downstream' processing of agricultural products, primarily Livestock. To undertake a more comprehensive assessment of Livestock farming, it would be necessary to compare the combined value-added from both stages (Livestock farming and Meat processing) to the combined water used in both stages.

To undertake a more comprehensive assessment of Livestock farming, it would be necessary to compare the combined value-added from both stages (Livestock farming and Meat processing) to the combined water used in both stages. For Livestock, the combined value-added in 2001/2002 is N$593 million (N$485 million from Livestock farming and N$108 million from Meat processing). The combined water use was 27.7 Mm^3 (26.3 Mm^3 for Commercial livestock and 1.4 Mm^3 for Meat processing). This yielded a GDP/m^3 water of N$ 21.40. This figure is about 16% higher than commercial Livestock alone, but still less than half the economy-wide average.

6.3.2 Water Productivity in Non-agricultural Sectors

The decline in water productivity at the macroeconomic level is not reflected in all sectors and in many non-agricultural sectors water productivity increased. The non-agriculture GDP per cubic metre of water input actually increased 8% from N$157 to N$170. Improvements in water productivity occurred in Mining (26%), Services (5%), and Government (11%). In Manufacturing the decline was very small; in fact, water productivity improved in all sub-sectors except Fish processing, where the decline in water productivity decreased down the average for the sector.

6.4 INTERNATIONAL COMPARISONS:

6.4.1 Water Use in Namibia, Botswana and South Africa

Botswana constructed water accounts for the period 1993-1998 (Lange et al., 2002), which have recently been updated to 2000. Crafford et al. (2001) constructed water accounts for South Africa in 1998 and Statistics South Africa recently compiled water accounts for 2000 by South Africa's 19 water management areas (Statistics South Africa, 2004).

The first cross-country comparison among Namibia, Botswana and South Africa based on the water accounts was reported for 1996 in (Lange et al. 2003), based on the first water accounts for each country:

- Namibia, 1993 and 1996 by (Lange, 1997; Lange et al., 2003)
- Botswana, 1993-1998 by (Lange et al., 2002)
- South Africa, 1991-1998 by (Crafford et al. 2001)

The accounts have since been updated in each country. The effort in Namibia, covering the period 1997 to 2001, is discussed in this report. Botswana's water accounts were recently updated through 2001 by (Arntzen, 2004), and Statistics South Africa compiled water accounts for 2000 by South Africa's 19 water management areas (Statistics South Africa, 2004).

The new accounts for Namibia and Botswana provide accounts for water use and supply by detailed economic sector, supply institution and natural source. The accounts for South Africa, however, do not provide much information about sectoral use and includes only 10 sectors:

- Irrigation agriculture
- Livestock (except stock watering is partly included under Rural requirements)
- Afforestation and alien plants
- Fisheries
- Energy
- Mining and heavy industries (all industries that are not located in urban areas)
- Water utilities
- Sewerage

- Households (urban)
- Urban requirements for commercial/industrial users
- Rural requirements for domestic use, livestock watering and rural economic activities

This classification does not correspond to the classification used for economic accounts, so the water accounts cannot be easily linked to economic information for policy analysis. By contrast, the end-users in the water accounts for Botswana and Namibia are classified according to the classifications in the national economic accounts so they can easily be linked to economic data for analysis. Since all countries use a similar classification system for economic accounts, the Botswana and Namibia water accounts can also be readily compared.

Consequently, only macroeconomic indicators can be constructed for South Africa, such as economy-wide water productivity.

6.4.2 Lessons from Australia

In Australia, where water scarcity may create hardship in certain areas, they are actively pursuing water demand management and water reuse within all the sectors. They aim to produce statistics on an annual basis for all the sectors with updated accounts every 4 years.

They identified the agricultural water use, industrial use, energy and gas, as well as residential water consumption, as their main focus areas that consume approximately 90% of the water consumption in Australia. Agriculture used approximately 66% of the total water consumption in 2000/01 and much effort was put into this sector to increase water use efficiency, as well as the production of higher value crops. The contribution to the GDP of irrigated agricultural production increased with 32.5% from 1996/97 to 2000/01. (Vardon & Peevor, 2004)

The approach in Australia may be worthwhile to explore by issuing statistical information on the main sectors and a formal updating of the accounts every 4 years, instead of trying to create a continuous series of NRA on an annual basis.

6.5 IMPROVEMENTS OF THE WATER ACCOUNTS

Water use is increasing more rapidly than population or GDP growth due to the growth of water-intensive sectors, mainly crop irrigation. As mentioned in the introduction, increasing water use is not a negative development if it is based on utilization of new or underexploited water resources to generate income. This trend needs to be evaluated against the long-term sustainable supply of water by region to assess the extent to which this trend can continue before it poses a serious challenge to Namibia’s water resources.

Water productivity for most sectors has been increasing—even for crop irrigation. For a few sectors such as communal agriculture, fishing (inland aquaculture) and fish processing, water productivity has declined significantly.

The increase in water productivity is a positive trend, but it would be useful to verify that this trend is occurring in all regions for all subsectors. Better information is required from

Municipalities concerning the sectoral use of water to verify this trend and to assess the potential impact of Water Demand Management. At present, actual figures for sectoral water use for more than one year are only available for a few Municipalities, because the billing system used by most Municipalities does not save data for more than a year. The billing system should be changed so that a consistent time series can be constructed at regional level.

Declining water productivity in communal agriculture has resulted from an increase in irrigation schemes, mainly oriented toward commercial, rather than subsistence production.

The economic data used to calculate water productivity is not very reliable for some sectors, especially at the very detailed level. If there is uncertainty about both the water use data and the economic data, the trends in water productivity will not be very meaningful. The national accounts should be expanded and its data collection activities should be strengthened. (Suggestions for these improvements were discussed in the report on the Namibian Social Accounting Matrix (Lange et al., 2004).

There are many areas in which the water accounts can be improved, and the priorities should be based on policy needs. The discussion of policy implications above, and the data gaps identified during that discussion, can help set priorities which should include:

- Improving the water accounts for agriculture: more reliable information is needed for the annual amount of water abstracted by both NamWater and self-providers, areas under irrigation for each crop, irrigation methods and crop yields.
- Irrigation warrants more detailed studies to determine more detailed figures linked to crop types for value added, including value added through the supply chain through agro-industry.
- Improving the water accounts for all Self-Providers, most of which fall into the agriculture sector, as discussed above, but there are several additional categories of Self-providers that are not well covered at all, notably Construction, Tourism and inland Aquaculture.
- Improving water accounts for Municipalities. Given the current accounting systems used by most Municipalities, the only method of determining time trends is to collect the data every second year, before they are deleted. Also, DWA economists should work more closely with the data services company providing the data, to ensure that the end-users are being correctly classified by industry corresponding to the economic accounts.
- Completing the monetary accounts including costs of supply and user charges. Water pricing and end-use tariffs is an important component of the incentives for economic development, which are appropriate both in terms of the type of economic activity and its geographic location. At a minimum, annual Financial Statements are required for all Local Authorities.
- Compiling water accounts by region (river basin or water management area) is an important long-term goal provided that the economic figures are also segregated by the National Planning Commission. Factors such as population,

economic activity and land use increase normally water use, but they are often concentrated in specific areas rather than distributed evenly across a country.

- Similarly, the availability of water resources varies enormously across the country. National trends in water use, water productivity and cross-subsidies do not provide an accurate picture of regional water use and scarcity. Water planning should be based at the regional level, and would benefit from water accounts compiled at the regional level.

Given the economic importance of these sectors as potential sources of economic growth it is important to target them. By better understanding water use in these sectors, policies and actions to improve water efficiency can be designed.

It is suggested that annual statistical information on the main sectors Agriculture (74% of the use) with emphasis on Irrigation (57%), Mining (2%), Urban[10] distribution be complied and that the formal updating of the NRA accounts be done every 5 years, instead of trying to create NRA on an annual basis.

[10] Residential, Government, Industrial etc

7 POLICY IMPLICATIONS FOR NAMIBIA

Water accounting is particularly important for countries such as Namibia, where increasing water scarcity and mounting water supply costs make it imperative to use the available resources sustainably, equitably and efficiently. A discussion of the use of Water Accounts for water management is provided in the UN's draft Handbook on Accounting for Water (UN, 2004). Water accounts can assist policy makers to monitor resource trends, resource allocation and user efficiency, which are important government responsibilities under the New Water Act. Water accounts also provide a valuable tool in the planning process, because they can be used with economic models to calculate, for example, the water requirements for long-term development plans such as Vision 2030 and the Green Scheme, as well as medium-term plans such as the NDPs.

Section 7.1 discusses the contributions Water Accounts can make to the implementation of the New Water Act and to achieve the goals of Vision 2030 with respect to water. It then goes on to highlight key results and their policy implications, as well as identifying areas where future work is needed to improve the usefulness of Water Accounts.

7.1 WATER ACCOUNTS, THE WATER ACT AND VISION 2030

The Water Act and Vision 2030, a long-term development plan, address water management in considerable detail. Both start off by "…recognizing the economic value of water and that its abstraction, use and management must be efficient, cost-effective and promote equitable and sustainable socio-economic development." (Preamble to the Draft Water Bill). By providing an economic tool for water management, water accounting can contribute to implementing the New Water Act and achieving Vision 2030.

Chapter Eleven of the New Water Act outlines the Minister's responsibility to ensure water use efficiency and conservation. One of the major responsibilities is to identify appropriate economic instruments to promote efficiency and water conservation. In the chapter addressing internationally shared water resources, the Minister is charged to collect information about the quantity of water abstracted, the nature and economic value of its use, the number of people depending on the water and likely future water demands. This information is exactly what water accounts are designed to provide. Regarding future water demands, the water accounts can be linked to an economic model to calculate such demands.

Vision 2030, recently adopted by Cabinet, is quite specific about the goals Namibia wants to achieve with respect to water and what should be done to achieve these goals as well as what should be avoided. Vision 2030 recommends, among other things, adopting a stricter economic approach to water pricing to encourage all sectors to use water as efficiently as possible. Achieving this requires:

- Promoting high value-added economic uses for water (e.g. nature centered low-impact tourism and high value crops such as grapes, dates and olives) and the importation of low-value, water-intensive goods such as lucerne or maize.

- Abolishing subsidies for water that encourage water wastage, and ensuring the full recovery of water supply costs in urban and rural areas subject to equitable access to water by both the urban and rural poor through a system of cross-subsidisation within the water sector.
- Implementation of Water Demand Management approaches and more efficient end-use technology (e.g. reduction in of non-revenue water, improved irrigation technology, reuse of water in the mining sector)
- Discouraging domestic production of low-value, water-intensive cash crops in favour of imports by charging a management fee for “free” water.
- Adopting tools such as Natural Resource Accounting and Strategic Environmental Assessment to help guide policies regarding future water use and prevention of degradation of freshwater ecosystems.

Efficient and sustainable water management primarily requires information about the amount of water used by each sector of the economy, and the natural source of that water, information that is provided by the water accounts. The advantage of water accounts over other databases about water use is that the water accounts are linked to the economic accounts. This is critical for water management because the pressure on water resources comes mainly from use for economic activities and domestic requirements.

The water accounts provide a ranking of sectors according to the sectoral value-added per cubic metre of water used, or sectoral employment per cubic metre of water. Linked to a multi-sectoral economic model based on the Namibian Social Accounting Matrix (SAM), the water accounts can further calculate how much the economy would benefit from a development strategy that encourages growth of high value-added, low water intensity sectors, and what it would ‘cost’ if such a strategy were not pursued. Benefits would include national income generated, employment created, effect on balance of payments, and water saved relative to current usage. Similarly, analysis of Water Demand Management and water efficient technologies can be analysed within this framework.

The water accounts provide a comprehensive accounting for losses in the system, which in some instances can be reduced to increase supply efficiency.

The water accounts also clearly identify water subsidies by sector and, when linked to the SAM model, can calculate the impact on the economy of removing such subsidies.

7.2 PRIORITIES FOR FUTURE WORK

With the implementation of the New Water Act regulations are required to regulate various activities within the water sector. The information collected and analysed for the NRA identified important issues for more detailed attention to fulfil goals set in Vision 2030, NDP 2 and the Green Scheme.

7.2.1 Costing, Tariffs, Subsidies and Credit Control

Many local authorities allocate cost for the provision of water services on an ad hoc basis with no relevance to the real cost to provide water services. It seems that no or little provision is made for proper maintenance of water networks and water meters especially in smaller local authorities. In many cases the cost allocated to the rendering of water services is not clearly stated nor accounted for. NamWater is in the process to review their cost allocation system. In the existing system there seems to be many deficiencies on the allocation of depreciation, capital redemption cost and allocation of overheads. Clear policy guidelines are required.

Water supply in Namibia is based on full cost recovery principles, ie. it is accepted that water is an economic commodity. There is no subsidy from the Government through the social security system to provide water related services to the urban or rural poor except for support services by RWS. If cross-subsidisation is being considered, then a system needs to be put in place, which is able to identify and assist only the truly needy, if economic efficiency is to be achieved. In this respect it must be remembered that water is a commodity, common to all. This implies that it has a social element and that there is a concomitant social responsibility to make water available to needy groups for basic needs.

Some end-users receive considerable water subsidies, while others pay charges in excess of supply costs. Among NamWater's customers, Municipal Authorities and RWS pay user charges in excess of costs, which offset, in part, subsidies to mining and other end-users, especially rural households and social services. In Windhoek, middle and high-income households pay excess charges, which offset subsidies to government, schools, social services and low-income households. In Windhoek wet industries are also subsidised. At this time the extent of cross-subsidisation between different groups of households cannot be determined from the water accounts. The intention in both Windhoek and Rehoboth is to subsidise low -income households to make baseline water (40 litre/person/day) available at a lower price. Subsidies for groundwater use in rural areas (RWS) exceed those for all other water sources. Subsidies for water that encourage water wastage need to be abolished. Instead full recovery of water supply costs in urban and rural areas needs to be implemented while providing equitable access to water by both the urban and rural needy through a system of cross- subsidisation within the water sector and/or through a direct subsidy to needy families.

As stated earlier with the comparison of water services tariffs for three urban areas low-income families, under employed individuals or pensioners with an income of less than N$ 600/month cannot afford to use 6 m^3/month, which is regarded as baseline water for a urban family of 5 with full water services. There is also no similar information available to do similar calculations for rural areas. The situation may be the same or even worse. Efforts by NamWater and Local Authorities to compensate for non-payment worsen the situation by making water services even more unaffordable to the needy families in Namibia.

There are no uniform national guidelines regarding NamWater and end-use water tariffs in Namibia. In many of the villages the water is sold well below the NamWater tariff. A tariff policy for both NamWater and End-users (taking ability to pay and equitable access into account) needs to be compiled as a matter of urgency.

An important aspect of the water pricing policy at the municipal level is the effective collection of revenue. A number of towns are in arrears to NamWater for their bulk water purchases, due to failure to collect payments from local users. At this point in time, there is insufficient data to explore this issue for 2001/2002. It is suggested that as part of the updating of the accounts for 2003/2004, a more detailed investigation be done. The estimated figure for debt owed to all local authorities (including Windhoek) in February 2005 indicated that the figure for outstanding service accounts was well above N$ 400 million. Proper policy guidelines for credit control are required to change the culture of non-payment taking social and economic conditions into account. Experience in Rehoboth demonstrated that it is possible to change a culture of non-payment provided that equitable tariffs are developed through community involvement in combination with the implementation of a fair credit control policy.

7.2.2 Regulation of Service Providers and Self Providers

The water accounts provide some information about the efficiency of water supply in terms of losses and allocation among end-users, but cannot be used to determine whether the supply of water is managed efficiently. Management and supply costs are special concerns for monopolies like NamWater or local Municipalities that are not subject to competition. More transparent information about supply costs and pricing calculations would assist in allowing independent assessment of the efficiency of these monopolies.

As from 2001, Self-providers (mainly stock farming, irrigation and mines) surpassed NamWater as the largest abstractors of water, accounting for 44% of all water abstractions. Given the very large amount of water used, it is critical for policymakers to obtain accurate figures for water abstractions by Self-Providers and the purposes for which the water are used. This will assist generally in water planning and especially for Water Demand Management.

National Regulations are required for regulation of service providers including self-providers to report key operational information/data to the MAWF to ensure a high level of service and sustainable use of water resources.

7.2.3 Aquaculture Water Use

Freshwater aquaculture has been identified as a sector with high-growth potential so monitoring water use should be a priority. In the past few years aquaculture has developed near Hardap Dam and is now a major user of water. Ponds for aquaculture have also been established in the northeast, but no figures on water use are currently available. Economically, freshwater aquaculture is still quite small compared to marine fishing but it is as water intensive as crop irrigation. Most of the implemented schemes require a daily input of 10 to 15% fresh water relative to the storage in the pond. The overflow is normally used for small-scale irrigation schemes provided that the effluent is suitable for irrigation. Reuse of water within the ponds requires expensive filtration systems and is only applied in a few small-scale operations.

7.2.4 Agricultural Water Use

Agriculture has increased its share of water use from 71% in 1997-98 to 74% in 2001-2002. In 1993, agriculture was estimated to account for only 64% of total water use. The highest growth occurred in the irrigation, which consumed 56% of the total water abstracted in 2001/2002. Stock farming consumed 18.3% of the water abstracted in 2001/2002. Most of the growth in water use is due to the rapid expansion of land under irrigation. This has caused a decline in water productivity ie. value of national income generated by a cubic metre of water.

The impact of agricultural policies on water use and poverty should be assessed. A case study in the mid-1990's by MAWRD determined that local maize price determination mechanism had a negative effect on poor households. This study should be linked to water use and extended to all agricultural polices. However, this should also take household and national food security into account.

For informed decision making with the implementation of the "Green Scheme" information on the expected gross margin of crops, Net Disposable Income and number of permanent and seasonal workers needs to the assessed. In evaluating water use in primary economic activities such as Agriculture, it is useful to consider the entire 'value-chain', ie. the 'upstream' and 'downstream' activities, which are linked as suppliers of inputs to, or users/processors of output from the primary activity. In the case of Agriculture, the most important linkage is the 'downstream' processing of agricultural products (agro-industry).

Information collected including access to international data banks should be accessible through internet as well as though the Agronomic Board and the office of the "Green Scheme".

The following information was identified to collect more detailed analyses to asses and improve the performance of Irrigation Sector in future:

- assessing the impact of higher fixed maize prices on poor households, taking household and national food security into account
- collecting and processing information on gross margins, net disposable income, and the number of seasonal and permanent job opportunities provided by different crop types
- determining the effect of the entire value chain by including the effects of the agronomic industry
- training of farmers, distribution of information including access to international data, through the Namibia Agronomic Board and the offices of the Green Scheme
- addressing proper irrigation scheduling, water metering (after detailed investigation), appropriate water pricing and installation of water efficient irrigation systems
- establishment of a website to make information easily available to irrigation farmers

7.2.5 Water Demand Management Initiatives

Losses for NamWater appear to be quite low, but losses are much higher for most Municipalities. Local authorities distributed approximately 23% of the water abstracted in 2001/2002. Municipalities with non-revenue water of 20% or higher account for 37% of Municipal water distribution, while 7 towns have non-revenue water over 60%. Reduction of non-revenue water is clearly a priority, especially for those towns with very high system losses, and particularly in areas where water resources are limited. The benchmarking of infrastructure leakage indexes for urban areas will provide valuable information on the condition of the infrastructure as well as the technical management capabilities. Reduction of non-revenue water will require an investment in the development of human resources at Municipalities to manage service delivery effectively and efficiently and to maintain the infrastructure. Municipalities may need stronger technical support from the private sector and supervision from the Ministry of Regional and Local Government and Housing and Rural Development for some time.

The reduction of non-revenue water could be part of an ongoing water demand management initiative. If there is a culture of non-payment, water is normally wasted. In a programme of management assistance that was implemented in Rehoboth, the water demand was reduced form 1.7 Mm^3 (2001) to 1.3 Mm^3 (2003) through the lowering of non-revenue water and leakage reduction combined with equitable tariffs and an efficient credit control policy.

Efficiency of water use in irrigation schemes is important and there is normally room for improvement. In the recent Orange River Study (LORMS, 2005) training of irrigation farmers, access to information, proper scheduling, metering and water pricing and efficient irrigation systems water were identified as the main issues that need to be addressed.

Experience elsewhere in the world has demonstrated that WDM in the irrigation sector has been successful if the farmers benefited through the implementation. A good example is the "Water for Profit" scheme in Queensland (Australia) where farmers are supported by the Government to improve irrigation systems and farm management to save water and to increase crop production. With an investment of A$ 41 million by the Queensland Government, 180 Mm^3/a was saved and the value of crop yield improvement was A$ 280 million/annum. There are no similar examples documented in Southern Africa and the benefit to the farmers needs to be demonstrated before they will participate actively in WDM initiatives.

As a first step the mandatory reporting of accurate information on water losses (NamWater), non-revenue water (Local Authorities) and water abstracted by self-providers are required to identify opportunities for the implementation of WDM with a high financial return.

8 CONCLUSIONS

8.1 PHYSICAL FLOW ACCOUNTS

The abstraction of freshwater and production of recycled water[11] (hereafter, the term freshwater includes recycled water unless otherwise stated) have increased from 274 Mm^3 in 1997/98 to 326 Mm^3 in 2001/02. Water use has grown slightly faster, from 234 Mm^3 to 282 Mm^3 over the same period. Losses have also increased from 40 to 44 Mm^3.

Abstraction of water was divided in sources ie. groundwater, perennial rivers, ephemeral rivers and recycled water. Groundwater has been the single largest natural source of water in all years, accounting for an average of about 40% of freshwater; perennial rivers and ephemeral rivers each provide roughly 30% of freshwater. Recycled water, although locally important, has not provided more than 1% of freshwater in any year. The distribution of water form the different sources is illustrated in Figure

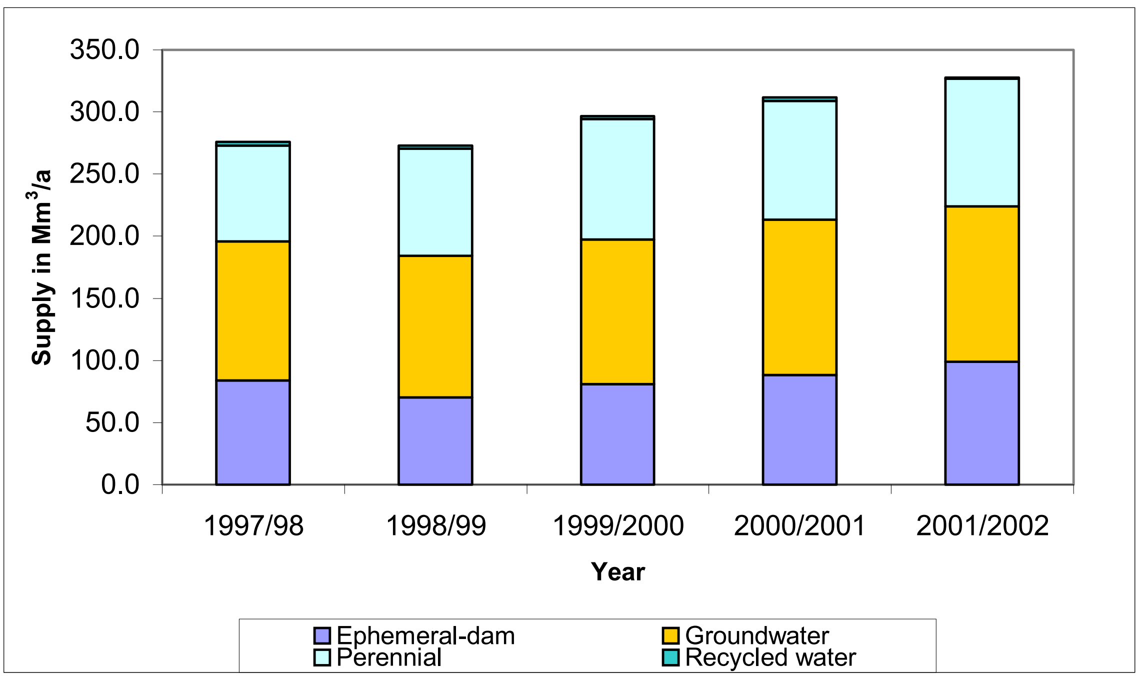

Figure 8.1: Distribution of Freshwater Supply by Natural Source, 1997/98 to 2001/02

In 1997/98 NamWater was the largest supplier of freshwater, accounting for 43% of all freshwater supply, followed closely by agricultural self-suppliers accounting for 40%. By 2001/02, the situation had reversed; agricultural self-providers surpassed NamWater to become the largest suppliers of water, accounting for 45% of all freshwater abstractions as illustrated summarised in **Figure 8.2.**

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[11] Recycled water was defined and discussed in Chapter 2 (Methodology) and Chapter 3 (Data sources) of this report. The water accounts do not, at this time, distinguish different qualities of recycled water.

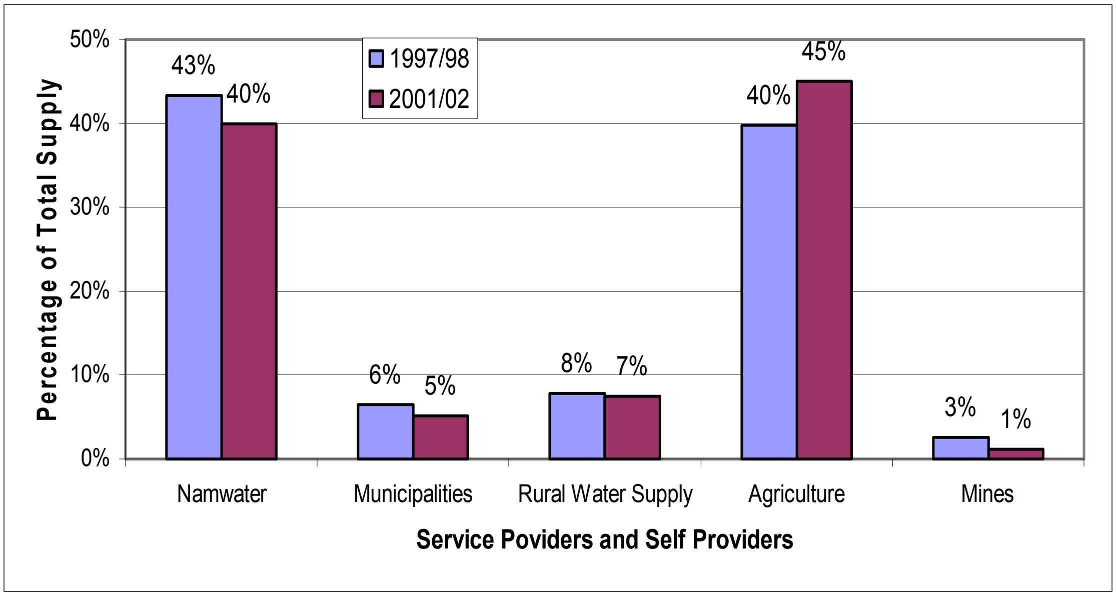

Figure 8.2: Share of Total Freshwater Supply Abstracted by Institution*, 1997/98 and 2001/02

In terms of deliveries to end users—after taking into account transfers among utilities and losses—agricultural self-providers are the largest group in all years, followed by Namwater, municipalities, and RWS.

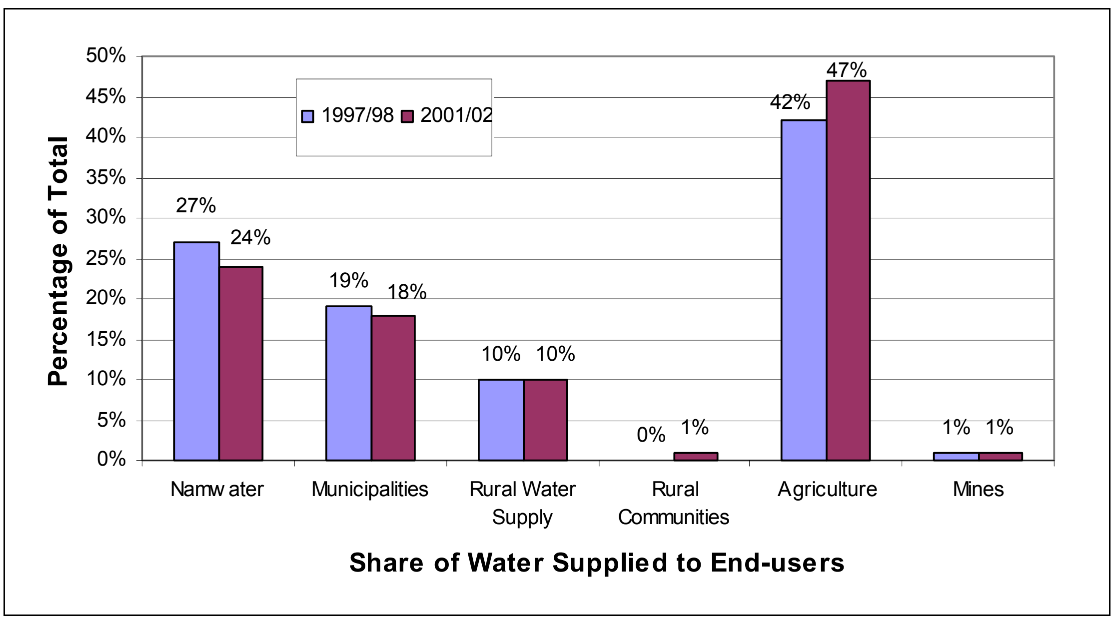

Figure 8.3: Share of Freshwater Supplied to End-users by Institution,

Water losses and non-revenue water is of concern. In many cases abstraction is not measured and it is impossible to do water balances. The following figures was accepted for the different suppliers for the purposes of the account calculations,

- 6% losses for NamWater (No raw water abstraction figures available ephemeral dams)
- 8% losses for Rural Water Supply
- 25% losses for Rural Communities
- 10% for Self-providers in agriculture and mining
- 10 to 85% for Local Authorities (non-revenue water=losses + unaccounted for)

The water use and employment for each Economic Sector is summarised in **Table 8.1** below.

Table 8.1: Percent Contribution by Major Economic Sector to GDP, Employment and Water Use 1997/98 and 2001/02

Economic Sector	1997/98		2001/02		
	% of GDP	% of water use	% of GDP	% of water use	% of employment
Agriculture	7%	72%	6%	74%	24%
Commercial agriculture	4%	47%	4%	49%	7%
Communal agriculture	3%	25%	2%	24%	17%
Fishing	4%	*	4%	*	2%
Mining	8%	4%	7%	3%	1%
Manufacturing	11%	3%	11%	2%	5%
Total for Food processing	8%	1%	7%	1%	2%
Other Manufacturing	3%	1%	4%	1%	4%
Utilities + Construction	4%	*	5%	*	7%
Services	26%	3%	27%	3%	45%
Trade, hotels & restaurants	11%	1%	11%	1%	13%
Transport & communication	6%	*	8%	*	4%
Finance & business services	7%	*	8%	*	11%
Social services	1%	1%	1%	1%	17%
Government	22%	6%	21%	5%	15%
Total	82%	87%	82%	88%	100%

*less than 1% Note: Percentage of GDP in constant 1995 prices. The above table excludes the contribution from owner occupied houses and taxes less subsidies.

8.2 MONETARY ACCOUNTS

In the past, the NamWater user charges did not cover all costs; but a policy of full-cost recovery was gradually implemented in the 1990s. The effect of this policy can be seen in the difference between costs of supply and water charges: in 1999, costs still exceeded billed charges by $43 million and both other water utilities and end-users were subsidized. As from 2000/2001 and 2001/2002 user charges were respectively N$ 13 million and N$ 11 million more than the supply costs. The national figures do not represent the cost-tariff relationship for every water scheme.

The average tariff charged be NamWater was N$ 2.89/m^3 while the average cost was N$ 2.79/m^3. There is a huge variation in cost and tariffs for the different NamWater supply areas. Tariffs for individual customers vary within the NamWater supply areas. During 2001/2002 Namwater made a surplus on water sold to Local Authorities and Rural Water Supply amounting to N$ 37.3 million and N$ 5 million respectively. Water was sold well below cost at a lost of N$ 28 million/a to various end-users. The end-user groups that benefited included Commercial Livestock (N$ 0.82 million/a), Communal Irrigation (N$ 0.42 million/a, Other Mining and Quarrying (N$ 11 million/a), Utilities, Construction, Services (N$ 8.5 million/a of which N$ 6.5 million/a was for social services) and the Government (N$ 1.05 million/a).

NamWater is in the process (2005) to update their system of cost allocation per scheme. This may influence the above figures to a large extend. They are also busy with a tariff study on uniform water tariffs which outcome may influence the setting of future tariffs.

RWS abstracts much of the water it distributes itself at a cost of $3.43/m^3, but it also obtains a small amount from NamWater which raises its unit costs to $3.63/m^3. Groundwater is not only the main source of water for RWS but also the cheapest. Rural Communities do not abstract water themselves[12] and obtain their water from NamWater. The unit cost of the water they obtain, $3.42/m^3, is higher than the average unit cost for water abstracted by NamWater, $2.01/m^3, indicating that it is obtained from water schemes that are very expensive to operate. Rural Water Supply and Rural Communities both receive extensive subsidies, with water costs far exceeding water charges, if any. RWS does not levy any user charges; Rural communities levy charges and appear to be increasing the share of costs that these charges cover. In 1999, user charges recovered only about 20% of supply costs, but by 2001 the recovery rate had increased to about 65%.

An estimate was made of the cost incurred by Agricultural self-providers to abstract groundwater, based on the number of operating boreholes, average capacity, water requirements and pumping time. The estimated average cost for 2001-02 is $4.18/m^3, which is on the high side, but well within the range of water abstraction costs.

Windhoek is the only city which provided information and for which complete water accounts can be constructed. Windhoek's water revenues exceed supply costs by about

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[12] Rural communities do collect payment for water themselves, but there is no information about the volume, time-cost or other aspects of this source of water.

11% of costs, with an average user charge per m^3 of $7.34 and costs of $6.59, but not all sectors pay the full cost of water. Households pay 23% more than the cost of their water and this surplus (N$ 15 million/a) subsidises some Manufacturing and Service industries and Government institutions. Low-income households are also subsidized, but the water accounts do not distinguish different categories of households to be able to calculate the exact subsidy. Not all industries receive subsidies: subsidies are received by some of the most water-intensive industries including Food processing (Meat processing and Beverages (N$ 159 000/a), Trade, Hotels & restaurants (N$ 65 000/a), Real Estate and Business services (N$ 40 000/a), Social services (especially Schools and Hospitals N$ 1.5 million/a) and Government (N$ 470 000/a).

There is no detailed information available on the outstanding arrears on the water account only. According the Financial Statements of the City of Windhoek the outstanding debtors amounted to N$ 281.7 million for 2001/2002 and N$ 313.7 million for the 2002/2003 financial years. According to the Budget Services and Financial Statements Division of the City of Windhoek approximately 80 to 85% of this amount was with respect to service accounts including water services. The estimated national outstanding debt for services rendered by local authorities is estimated at N$ 400^+ for 2005.

From the information of 14 local authorities obtained from the Audit Reports from the Office of the Auditor General 12 shows a surplus on their water account. It is clear that most of the local authorities aim to make a surplus on their water account. The self-providers make very high surpluses with Omaruru (110%) Grootfontein (86%), Outjo (76%) and Tsumeb (30%) amongst the highest 6. Henties Bay (76%), Rehoboth (34.4%) and Luderitz (30.3%) are amongst the highest 3 of the Local Authorities that get water from NamWater. The collected figures do not reflect the payment level of these accounts nor the outstanding arrears on the accounts.

There is no uniform national policy regarding end-use water tariffs in Namibia. In many of the villages the water is sold well below the NamWater tariff. In many cases the cost allocated to the rendering of water services is not clearly stated nor accounted for.

Water is in general, affordable to commercial and industrial undertakings and to the middle and high income groups for domestic consumption. The cost of water to industry is normally small in comparison to their overall cost structure. Cost recovery from these groups is not seen as a problem.

Affordability is a major problem for low-income families. In a recent surveys in Windhoek (2001) it was determined that 80% of the surveyed households could 80% of the households could afford to pay N$ 58.20/month for land and services while if it is accepted that a household should not pay more than 15% of its monthly income on land and services (The total cost of land and services in urban areas is made up of occupational rent or mortgage repayments, water and sewer basic, water consumption, refuse removal and a general rates and taxes). In another survey in Tsumeb (2002) it was determined that a large proportion (64%) of the population has an income of between N$ 0.00 and N$ 400.00 per month and that only 16% of the households in Soweto have a positive Primary Household Subsistence Level (PHSL). In other words 84% of the formal households make a living below the poverty line.

Water productivity is the ratio of the value added from each sector divided by the water use in each sector. For this comparison, the value-added for both years is given in the same year's prices, 1995 prices, in order to adjust for inflation, which would otherwise bias the comparison in favour of 2001/02. Overall, the economy is producing less national income for a given amount of water in 2001/02 than in 1997/98: the value fell from N$59 to N$56 per cubic metre of water used.

Table 8.2: Freshwater Contribution to National Income by Economic Sector Including the Percentage Employment for 2001/2002

Economic Sector	% of Total Employment	GDP (N$ million) and N$ Value-added per m^3 of water used (constant 1995 prices	
		GDP	Value Added (N$/$m^3$)
		2001/2002	2001/2002
AGRICULTURE	**24%**	**918**	**4.54**
Commercial agriculture [(a)]	**7%**	**623**	**4.61**
Commercial Crops		59	0.55
Commercial Livestock		485	18.44
Communal agriculture	**17%**	**296**	**4.41**
Communal Crops		-17	-0.49
Communal Livestock		313	9.92
FISHING	**2%**	**649**	**939.04**
MINING	**1%**	**1 162**	**127.20**
Diamond Mining		838	891.14
Other Mining & Quarrying		324	39.58
MANUFACTURING	**5%**	**1 697**	**260.62**
Total for Food processing	**2%**	**1 133**	**314.31**
Meat Processing		108	77.70
Fish Processing on shore		199	218.38
Beverages		504	451.48
Other food processing		323	1 645.87
Other manufacturing	1%	566	194.67
Textiles		20	153.19
UTILITIES	**7%**	**229**	**998.46**
CONSTRUCTION	Included above	**510**	**1 850.68**
TOTAL FOR SERVICES	**45%**	**4 373**	**551.92**
Trade	13%	1 513	775.70
Hotels & Restaurants	Included above	298	164.81

Economic Sector	% of Total Employment	GDP (N$ million) and N$ Value-added per m^3 of water used (constant 1995 prices	
		GDP	Value Added (N$/$m^3$)
		2001/2002	2001/2002
Transportation	4%	753	1 771.61
Post and Communications	Included above	477	7 816.60
Financial, Business services and Real Estate	11%	1198	1 681.43
Social services	17%	134	45.19
GOVERNMENT	**15%**	**3 313**	**234.16**
ECONOMY-WIDE AVERAGE:			
GDP/m^3 water, all uses		**15 720 (b)**	**57.23**
GDP/m^3 water, excluding agriculture		**14 802**	**203.76**
		193.30	

8.3 POLICY IMPLICATIONS FOR NAMIBIA

Water accounting is particularly important for countries such as Namibia, where increasing water scarcity and mounting water supply costs make it imperative to use the available resources sustainably, equitably and efficiently. Water accounts can assist policy makers to monitor resource trends, resource allocation and user efficiency, which are important government responsibilities under the New Water Act. Water accounts also provide a valuable tool in the planning process, because they can be used with economic models to calculate, for example, the water requirements for long-term development plans such as Vision 2030 and the Green Scheme, as well as medium-term plans such as the National Development Plan, (NDP2).

8.4 WATER ACCOUNTS, THE DRAFT NEW WATER ACT AND VISION 2030

The Water Act and Vision 2030, a long-term development plan, address water management in considerable detail. Both start off by "…recognizing the economic value of water and that its abstraction, use and management must be efficient, cost-effective and promote equitable and sustainable socio-economic development", (Preamble to the Draft Water Bill). By providing an economic tool for water management, water accounting can contribute to implementing the Water Act and achieving Vision 2030. Vision 2030 is quite specific about the goals Namibia wants to achieve with respect to water and what should be done to achieve these goals, as well as what should be avoided. Vision 2030 recommends, among other things, adopting a stricter economic approach to water pricing to encourage all sectors to use water as efficiently as possible.

8.5 PRIORITIES FOR FUTURE WORK

With the implementation of the Water Act regulations are required to regulate various activities within the water sector. The information collected and analysed for the NRA identified important issues for more detailed attention to fulfil goals set in Vision 2030, NDP 2 and the Green Scheme.

8.5.1 Costing, Tariffs, Subsidies and Credit Control

Many local authorities allocate cost for the provision of water services on an ad hoc basis with no relevance to the real cost to provide water services. It seems that no or little provision is made for proper maintenance of water networks and water meters especially in smaller local authorities. In many cases the cost allocated to the rendering of water services is not clearly stated nor accounted for. NamWater is in the process to review their cost allocation system. In the existing system there seems to be many deficiencies on the allocation of depreciation, capital redemption cost and allocation of overheads. Clear policy guidelines are required.

Water supply in Namibia is based on full cost recovery principles, ie. it is accepted that water is an economic commodity. There is no subsidy from the Government through the social security system to provide water related services to the urban or rural poor except for support services by RWS. If cross-subsidisation is being considered, then a system needs to be put in place, which is able to identify and assist only the truly needy, if economic efficiency is to be achieved. In this respect it must be remembered that water is a commodity, common to all. This implies that it has a social element and that there is a concomitant social responsibility to make water available to needy groups for basic needs.

Some end-users receive considerable water subsidies, while others pay charges in excess of supply costs. Among NamWater's customers, Municipal Authorities and RWS pay user charges in excess of costs, which offset, in part, subsidies to mining and other end-users, especially rural households and social services. In Windhoek, middle and high-income households pay excess charges, which offset subsidies to government, schools, social services and low-income households. In Windhoek wet industries are also subsidised. At this time the extent of cross-subsidisation between different groups of households cannot be determined from the water accounts. The intention in both Windhoek and Rehoboth is to subsidise low -income households to make baseline water (40 litre/person/day) available at a lower price. Subsidies for groundwater use in rural areas (RWS) exceed those for all other water sources. Subsidies for water that encourage water wastage needs to be abolished. Instead full recovery of water supply costs in urban and rural areas needs to be implemented provided that equitable access to water by both the urban and rural needy through a system of cross- subsidisation within the water sector and/or through a direct subsidy to needy families.

As stated earlier with the comparison of water services tariffs for three urban areas low-income families, under employed individuals or pensioners with an income of less than N$ 600/month cannot afford to use 6 m^3/month, which is regarded as baseline water for a urban family of 5 with full water services. There is also no similar information available to do similar calculations for rural areas. The situation may be the same or even worse. Efforts by NamWater and Local Authorities to compensate for non-payment worsen the situation by making water services even more unaffordable to the needy families in Namibia.

There are no uniform national guidelines regarding Namwater and end-use water tariffs in Namibia. In many of the villages the water is sold well below the NamWater tariff. A tariff policy for both NamWater and End-users (taking ability to pay and equitable access into account) needs to be compiled as a matter of urgency.

An important aspect of the water pricing policy at the municipal level is the effective collection of revenue. A number of towns are in arrears to NamWater for their bulk water purchases, due to failure to collect payments from local users. At this point in time, there is insufficient data to explore this issue for 2001/2002. It is suggested that as part of the updating of the accounts for 2003/2004, a more detailed investigation be done. The estimated figure for debt owed to all local authorities (including Windhoek) in February 2005 indicated that the figure for outstanding service accounts was well above N$ 400 million. Proper policy guidelines for credit control are required to change the culture of non-payment taking social and economic conditions into account.

8.5.2 Regulation of Service Providers and Self Providers

The water accounts provide some information about the efficiency of water supply in terms of losses and allocation among end-users, but cannot be used to determine whether the supply of water is managed efficiently. Management and supply costs are special concerns for monopolies like NamWater or local Municipalities that are not subject to competition. More transparent information about supply costs and pricing calculations would assist in allowing independent assessment of the efficiency of these monopolies.

As from 2001, Self-providers (mainly stock farming, irrigation and mines) surpassed NamWater as the largest abstractors of water, accounting for 44% of all water abstractions. Given the very large amount of water used, it is critical for policymakers to obtain accurate figures for water abstractions by Self-Providers and the purposes for which the water are used. This will assist generally in water planning and especially for Water Demand Management.

National Regulations are required for regulation of service providers including self-providers to report key operational information/data to the DAWF to ensure a high level of service and sustainable use of water resources.

8.5.3 Aquaculture Water Use

Freshwater aquaculture has been identified as a sector with high-growth potential so monitoring water use should be a priority. In the past few years aquaculture has developed near Hardap Dam and is now a major user of water. Ponds for aquaculture have also been established in the northeast, but no figures on water use are currently available. Economically, freshwater aquaculture is still quite small compared to marine fishing but it is as water intensive as crop irrigation. Most of the implemented schemes require a daily input of 10 to 15% fresh water relative to the storage in the pond. The overflow is normally used for small-scale irrigation schemes provided that the effluent is suitable for irrigation. Reuse of water within the ponds requires expensive filtration systems and is only applied in a few small-scale operations.

8.5.4 Agricultural Water Use

Agriculture has increased its share of water use from 71% in 1997-98 to 74% in 2001-2002. In 1993, agriculture was estimated to account for only 64% of total water use. The highest growth occurred in the irrigation, which consumed 56% of the total water abstracted in 2001/2002. Stock farming consumed 18.3% of the water abstracted in 2001/2002. Most of the growth in water use is due to the rapid expansion of land under irrigation. This has caused a decline in water productivity ie. value of national income generated by a cubic metre of water.

The impact of agricultural policies on water use and poverty should be assessed. A case study in the mid-1990's by MAWRD determined that maize protection (pricing and import controls) had a negative effect on poor households. This study should be linked to water use and extended to all agricultural polices. However, this should also take household and national food security into account.

For informed decision making with the implementation of the "Green Scheme" information on the expected gross margin of crops, Net Disposable Income and number of permanent and seasonal workers needs to the assessed. In evaluating water use in primary economic activities such as Agriculture, it is useful to consider the entire 'value-chain', ie. the 'upstream' and 'downstream' activities, which are linked as suppliers of inputs to, or users/processors of output from the primary activity. In the case of Agriculture, the most important linkage is the 'downstream' processing of agricultural products (agro-industry).

Information collected including access to international data banks should be accessible through internet as well as though the Agronomic Board and the office of the "Green Scheme".

8.5.5 Water Demand Management Initiatives

Losses for NamWater appear to be quite low, but losses are much higher for most Municipalities. Local authorities distributed approximately 23% of the water abstracted in 2001/2002. Municipalities with non-revenue water of 20% or higher account for 37% of Municipal water distribution, while 7 towns have non-revenue water over 60%. Reduction of non-revenue water is clearly a priority, especially for those towns with very high system losses, and particularly in areas where water resources are limited. Reduction of non-revenue water will require an investment in the development of human resources at Municipalities to manage service delivery effectively and efficiently and to maintain the infrastructure. Municipalities may need stronger technical support from the private sector and supervision from the Ministry of Regional and Local Government and Housing and Rural Development for some time.

The reduction of non-revenue water could be part of an ongoing water demand management initiative. If there is a culture of non-payment, water is normally wasted. In a programme of management assistance that was implemented in Rehoboth, the water demand was reduced form 1.7 Mm^3 (2001) to 1.3 Mm^3 (2003) through the lowering of non-revenue water and leakage reduction combined with equitable tariffs and an efficient credit control policy.

Efficiency of water use in irrigation schemes is important and there is normally room for improvement. In the recent Orange River Study (LORMS, 2005) training of irrigation farmers, access to information, proper scheduling, metering and water pricing and efficient irrigation systems water were identified as the main issues that needs to be addressed.

Experience elsewhere in the world has demonstrated that WDM in the irrigation sector has been successful if the farmers benefited through the implementation. A good example is the "Water for Profit" scheme in Queensland (Australia) where farmers are supported by the Government to improve irrigation systems and farm management to save water and to increase crop production. With an investment of A$ 41 million by the Queensland Government, 180 Mm^3/a was saved and the value of crop yield improvement was A$ 280 million/annum. There are no similar examples documented in Southern Africa and the benefit to the farmers needs to be demonstrated before they will participate actively in WDM initiatives.

As a first step the mandatory reporting of accurate information water losses (NamWater), non-revenue water (Local Authorities) and water abstracted by self-providers are required to identify opportunities for the implementation of WDM with a high financial return.

9 RECOMMENDATIONS

To implement the Water Act through the promulgation of National Regulations may take many years. As part of the implementation process it is suggested that detailed guidelines be developed by DWAF (Department of Water Affairs and Forestry) in consultation with stakeholders within the water sector as a first step. These guidelines can then be tested and be amended to refine it for practical use. After a period of three to five years of use and refinement, the guidelines may then be changed into National Regulations that would be mandatory after promulgation. The principle of the guidelines and regulations should be based on self-regulation and reporting to the DWAF as regulator of water within Namibia.

As part of the implementation process of the New Water Act it is recommended that:

1 Guidelines be drafted and distributed for implementation to address:

- Allocation of costs (overheads, capital, depreciation, operation, maintenance and others to be identified) for the provision of water services to all end-users
- Targeting cross-subsidising within the water sector and/or national subsidies from Central Government to achieve equitable access to water by vulnerable groups of society and where it is deemed vital for the support national development priorities
- Setting of water and sanitation (sewage) tariffs by NamWater and Local Authorities as applicable
- Credit control by NamWater and Local Authorities taking into account access to baseline water as well as the socio-economic conditions of the communities

2 Guidelines be drafted to regulate water service providers requiring them to report key operational information to the DWAF to improve the level of service and efficiency for the sustainable use of water resources. This will include mandatory reporting of accurate information on water abstracted, water losses, non-revenue water, infrastructure leakage indexes, collection of revenue, outstanding debt and other performance indicators as identified within the guidelines.

3 Guidelines be drafted to regulate self-providers (mainly Agricultural and Mining Sector) of water requiring them to report key operational information to the DWAF to improve the level of service and efficiency for the sustainable use of water resources. This will include mandatory reporting of accurate information on water abstracted, water losses, as well a cost breakdowns (capital, maintenance and operational costs) for their water systems, including other performance indicators as identified within the guidelines.

4 Guidelines be drafted to regulate inland (excluding marine) aquaculture, which was identified as a sector with high growth potential, due to the high water requirement (including possible pollution potential) as discussed in **Section 7.2.3**.

5 The irrigation sector requires special attention as discussed in **Section 7.2.4** to improve its water use efficiency and its contribution to the national economy. Viable water-saving technologies should be promoted and high value crops identified in order to increase the water use efficiency of irrigation schemes and the returns to the national economy.

6 The information be processed on an annual basis to identify opportunities for the implementation of Water Demand Management initiatives with high financial returns on the investment. Information should be accessible for DWAF on an annual basis.

7 Progress be monitored through the NRA by releasing annual statistical information covering the main sectors such as Agriculture (Stock farming and Irrigation,) Urban[13] use and Mining as well as a formal updating of the NRA accounts once every 5 years to serve as input to the National Development Plans.

8 More detailed assessments through the use of the Social Accounting Matrix (Namibia) be done in areas with high economic growth and limited supply augmentation options (insufficient water sources in the river basin) to determine the real social and economic benefits to avoid unaffordable capital projects for water augmentation that may be harmful (relative low value added) for the long-term development of the country.

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[13] Classified as Residential, Government, Industrial, Services etc

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11 APPENDICES

Note: Appendices are available in a hard copy or electronic format from the Department of Water Affairs and Forestry on request.

A1. Water use accounts by natural source, supplying institution and end-users: 1997/98 to 2001/02

National level, all water suppliers

Municipalities

A2. Accounts for the cost of water supply by natural source, supplying institution and end-use: 1999/2000 to 2001/02

National level, all water suppliers

Municipalities (only Windhoek is available)

A3. Accounts for user charges by natural source, supplying institution and end-use: 1997/98 to 2001/02

National level, all water suppliers

Municipalities (only Windhoek is available)

A4. Water use accounts for Self-providers in Agriculture by natural source: 1997/98 to 2001/02

Crop irrigation

Livestock watering

A5. Water use accounts for Self-providers in Mining by natural source: 1997/98 to 2001/02