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REPUBLIC OF MOZAMBIQUE
MINISTRY FOR THE COORDINATION OF ENVIRONMENT AFFAIRS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

FORMULATION OF A REGIONAL MANAGEMENT PLAN FOR THE UMBELUZI, MAPUTO AND INCOMATI RIVER BASINS IN MOZAMBIQUE

Projectno.: 21/5/0067

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Contents

LIST OF ABBREVIATIONS

ARA	Regional Water Authority
CNA	National Council for Water Affairs
DNA	National Directorate for Water
DWAF	Department for Water Affairs and Forestry (RSA)
EC	Electrical Conductivity
MAR	Mean Annual Runoff
MICOA	Ministry for Coordination of Environmental Affairs
Mm^3/yr	Million m^3 per year
m MSL	Elevation in metres above Mean Sea Level
NEMP	National Environmental Management Programme
NGO	Non Government Organization
PRN	National Plan for Reconstruction
RSA	Republic of South Africa
SADC	Southern African Development Community
SEA	Swaziland Environmental Authority
SRBMB	Southern African River Basin Management Board
TDS	Total Dissolved Solids
TPTC	Tripartite Permanent Technical Committee
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
USD	United States Dollars
WRB	Water Resources Branch (Swaziland)

SUMMARY

1. General

The river basins of the Umbeluzi, Maputo and Incomati Rivers are shared by Mozambique, Swaziland and the Republic of South Africa (RSA). Maputo Province (the most southern part of Mozambique), entire Swaziland and the Eastern Transvaal Region in RSA depend for their water requirements almost completely on the surface water resources, generated within these river basins. Most of the river basin tributaries originate in RSA, and they flow into the sea in Mozambique near the capital Maputo.

General data on the 3 river basins are given in the table below.

River basin		Mozambique	Swaziland	RSA
Umbeluzi	MAR/use, Mm^3/yr *)			
	- natural	490 (at river mouth)	370	
	- estimated actual	160 (at Swaziland border)		
	- consumption	110.9	180	
	Area, km^2	2,300	3,300	
	Population			
Maputo	MAR/use, Mm^3/yr			
	- natural	3,330 (at river mouth)	2,010	1,244
	- estimated actual	no data		
	- consumption	14	335.7	463
	Area, km^2	1,570	10,800	17,430
	Population			
Incomati	MAR/use, Mm^3/yr			
	- natural	3,680	1,067	3,346
	- estimated actual	405 **)		
	- consumption	400	227	1,140
	Area, km^2	14,900	2,600	28,700
	Population			1,100,000

*) MAR = Mean Annual Runoff under natural conditions
**) Mainly from the Sabie River, contributing about 400 Mm^3/yr

Economic development and population growth result in a significant increase of the water requirements in the 3 river basins. Consequently extensive water resource development plans are made and carried out, targeting at the maximum utilization of the available water for urban and industrial water supply, hydro-power generation and irrigation schemes, resulting in a significant reduction of the river water flows downstream. The water runoff into some of the rivers is also reduced by implementation of extensive afforestation programmes in RSA and Swaziland. Water resource development programmes, with the most serious consequences for depletion of the water resources downstream, are carried out in RSA. Development programmes include: expansion of the industrial and urban water supply, irrigation schemes, afforestation programmes, construction of a large number of dams and systems for diversion of water to other river basins. These developments will cause a reduction of the water availability for Swaziland and Mozambique. The situation is further aggravated by the frequent occurrence of years with less than the average rainfall.

It is also feared that the water quality in the rivers will deteriorate as a result of the increasing population and economic activities, with the inherent increase of sources of water pollution. Water quality monitoring results indicate that the concentrations of salts and nutrients are increasing in all rivers. Other environmental problems in the river basins include deforestation, loss of soil water retention capacity, soil salination and degradation of estuary areas.

Agreements between the 3 countries regarding equitable distribution of the available water resources in the 3 river basins and for protection of the water quality are urgently required. This is particularly important for Mozambique since development in Maputo Province and the water supply to metropolitan Maputo depend entirely on these rivers for their water needs. Various initiatives have been taken already for development planning and assessment of the water needs. Technical aspects of water resource development in the 3 river basins are regularly discussed within a Tripartite Permanent Technical Committee (TPTC) with representatives from the 3 countries. This report contains the results of a study, funded by UNIDO, which focuses of environmental aspects of the 3 river basins and the needs for integrated regional development planning for the Mozambican parts of the river basins.

2. Environmental aspects

2.1 Umbeluzi River Basin

The Umbeluzi River has its major sources in the Swaziland Highveld. There are a number of relatively small tributaries in Swaziland and Mozambique. The river flows through Mozambique into an estuary, and subsequently into Maputo Bay. There are 2 major dams in the river, Mnjoli in Swaziland and Pequenos Libombos in Mozambique. The river water is used for the following purposes:

- water supply to Mbabane and Maputo;
- irrigation in Swaziland and Mozambique (mainly sugarcane and citrus);
- water supply to a diamond mine and a sugar factory, both in Swaziland;
- small scale use by the riparian population.

Currently there are no point sources of water pollution in the basin. The salts concentration of the river water is increasing as a result of agricultural runoff. Soil degradation, caused by deforestation and inappropriate agricultural practices, is a major environmental problem in the Mozambican part of the river basin. An ethanol distillery is in construction in Swaziland. Measures to prevent the discharge of distillery effluent into the river should be taken.
In Swaziland some of the water users are concerned about the decreasing water flow in the river, which has led to the creation of the Umbeluzi Catchment Association.

The river water quality in Mozambique is still adequate for domestic use. Major environmental problems occur in the estuary, as a result of human activities (mangrove cutting and salt production) and reduced river flows, resulting in progressive salination upstream.

2.2 Maputo River Basin

The Maputo River Basin consists of 3 major tributary sub-basins:

- Pongola River basin in RSA;
- Usutu River basin in RSA and Swaziland;
- Ngwavuma River basin in Swaziland.

These rivers are combined into one flow, just before the Mozambique/RSA border, to form the Maputo River, which flows out into an estuary and subsequently into Maputo Bay.

Pongola River Basin

In RSA Pongola River water is used extensively for irrigation and afforestation. The only industry is a sugar mill near Pongola. Major source for downstream irrigation schemes is the Pongolapoort Dam at the border of RSA and Swaziland. Much attention is given to socio-economic development in the Kwa Zulu region. Current water resource development plans would result in a significant reduction of the river flow into Mozambique.

Usutu River Basin

The Usutu River and its major tributaries flow from RSA into Swaziland, and subsequently along the Swaziland/Mozambique border into the Maputo River. In Swaziland the Usutu system is a very important water source for urban and industrial water supply, generation of hydro-power (Usophohlo Dam) and irrigation. The river receives large quantities of urban and industrial effluents, including the cities of Mbabane and Manzini, Matsapha Industrial Complex, a pulp mill, a fruit canning factory, a pulp and paper mill, a textile mill and a sugar mill. Although most factories have installed systems for water pollution control, but accidental spills occur periodically, resulting in high concentrations of organic matter and phenol, which has serious implications for the downstream users, that use the water extensively for domestic and agricultural purposes. In spite of the significant waste loads into the river, the river water quality is generally good at the entrance point into Mozambique.

In RSA there are 4 dams in the Usutu River system, and 3 new dams have been proposed. A substantial amount of water is transferred from the Usutu River basin to the Vaal River basin to supply water to the coal-fired power plants in the Eastern Transvaal Highveld. Vast areas of exotic forest reduce the runoff into the rivers significantly. Current water resource development plans in RSA will cause a significant on the water availability in Swaziland.

Ngwavuma River Basin

This is a relatively small river basin. The river has its sources in the border region of RSA and Swaziland and it joins the Pongola River in RSA. Small scale farming is the major activity in the basin. There are no specific sources of water pollution.

Maputo River Basin

In the Maputo River basin in Mozambique are currently very little economic and agricultural activities. Consequently there are no specific sources of water pollution.

2.3 Incomati River Basin

The Crocodile River, the Komati River and the Sabie River (all originating in RSA) are the major tributaries of the Incomati River.

Crocodile River Basin

The Crocodile River basin lies entirely in Eastern Transvaal. The river water is extensively used for urban and industrial water supply, irrigation and mining. The river receives large volumes of urban and industrial effluents, which result in increasing concentrations of salts and nutrients. Just before the Mozambican border, near Komatipoort, the Crocodile conflues with the Komati River.

Water pollution problems, caused by discharge of effluents from a large pulp mill, urban wastewater treatment plants, mining and agricultural runoff have been reported. Pollution problems concern increased concentrations of ammonia, arsenic, manganese, chloride and pesticides. In general, however, the river water quality is still acceptable for its designated uses.

The river flow gradually decreases as a result of exotic afforestation in the higher regions of the river basin.

Komati River Basin

The Komati River flows from RSA, through Swaziland, into the Crocodile River. In RSA and Swaziland water from the river is used for irrigation and afforestation. There are no point sources of water pollution. In RSA water from the Komati River is diverted to the Vaal River basin.

Sabie River Basin

The Sabie River flows from RSA, through the Kruger National Park, into the Incomati River in Mozambique. In RSA water from the river is used for irrigation and afforestation. In RSA a number of new dams has been proposed, which may result in a severe reduction of the water flow into the Kruger National Park and Mozambique. The Corumana Dam in Mozambique is used for hydro-power generation and for supply of irrigation water. The physical characteristics of the river bed downstream of the Dam are adversely affected by inadequate management of the dam system. There are no point sources of pollution.

Incomati River Basin

In the final section of the Incomati River basin in Mozambique are little economic activities and as such there are no point sources of water pollution. There is one sugar mill, producing raw sugar, which uses all its effluents for irrigation. Due to the extensive use of the Komati and Crocodile water upstream, the river has turned into a dry river in Mozambique. The water flow is sustained, to some extent, by inflow from the Sabie River. The river flows out in an estuary and finally into the sea, to the north of Maputo City.

3. Institutional aspects

In Mozambique the Ministry of Public Works and Housing is responsible for management of the water resources, with the main objectives (i) to ensure the proper use of the surface water and groundwater resources in order to fulfil the requirements of the national economy and the population, and (ii) to guarantee safe drinking water supply and sanitation. The National Directorate for Water (DNA) is responsible for execution of the water resource management tasks. DNA develops policies and strategies for water resource management, and it carries out studies and projects regarding assessment of the water resources and for development of plans and programmes. DNA also participates in negotiations on international water resource management issues. The Regional Water Authority for the southern river basins (ARA-Sul) is responsible for technical management of the water resources in the Umbeluzi, Maputo and Incomati River basins. In this context ARA-Sul is responsible for distribution of water to the major users, such as urban water supply companies and irrigation schemes, and for operation and maintenance of the infrastructure for water resource management.
The Ministry for the Coordination of Environmental Affairs (MICOA) is responsible for environmental management and protection of the natural resources in Mozambique. Its functions include formulation of environmental policies and planning, and enforcement of environmental legislation. In this context MICOA plays a coordinative and supervisory role in protecting the quality of the country's water resources and the related ecological resources.

In Swaziland the Ministry for Natural Resources and Energy is responsible for environmental and water resources management. The tasks related to quantitative and qualitative water resources management are executed by the Water Resources Branch (WRB), whereas the Swaziland Environment Authority (SEA) is responsible for environmental management. SEA also participates in international negotiations regarding the water resources in the trans-boundary river basins.

In South Africa the Department of Water Affairs and Forestry (DWAF) is responsible for management of the water resources in the country. It prepares water resource development plans, studies and designs. In addition it coordinates water quality monitoring programmes and it issues permits to major water users. DWAF also participates in international negotiations and programmes regarding the water resources in the trans-boundary river basins.

4. International arrangements

From 1976 Mozambique and Swaziland have an agreement for sharing the water in the Umbeluzi River basin.

A Tripartite Permanent Technical Committee (TPTC), with representatives from Mozambique, Swaziland and RSA, has been established to discuss and assess all matters concerning the use and development of the water resources in the river basins, shared between these 3 countries.

The Southern African Development Community (SADC) has taken initiatives for integrated international river management. An international action plan for the Zambezi River basin is being prepared.

Other initiatives towards joint river basin management include:

- proposal for a collaborative research and capacity building programme for the management of the shared rivers of Mozambique and RSA;
- proposal for development of a conceptual framework for the development of the Pongola River basin downstream of Pongolapoort.

5. Conclusions

The water quality of the studied rivers is in general still adequate for the designated uses. Gradual increases of the salt and nutrient concentrations are observed as a result of agricultural runoff and industrial and domestic effluent discharges. The process of mineralization of the river waters will be accelerated by increased water use domestic, industrial and agricultural use, resulting in reduction of the natural river flows and an increase of the inflow of polluted waters.

The Crocodile River (in RSA) and the Usutu River (in Swaziland) are most seriously affected by urban and industrial effluents, mainly form pulp mills, metal refineries and mining activities. Serious pollution problems occasionally occur as a result from accidental spillages.

Extensive afforestation with exotic tree species, especially in RSA, causes a significant reduction of the natural river flows, by 15-20%.

Extensive water resource development plans in RSA will have severe consequences for the availability of water in Swaziland and Mozambique.

Shortage of water is a major threat in the 3 river basins. It will seriously affect the realisation of socio-economic development plans in the 3 countries. Establishment of agreements on equitable distribution of the available water between the 3 countries is therefore considered as a priority. For this purpose the collaboration between the 3 countries should be strengthened significantly.

Mozambique should determine, urgently, its water requirements from the 3 rivers for realization of regional development plans and for protection of the ecological resources in the river basins in order to strengthen its position in the negotiations on water resource distribution with the other countries.

6. Recommendations

It is recommended that an integrated programme be formulated and implemented with the objectives (i) to achieve equitable sharing of the water resources between the 3 countries, and (ii) to enhance sustainable socio-economic development in the Mozambican parts of the 3 river basins. Major components of such a programme are:

- determination of the water requirements for development plans for Maputo Province and Maputo City, which for their water resources depend on the 3 rivers;
- development and implementation of an integrated development plan for the rural areas of Maputo Province;
- institutional strengthening with establishment of a tripartite regional river basin management board and strengthening of the water resource management authorities in Maputo Province.

1 INTRODUCTION

An important part of the surface water resources in Mozambique, about 60%, has its origins in adjoining countries, where all major rivers flowing through Mozambique to the Indian Ocean, have their sources. The water resources are fairly unequally distributed over the country. For example, the Zambezi River transports 75% of the total river water inflow into the country. Mozambique is in a vulnerable position with respect to a continuous and reliable provision in its water requirements, since the water availability depends to a large extent on the level of utilisation of the water resources in the upstream countries. Current trends in the upstream countries entail significant further development and exploitation of the water resources, which will result in gradual reduction of the river water flows into Mozambique and which will cause deterioration of the quality of the water with negative impacts for the water use potentials. Agriculture in Mozambique depends largely on the availability of irrigation water from surface waters, since rainfall is in most parts of the country not sufficient to support cultivation of crops. In view of the importance of agricultural development, it is vital that Mozambique ensures guarantees regarding a sufficient share in the international water resources to meet its water requirements. The water supply situation in the region is further aggravated by the large variations in the rainfall, which cause periodical shortage of water in all countries sharing the river basins.

Maputo Province, the most southern province of Mozambique, depends for its water supplies almost entirely on the Umbeluzi, Incomati and Maputo river basins. Mozambique shares these river basins with Swaziland and the Republic of South Africa (RSA). All 3 countries have plans to increase their abstraction from these river systems for hydropower generation, irrigation schemes and water supply to the growing population and the increasing industrial activities. Satisfaction of the water needs in the 3 countries is also influenced by the irregular rainfall pattern. Extended periods of drought are not an exception, which makes equitable distribution of the available water even more problematic. As a result it is urgently required that the 3 countries agree upon a common plan for sustainable development of the water resources, which would ensure that Mozambique will receive sufficient water of appropriate quality to meet its requirements for urban and industrial water supply, agriculture and control of seawater intrusion in the river estuaries.

A treaty between Swaziland and Mozambique regarding the use of waters of common interest has been signed in 1993. By an agreement of 1976 Mozambique is entitled to 40% of the water flow in the Umbeluzi River, which has its sources in Swaziland. Since 1982 there is a Tripartite Permanent Technical Committee to negotiate agreements on sharing the common water resources of the 3 countries. This committee discusses all initiatives and plans for water resources development in the basin and it considers consensus regarding the authorization of development plans. However this commission does not have yet an official status.

The National Directorate of Water (Direccao Nacional de Aguas, DNA) is the major institution for river basin management in Mozambique. The recently established Ministry for Coordination of Environmental Affairs (MICOA) plays a central role in coordination and supervision of all environment-related issues in the country. In 1994 a National Environmental Management Programme (NEMP) was prepared, which shall serve as a master plan for achieving sustainable socio-economic development in the country. The NEMP was approved by the Government of Mozambique in 1995.

2 DESCRIPTION OF THE RIVER BASINS

2.1 Introduction

The major characteristics of the river basins in the 3 countries are summarised in this chapter. The 3 river basins have been described in 3 separate sections, with attention to the following aspects:

1. Hydrographic data

   For each river, and its major tributaries, data on the Mean Annual Runoff (MAR) of the river's catchment area are given. The MAR represents a theoretical value for the catchment's runoff under natural conditions, calculated by means of mathematic models. The MAR will generally differ significantly from the actual annual river flow. In many catchment areas the runoff has decreased as a result of water abstraction and by exotic afforestation. The man-made forests are usually located in the areas with the highest precipitation, and they are very effective in utilising the rainwater before it can run off into the river. It is estimated that in some catchment areas the MAR has been reduced by 20% as a result of exotic afforestation. Pine and Eucalyptus are the most planted tree types in these forests.

   In some cases river flow measurement data, from permanent hydrometric stations, are given. These data, however, are often not accurate or reliable due to malfunctioning of the stations, e.g. by siltation.

2. Data on dams, irrigation and afforestation

   Data on dams, irrigation schemes and exotic afforestation are given for each river basin in terms of area and water consumption. In most cases the data are given separately for the major tributary sub-basins and for the different countries sharing the basin.

3. Environmental aspects

   The river (sub-)basins are described in general terms, including data on population, surface area, urban centres, land use and water use. The major potential sources of pollution water quality aspects are described. Water resources development plans are also described.

The location of the river basins is shown in Figure 2.1.
A brief description of the 3 countries, sharing the river basins, is given below.

a. Mozambique

The Mozambican sections of the basins of the Umbeluzi, Maputo and Incomati rivers are located in the very south of the country, entirely in the province of Maputo. Maputo Province contains the following river basins:

- Incomati River;
- Matola River (tidal creek);
- Umbeluzi River;
- Tembe River;
- Maputo River;
- Futi River.

The Matola, Tembe and Futi rivers are not discussed separately in this report since these rivers are located completely in Mozambique. The Mozambican area of the river basins of the Umbeluzi, Maputo and Incomati rivers is located in the Province of Maputo. The northern border of Maputo Province is the same as the northern boundary of the Incomati River basin. Maputo Province has approximately 1,850,000 inhabitants (estimate for 1995) on a land area of 26,358 km^2. The urban conglomerate of Maputo and Matola has approximately 1,400,000 inhabitants. Mozambique has a land area of 804,380 km^2 with an estimated number of 18,000,000 inhabitants (1995). The northern border of Maputo Province is the same as the northern boundary of the Incomati River basin.

Maputo Province consists of relatively flat alluvial lands, which rise to a level of about 800 m above MSL at the borders with Swaziland and RSA. Average climatological data are given in Table 2.1 (Ref 5). Annual rainfall varies between 600 and 800 mm. The wettest months are October to April. The south-western part is the driest part, with an average rainfall less than 700 mm/yr.

Table 2.1 Climatological data of Umbeluzi Basin (average monthly figures)
Umbeluzi Station, altitude = 12 m MSL

Month	Temperature, °C	Potential evapo-transpiration, mm (Penman)	Precipitation, mm
January	26.6	196	127
February	26.5	164	119
March	25.6	145	69
April	23.6	124	60
May	20.5	102	17
June	18.0	84	18
July	17.8	88	18
August	19.8	121	14
September	21.7	139	34
October	23.6	165	55
November	24.6	170	71
December	26.2	194	79
Year	22.9	1691	679

b. Swaziland

The Kingdom of Swaziland, with an area of 17,364 km^3 lies entirely in the Umbeluzi, Maputo and Incomati river basins. The Umbeluzi has its springs in the north-western part of Swaziland. The Komati River, tributary of the Incomati, flows through the northern part of Swaziland. The Usutu River has its sources in RSA. It flows through Swaziland into RSA, where it joins the Pongola River, which after entering Mozambique is known as the Maputo River. The Ngwavuma River has its source in Swaziland. It flows into RSA, where it joins the Pongola River.

Swaziland is divided in 4 clearly defined physio-geographical regions, respectively the Highveld to the west, the Middleveld, the Lowveld and the Lubombo Plateau to the east. The boundaries between the different parts roughly follow a north-south direction. Some characteristics on these different regions are given below (Ref 13):

Region	Average altitude, m	Area, km_2	Average annual rainfall, mm
Highveld	1,300	5,035	1,200
Middleveld	700	4,510	940
Lowveld	200	6,425	700
Lubombo	600	1,394	800

Swaziland has a population of 839,000 (1991). The annual population growth is 3.2%. The capital, Mbabane, has about 51,000 inhabitants, Greater Manzini, with the largest industrial development, about 60,000 and the other cities have a population of about 82,000 (all data of 1991).

The total cultivated land area equals about 670,000 ha, of which 195,000 ha is used for cultivation of crops. Major crops are maize, sugarcane, cotton and fruits. The irrigated land area is 42,000 ha. The total water use for irrigation amounts to 629 Mm^3/yr. The estimated potential area for irrigation is 90,000 ha (Ref 15). A relatively large land area is used for livestock farming.

The estimated water demands in the year 2000 for purposes other than irrigation are (as Mm^3/yr):

- municipal and industrial use: 11.4;
- rural domestic use: 2.6;
- livestock: 9.2.

The total forest area is about 475,000 ha, of which about 100,000 ha is planted with exotic forest (data of 1991). The western area of the Highveld, along the border with RSA, is for a large part covered with pine forests.

There are 3 major national parks:

- Malolotja in the north-western Highveld with an area of 18,000 ha;
- Mlawula in the Lowveld and Lubombo Plateau with an area of 31,138 ha;
- Milwane in the Middleveld with an area of 4,545 ha.

Hlane, 14,164 ha, in the Lowveld is classified as a game reserve. Twelve other sites have been identified for natural reserves.

There is a number of relatively small-scale hydro-power plants in Swaziland, but the country depends for its power supply strongly on the East Transvaal Highveld coal fired power plants. The totally installed hydro-power capacity in Swaziland is 40 MW, sufficient for 14% of Swaziland's energy needs. The remainder is imported from RSA.

The western part of the country, with most of the population, depends mainly on the rivers for its water supply, whereas the eastern part widely uses groundwater. About 63% of the urban population is connected to municipal water supplies, and 12% of the urban population is served by water-borne sewerage (Ref 13). Groundwater quality surveys in the eastern part of the country show high concentrations of nitrate (>45 mg/l) and of fluoride (> 2 mg/l) at a number of locations, indicating that groundwater

mg/l) and of fluoride (> 2 mg/l) at a number of locations, indicating that groundwater contamination may form a significant threat to the groundwater resources.
There is still a high prevalence of water-borne and water-related diseases in the country, such as typhoid, cholera, malaria and schistosomiasis.

The Government of Swaziland has not yet enacted specific environmental legislation. Existing laws, relating to environmental protection, deal with national parks and wildlife, mineral resources development, and water and air quality control. A new Water Act (The Water Act 1988) is being drafted. This Act targets at establishing of integrated water resources management and planning in the country.

The Ministry for Natural Resources and Energy is responsible for environmental protection in Swaziland. The Swaziland Environment Authority (SEA), created in 1990, functions under this Ministry. The tasks and objectives of SEA include:

- advice to the Government on environmental issues;
- coordination of all activities related to environmental management;
- monitoring of environmental quality trends and on the state of the environment;
- initiation and conduction of studies, investigations and research;
- functioning as a focal point with national and international organizations;
- establishing of environmental standards and guidelines.

The Water Resources Branch (WRB), under the Ministry of Natural Resources and Energy, is responsible for water resources management in Swaziland. The WRB is subdivided in 6 divisions: Hydrology, Meteorology, Water quality, Water control, Engineering and Dam operation and maintenance. The Water Quality Division operates a water laboratory, and carries out river water and effluent quality monitoring programmes.

The Water and Sewerage Board, which recently has been privatised, is responsible for urban water supply and sanitation, including operation of municipal and central wastewater treatment plants.

c. Republic of South Africa

The South African parts of the Maputo and Incomati River systems are located in the Eastern Transvaal region. Major tributaries in RSA are the Usutu and Pongola Rivers (in the Maputo River basin), and the Komati, Crocodile and Sabie Rivers (in the Incomati River basin). The region is characterised by increasing water demands for domestic use, agriculture, afforestation, industries, mining and tourism. The Kruger National Park, intersected by the Sabie River, is a key feature in the Incomati River basin.

RSA operates 3 systems for transfer of water from one river basin to another, respectively from the Komati River, the Usutu River and the Ngwempisi River. The total amount of water, diverted by these systems, equals 334 Mm^3/yr. The diverted water serves mainly for water supply to the coal-fired power plants in the East Transvaal Highveld.

The Department of Water Affairs and Forestry (DWAF) is considered as the custodian of the water resources in RSA. DWAF has recently altered its policy regarding the setting of effluent discharge quality standards. Effluent standards will now be developed on the basis of a receiving water quality approach for non-hazardous substances and a prevention approach for hazardous substances.

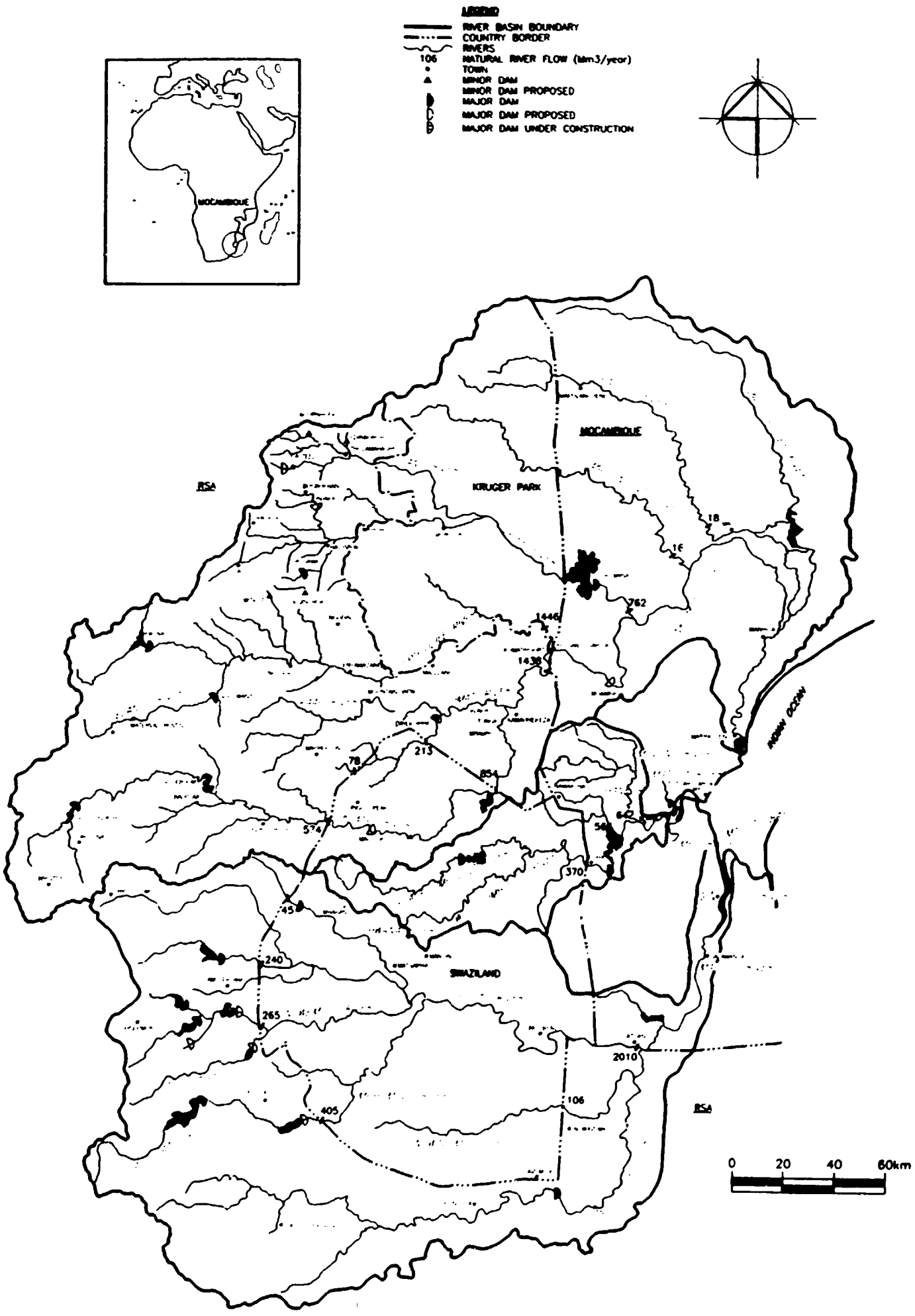

Figure 2.1 Lay-out of the Umbeluzi, Maputo and Incomati River basins with indication

2.2 Umbeluzi River

2.2.1 Hydrography

The Umbeluzi River drains an area of 5,600 km², of which 2,300 km² lies in Mozambique and 3,300 km² in Swaziland. The main tributaries are White Umbeluzi and Black Umbeluzi (both in Swaziland) and Calichane and Movene (both in Mozambique). Water flow data on the Umbeluzi River system, under natural conditions, are (Ref 1,2,5):

- Umbeluzi River (Station E-10, Goba at the Swaziland/Mozambique border):
  Mean Annual Runoff (MAR) = 370 Mm^3 (69 - 1394)

- Calichane-Impamputo sub-basin (catchment area = 552 km^2)
  Station E-16
  MAR = 56 Mm^3

- Movene sub-basin (catchment area = 1,472 km^2)
  MAR = 64 Mm^3

The actual river flow near Goba, however, is much lower due to abstractions upstream. It is currently estimated at an average flow of 160 Mm^3/yr.

2.2.2 Dams

a. Pequenos Libombos Dam (Mozambique)

The Pequenos Libombos Dam has been built in order to create a water reservoir for augmentation of the water supply of Maputo. The system has the capacity to provide a regular water supply of 7,000 m^3/h to Maputo. The dam was commissioned in 1987. The dam also supplies water to irrigation schemes in the river basin. A hydro-power plant, with a capacity of 2x1.5 MW is being installed. Data on the reservoir are:

Water surface area	3,800 ha
Maximum storage capacity	400 Mm^3
Dam crest length	1,540 m
Annual discharge (1987)	305 Mm^3

b. Mnjoli Dam in Black Umbeluzi River (Swaziland)

Operation of this dam started in 1976. It serves mainly for the supply of water to irrigation schemes in the eastern part of the country. Maximum storage capacity of the dam is 110 Mm^3.

2.2.3 Irrigation

2.2.3.1 Mozambique

Major irrigation schemes in the Umbeluzi valley, downstream of the Pequenos Libombos Dam are:

1. Citrus plantation.
2. Agro-Farm, various crops, including maize, tomato and green pepper.
3. INIA (Agricultural Research Station, production of seeds).

An Integrated Rural Development Project, in cooperation with the Italian Government, is implemented in the Boane area. This project includes some small-scale irrigation schemes.

Currently there are 12 irrigation schemes in the Umbeluzi River basin with a total area of 263.5 ha (see Appendix I). Major crops are maize, rice, vegetables, potatoes and citrus. The estimated total land area suitable for irrigation is 32,400 ha.

2.2.3.2 Swaziland

Major irrigation schemes occur along the Black Umbeluzi, downstream of the Mnjoli Dam towards the Lubombo Plateau. Sugarcane is the major crop. The most important estates are Simunye, Mhlume (both with a factory), Tambankulu and Vuvulane. The total irrigated area is 10,914 ha, with a water consumption of 173 Mm^3/yr, supplied by the Mnjoli Dam. It is planned to expand the irrigated area to 13,000 ha.
Citrus plantations (near Tshaneni), cattle grazing and pig farms are other agricultural activities in the area between the Mnjoli Dam and Maphevini. Molasses from the sugar mills is used as a feedstock for the animals.

Irrigation water for this area is also supplied from the Sand River dam in the Komati River system.

2.2.4 Environmental aspects

2.2.4.1 Mozambique

a. Water use and needs

Water supply to Maputo: 61.3 Mm^3/yr
Water supply to Boane and Namaacha: 3 Mm^3/yr
Irrigation water use: 30.6 Mm^3/yr
Control of seawater intrusion: 16 Mm^3/yr

b. Water quality and sources of pollution

The National Directorate of Water operates a water quality monitoring station at the hydrometric station E-10 in Goba near the border with Swaziland, but not many data are available and the number of analyzed parameters is limited to turbidity, electrical conductivity, chloride, nitrate and ammonia.
Some data on the quality of the Umbeluzi River water, which is used as raw water for the water supply of Maputo City, are given in Tables 2.2 and 2.3. In spite of increasing discharges of drainage water from irrigated fields, which may contain pesticides and nutrients, the water quality still can be considered as good. The water supply system of Maputo operates a treatment plant in Boane, from where the water is transported by pipe to Maputo. The water treatment system consists of: chlorination, flocculation/coagulation, sand filtration and post-chlorination. The capacity is 3,000 m^3/h, presently being expanded to 6,000 m^3/h. The back-wash water from the filters is discharged into the river, which may be considered as a potential source of chemical water pollution.
Over the period 1972 - 1982 the electrical conductivity (EC) of the Umbeluzi water in Mozambique increased from 150 to 450 umhos/cm, at a flow of about 7 m^3/s. Hence it can be concluded that the discharge of salts and solids into river shows a significant increase (Ref 10). Table 2.2 indicates that from that time the EC has further increased to over 600 umhos/cm.

Table 2.2 Unbeluzi River water quality data (Source: Aguas de Maputo)
Sample date: June 13, 1995
Units in mg/l unless otherwise mentioned

Sample location	Raw water intake	Treated water
Turbidity (NTU)	1.4	1.5
Temperature (°C)	22	20.1
Electrical conductivity (umhos/cm)	618	625
pH	8.1	8.0
Chloride	95.7	95.7
Sulphate	14.0	15.6
Carbonate	0	0
Bicarbonate	215	207
Nitrate	0	0
Nitrite	0	0
Organic matter (permanganate)	1.4	1.9
Silicium oxide	16	15.6

Table 2.3 contains data on the concentrations of metals. The samples were tested by the CSIR laboratory in RSA.

Table 2.3 Umbeluzi River water quality (Analyzed by CSIR, Pretoria, RSA)
Date: April 29, 1994
All units in mg/l unless otherwise indicated

Sample	Reservoir	Reservoir discharge	Downstream of dam	Raw water intake	Goba	Treated water
Sodium	50	57	53	65	47	63
Potassium	3	5	3	3	3	3
Calcium	26	24	24	25	22	26
Magnesium	27	17	18	18	18	18
Chromium	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Iron	0.24	<0.03	0.2	0.18	0.36	<0.03
Aluminium	1.23	0.3	0.3	0.25	0.32	0.28
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Mercury	0.001	0.002	<0.001	0.003	0.005	0.005
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	<0.03	<0.03	0.03	<0.03	<0.03	<0.03
Selenium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	0.03	0.06	0.1	0.05	0.05	0.05
Total Coli (count/100 ml)	200	42	600	450	205	0
Faecal Coli (count/100 ml)	8	1	25	10	1	0

The 6 samples of Table 2.3 have also been tested for levels of the pesticides Aldrin, DDT, Propaxur and Endosulphane. No traces of these pesticides were detected in the tested samples.

The only industrial activities in the Mozambican part of the river consist of a ceramic factory, bentonite mining in open pits and quarries for building stones. No point sources of water pollution exist in the basin, but the water quality may be adversely affected by the following factors:

- loss of the water retention capacity of the soil and erosion resulting from wind, overgrazing and deforestation;
- discharge of drainage water from irrigated lands, containing residues of fertilizers and pesticides;
- drought periods and excessive evaporation due to the presence of water plants, especially in the Movene River;
- salt water intrusion and salination of the soil in the lower stretches of the river.

Just upstream of the Maputo water supply intake the river water is used extensively by the local population for washing, cleaning of trucks and tankers and various other purposes. These activities may adversely affect the raw water quality for the Maputo water supply.

c. Pequenos Libombos Dam

The main purpose of the Pequenos Libombos Dam is to supply water to Maputo City. Potential environmental problems in relation to dams are:

- changes in the downstream river flow patterns, possibly resulting in stagnant conditions, diseases (Schistosomiasis, Malaria), eutrophication, water poliution, disturbance of fish migration cycles and seawater intrusion;
- social problems resulting from socio-economic developments in the dam area;
- siltation, eutrophication, weeds and water pollution in the reservoir;
- changes in the upstream environmental conditions due to the dam's lake impoundment.

No actual data on such effects from the dam are currently available. An Environmental Impact Assessment and Control study is due to start soon with assistance of the African Development Bank. The following recommendations are made for protection of the water resources:

- protection and rehabilitation of the vegetation on the banks;
- careful selection of lands for agricultural development, with respect to the available water volumes for irrigation;
- reforestation;
- creation of buffer zones between irrigated areas and water resources;
- already degraded lands, e.g. by salination, should not be rehabilitated at any effort, but possibly be converted into natural reserves.

The Pequenos Libombos reservoir has potential for fishery development. Studies to this purpose should be carried out, prior to considering introduction of new fish species into the lake.

d. Population

There are 3 villages in the Umbeluzi River basin, respectively Boane, Namaacha and Goba. There are no data on the population number. On the basis of a total rural population of 450,000 in Maputo Province, it is estimated that the population number equals approximately 45,000. Three social groups live in the Umbeluzi basin:

- land owners and workers;
- traditional rural population in villages and private properties;
- displaced persons more or less settled in the area.

All people are directly dependent on the river water for their water supply. Poor living conditions and lack of employment opportunities contribute to the social and environmental problems in the area.

e. Umbeluzi River Estuary (Ref 4)

The water in the Umbeluzi River estuary has a fluctuating salinity depending on the river flow and tidal inflow of seawater. The estuary contains a significant mangrove forest and it has a large variety of mammals, birds and aquatic organisms. It is also an important hatchery for fish and crusteceans. From about 1980 the local population has started to cut mangrove trees in order to fulfil their fuel wood demands, other wood sources having been depleted. A significant area of mangrove forest was also cleared for developing the production of salt. The clearing of mangrove forest, in combination with salt production and human settlements, has caused serious environmental impacts on the ecological resources in the estuary and on the natural system for protection against erosion and flooding. The current processes of erosion and loss of vegetation may result in moving the zone of tidal influence further inland.

f. City of Maputo water supply and wastewater disposal

The Pequenos Libombos Dam in the Umbeluzi River is the major source for water supply to the urban conglomerate of Maputo and Matola. The water supply system consists of an abstraction system at about 10 km downstream of the dam, a treatment plant, a main transportation pipe and the distribution network in the city. The present water supply capacity amounts to 150,000 m^3/d (144,000 m^3 from the Umbeluzi and 6,000 m^3 from groundwater resources). The estimated water demand for the year 1997 equals 112,700 m^3/d (Ref 8). The current capacity of the system is considered to be sufficient up to the year 1999.

Urban and industrial wastewaters are mainly discharged into the sewerage system, which serves part of the city, septic tanks and soakage pits. Part of the city is served by a wastewater treatment plant (anaerobic, facultative, maturation ponds system), which discharges its effluent into the Infulene river, which drains part of the city. The design flow of the wastewater treatment plant is 8,600 m^3/d, but the actual flow is in the range of 2,000 - 4,000 m^3/d (Ref 9). Some industries, including a brewery and a paper mill, discharge directly into the Infulene River.

Most of the wastewater and stormwater from Maputo is discharged directly into Maputo Bay by a large number of outfalls. Wastewater discharges from Maputo do not effect the water quality in the Umbeluzi and Maputo rivers, since the city's discharges are well downstream of the river outflows into Maputo Bay.

2.2.4.2 Swaziland

a. Water quality and sources of pollution

The Black Umbeluzi is the major source of the Umbeluzi River system. Its major source is located near Mkhaba in the Highveld. The water quality at the source is characterised by a high phosphate concentration, average 2.1 mg P/l. Since there are no sources of phosphate in the Mkhaba region, it is considered that this high concentration is caused by geochemical processes. In Maphevini, at a distance of 10 km from the border with Mozambique and downstream of the large irrigation schemes, the phosphate concentration of the river water has increased slightly to an average value of 2.3 mg P/l.

SEA operates 5 water quality monitoring stations along the Black Umbeluzi, 2 along the White Umbeluzi and 2 stations after the confluence of these rivers. Samples are taken once monthly. Average analysis results of 2 stations over the period January to June 1994 are given below:

Monitoring station	Mnjoli Dam	Maphevini
COD, mg/l	16	18
Nitrate, mg N/l	0.15	0.6
Phosphate, mg P/l	2.1	2.3
TDS, mg/l	40	80

The deterioration of the water quality can be contributed to domestic sources along the rivers, drainage water from irrigated fields, livestock farming and discharge of sugar mill effluents.

A diamond mine is in operation near Ovololwako, just upstream of the N'njoli Dam. The mine abstracts water from the Black Umbeluzi for processing the Kimberley ore. The slimes from the production process are stored in holding ponds. The effluent from these ponds is recycled to the mine.

Simunye Sugar Mill and proposed distillery at Simunye Sugar Estate (Ref 12)

The Royal Swaziland Sugar Corporation is constructing a distillery at the Simunye Sugar factory. Production is planned to start in November 1995 with a production capacity of 10,000 m^3 ethanol per year. The Simunye sugar factory processes 1.2 million t sugar cane per year with an output of 160,000 t raw sugar. The estate, with 9,800 ha irrigated sugar cane land, is located in the lowveld in the north-eastern part of Swaziland. The Black and White Umbeluzi rivers flow through the estate, receiving the effluents from the sugar factory and the future distillery. The sugar factory wastewater is treated in an activated sludge plant. Currently no adverse effects on the water quality in the receiving water courses have been observed from the discharge of the sugar mill effluents.

The distillery will produce the following quantities of waste:

- concentrated stillage: 85 t/d (55% dry matter);
- acid concentrate: 90 m^3/d (BOD = 17,000 mg/l; COD = 55,000 mg/l; pH = 4.8);
- floor washings: 10 m^3/d (COD = 4,000 mg/l; pH = 5);
- cooling water bleed: 50 m^3/d (COD = 50 mg/l; pH = 8.2).

The following system for handling the distillery wastes is proposed:

- the stillage is used as an organic fertilizer on the sugar cane fields, which will have a beneficial effect on the use of fertilizer and the organic matter content of the soil;
- the liquid wastes are led to the existing wastewater treatment plant, which will be upgraded with an anaerobic pond and a wetland system for effluent polishing;
- the treated effluents are reused as much as possible in the factory and for irrigation.

Proposed tannery at Simunye Sugar Estate

No data on this project were available yet.

Sand River Dam irrigation scheme

The water stored by the Sand River Dam in the Komati River basin is used for irrigation of citrus plantations. The drainage water from these plantations flows into the Umbeluzi River.

b. Water use

As indicated sub a. above, water from the Black Umbeluzi is used for irrigation, process and cooling water for sugar mills, livestock farming and for a diamond mine. The water supply of Mbabane also uses water from the Black Umbeluzi. The wastewater from Mbabane is treated in a ponds system and subsequently discharged in the Usushwana River (Maputo River basin). The total water abstraction from the Umbeluzi River system is estimated at 180 Mm^3/yr.

c. Ongoing plans

There is a plan, for the long term, to recycle the Umbeluzi River water from Maphivini (near the border with Mozambique) to the Mnjoli Dam reservoir. The impacts of this plan on the availability and the quality of the river water in Mozambique have to be assessed.

The Management of Tambankulu Estate has taken the initiative for creating an Umbeluzi Catchment Association with the objective to develop measures for appropriate management of the Umbeluzi River water resources in terms of utilisation and maintaining a good water quality.

2.2.5 Agreement on water resource sharing

From 1976 Mozambique and Swaziland have an agreement for sharing the water in the Umbeluzi river system. The agreement entails that Mozambique is entitled to 40% of the measured water inflows at the hydrometric stations GS-3 and GS-10 in the Black Umbeluzi and the White Umbeluzi, which amounts to an average water quantity of 91 Mm^3/yr.

2.2.6 Recommendations for environmental improvement

Measures for protection of the river water quality should be based on the following principles:

- minimization of pollutant loads from domestic, industrial and agricultural sources by prevention and treatment of effluents and improved agricultural practices, including non-irrigated buffer zones;
- protection and rehabilitation of forests, vegetation along the river and tributary banks, mangrove forests and plantation of wind breakers;
- introduction of regular water quality monitoring programmes and integrated water and land management in the river basin.

2.3 Maputo River

2.3.1 Hydrography

The Maputo River drains an area of 29,800 km^2, of which 1,570 km^2 lies in Mozambique, 17,430 km^2 in RSA and 10,800 km^2 in Swaziland. The main tributaries are the Usutu River, in Swaziland and RSA, and the Pongola River in RSA. The length of the river in Mozambique is 130 km. The highest altitude in the basin is about 2,000 m in Swaziland and RSA. Hydrological data on the Maputo River are (Ref 1,2):

- Maputo River (Station E-6, Madubula at the frontier with RSA):
  MAR 2,930 Mm^3

- Usutu sub-basin:
  MAR 2,010 Mm^3 (1,184 Mm^3 in dry year)

- Pongola and Mgwavuma sub-basins:
  MAR 1,244 Mm^3 (673 Mm^3 in dry year)

- Lake Mandjane and minor tributaries in Mozambique:
  MAR 76 Mm^3 (20 Mm^3 in dry year)

2.3.2 Dams

Pongolapoort Dam (RSA)

This dam, in the Pongola River, has a storage capacity of 2,500 million m^3 with a potential water supply capacity of 890 Mm^3/yr. However the capacity has been reduced to about 773 Mm^3/yr as a result of upstream exotic afforestation in the Pongola River basin (Ref 18). The dam plays an important role in regulation of excessive water flows. The dam's reservoir lies partially in Swaziland.

Dams in the Usutu River basin in RSA

In the RSA part of the Usutu River basin are 4 dams, respectively the Westoe, the Jericho, the Morgenstond and the Heyshope. Sites for 3 new dams have been identified, respectively the Merriekloof (which would cut off the water supply by the Ngwempisi River to Swaziland completely), the Ishelo and the Bakenkap.

Luphohlo Dam (Swaziland)

The Luphohlo Dam is located in the Usushwana River at the point of confluence with the Mbabane River. The dam is used for hydro-power generation (capacity is 20 MW).

Mkimkomo Weir (Swaziland)

The Mkimkomo Weir is located in the Usushwana River, near the Matsapha Industrial Complex, and just before this river's confluence with the Usutu River. The dam provides water to 2 hydro-power plants, Dwaleni (10.5 MW) and Makuduza (7.5 MW).

Small reservoirs in the Usutu River basin (Swaziland)

There are 3 small reservoirs in minor tributaries in the Big Bend area, supplying water to the irrigation schemes in that area. These reservoirs are: Nyetane Dam, Sufunga Dam and Hendrick Van Eck Dam.

Dam in Ngwempisi River, Swaziland (planned)

The Government of Swaziland has a plan, for the long term, to construct a dam in Ngwempisi River.

2.3.3 Irrigation and afforestation

2.3.3.1 Mozambique

Currently no large-scale irrigation schemes exist in the Mozambican part of the Maputo basin, but there are good potentials for agricultural development in river area. The total irrigable area is about 61,000 ha.

2.3.3.2 Swaziland

In Swaziland the following irrigation schemes are found along the Usutu River:

- Malkerns, between the Usutu and Ngwempisi rivers. Area is about 4,500 ha and the water consumption is 59 Mm^3/yr. Various crops are cultivated, including potato, maize and fruits.
- Big Bend, with mainly cultivation of sugarcane (location of the Ubombo sugar mill. Area is about 10,840 ha and the water consumption is 185 Mm^3/yr.
- along the Ngwavuma River is an irrigated area of about 2,600 ha with a water consumption 31 Mm^3/yr.

The area under exotic forest, in the western part of the river basin, equals about 70,000 ha.

2.3.3.3 RSA

Usutu River

No data on irrigation in the RSA part of the upper catchment area could be obtained. The area, covered with exotic forest, is approximately 200,000 ha. The area, available for additional afforestation, is 40,200 ha.

Pongola River

The irrigated area in the upstream area of the river basin equals 1,670 ha (planned to be expanded to 3,470 ha). The area under exotic forest is 34,000 ha, with a maximum potential expansion to 101,000 ha.

An irrigation scheme with an area of 6,400 ha is planned in the middle stretch of the river upstream of the Pongolapoort Dam.

The area, irrigated with water from the Pongolapoort Dam, is 10,800 ha, with a possible expansion to about 14,000 ha. It is further planned to use water from the Pongolapoort Dam for irrigation of 30,000 ha land in Kwa Zulu, downstream of the dam.

2.3.4 Environmental aspects

2.3.4.1 Mozambique

a. Water use

Currently the abstraction from the Maputo River in Mozambique is not controlled. Water is mainly used for domestic use and for supply to the city Bela Vista, and for small scale farming. River basin development plans in RSA entail a flow reservation of 65 Mm^3/yr in the Pongola River to Mozambique (calculated on the basis of the surface area of the Mozambican part of the river basin).

b. Water quality trends

DNA operates 2 water quality monitoring stations, respectively in Catuane at the Usutu River (hydrometric station E-393) and Madubula (hydrometric station E-6) after the confluence of the Usutu and Pongola rivers. Average results of 1993 are given in Table 2.4.

Table 2.4 Maputo River water analyses results, average data of 1993
Source: DNA

Station	E-393	E-6
Turbidity (NTU)	77	no data
EC (umhos/cm)	140	230
Chloride (mg/l)	17	27
Nitrate (mg/l)	1.3	1
Ammonia (mg/l)	0.36	0.3

Over the period 1972 - 1977 the electrical conductivity (EC) of the Maputo river water in Mozambique increased from 100 to 250 umhos/cm, at a flow of about 75 m^3/s. Hence it can be concluded that the discharge of salts and solids into river shows a significant increase (Ref 10).

c. Land use

Most of the Mozambican part of the Maputo basin consists of a fairly narrow strip of land in the river valley. The village of Bela Vista, the centre of the region, is located in the river valley.
Economic activities consist of small scale farming (maize, sugar cane, cashew, livestock), production of charcoal and exploitation of limestone deposits in the Salamanga area. There is a railway for transportation of the limestone to Maputo City. To the south of the Maputo basin, in the direction of the South African border is a large plantation of Eucalyptus, for which substantial volumes of water from the Maputo River are used. The low lying lands in the river valley probably have a high potential for agricultural development.

2.3.4.2 Swaziland

a. Water use

The estimated water use in Swaziland from the Usutu River basin water resources is about 325 Mm^3/yr (275 Mm^3 for irrigation and 50 Mm^3 for domestic and industrial uses). The abstraction from the Pongola River amounts to about 10.7 Mm^3/yr (Ref 18).

b. Water quality and sources of pollution

The Usutu river and its tributary, the Usushwana River, flow through the most developed region of Swaziland. The water quality of these rivers is somewhat affected by acid deposition from the East Transvaal Highveld coal-fired power plants. Monitoring results of the Usutu water at the South African border, near Sandlane, showed a decrease of the pH from 7.4 to 6.9, and an increase of the sulphate concentration from 1.2 to 2.2 mg/l, over the period 1982-1990.

Major sources of pollution of the Usutu and its tributaries are briefly described below:

Usushwana River

There are 5 water quality monitoring stations along this river.
Major sources of pollution are:

- tourist resort development near Ezulwini
  An extensive tourist resort complex is located near the Luphohlo Dam. The complex operates a wastewater treatment plant, consisting of stabilization ponds. The treated effluent is discharged into the Usushwana.

- Malkerns
  The urban centre of Malkerns discharges its effluent and run-off water into the Mhlambyathi River, which flows out into the Usushwana. The Mhlambyathi is used for water supply to the nearby community of Lobamba, with an intake downstream of the effluent discharge. The water supply for Malkerns is abstracted from the Usutu River, at about 20 km downstream of the Uputu Pulp Company (UPCO). The intake water is treated by chlorination.

- Swazican (fruit canning plant) in Malkerns
  This factory produces canned fruits and jams (mainly pine-apple and citrus). The pre-treated effluent is discharged in the same manner as the effluents from Malkerns. The effluent has COD-levels in the range of 1,000 to 4,000 mg/l.

Current wastewater treatment methods include: lime treatment and disposal into basins planted with reed and elephant grass.

- Matsapha Industrial Complex
  Major water polluting industries are the Swaziland Dairy Board, Swaziland Breweries, Swaziland Meat Industries and Conco (manufacture of Coca Cola concentrate). These industries discharge their wastewater into the Matsapha wastewater treatment plant (stabilization ponds). This wastewater treatment plant is managed by the Water and Sewage Board. The effluent is discharged just upstream of the Mkimkomo Dam. Two other major industries are located in this industrial area, respectively the National Textile Industry (Natex) and Swazi Paper Mills (SPM).

  Natex produces wastewater with COD-levels up to 2,000 mg/l and phenol concentrations up to 1,900 mg/l (data of 1989-1990, Ref 14). The factory operates a wastewater treatment system consisting of Dissolved Air Flotation and holding ponds. The effluent is discharged directly upstream of the water intake for the Dwaleni power station community, which implies significant health risks. The wastewater treatment system is gradually improved.

  SPM generates wastewaters with COD concentrations up to 5,000 mg/l and phenol concentrations up to 500 ug/l. It discharges its effluent downstream of the Mkimkomo Dam into the Usutu River. The flow is very high.
  Part of the effluent is sprayed over fields.

  As a result of the wastewater discharges from these industries the Usushwana River water is frequently of a poor quality with an average COD-level of 208 mg/l over the period 1988-1990. The people, living downstream of these factories along the Usutu River, are badly affected by the poor river water quality.

Usutu River

There are 11 water quality monitoring stations along this river.
Major sources of pollution are:

- Usutu Pulp Company (UPCO) in Bhunya
  UPCO applies the Kraft pulping process. The effluent has COD-levels up to 400 mg/l and occasionally very high phenol concentrations up to 3,000 ug/l. Fish kills in the river have been related to the high discharges of phenol. Two communities, about 20 km downstream of UPCO, depend on the river water for their water supply. In spite of the significant wastewater discharge the downstream water quality is generally good, except when there are accidental discharges from UPCO. Another source of water pollution at UPCO is an old waste dump from where polluted leaching water enters the river.
  UPCO has taken various measures to reduce its discharge of wastewater into the river. Measures include: modification of effluent discharge channels, ponding in combination with solar evaporation and seepage into the soil, and construction of a barrier between the river and the waste disposal sites.
  The average effluent discharge amounts to about 32,000 m^3/d.

- irrigation schemes and Ubombo Sugar Mill
  Along the Usutu are 2 major irrigation schemes, respectively Malkerns and Big Bend. The Ubombo Sugar Mill, located in Big Bend, is equipped with a pond system for wastewater treatment. The irrigation schemes may cause discharge of salts,

nutrients and pesticides into the river but there are no data on the effects on the river water quality.

- Manzini urban area
  The urbanised area of Manzini drains into the Usutu. Three different pond systems are operated in the area for treatment of the wastewaters. The city's water supply has an intake at the Usushwana, upstream of the Matsapha Industrial Complex.

- Coal mine, Emaswati
  This coal mine in the Lowveld was closed in 1990.

Mkhomovo and Ndlotane Rivers

These southern tributaries of the Usutu receive effluent from a paper mill near Piet Retief, RSA. This discharge causes incidentally pollution problems, with foaming and increased concentrations of phenol and sulphide. For example in 1990 a phenol concentration of 190 ug/l was measured near the village of Magubheleni.
There are 2 water quality monitoring stations along these rivers.

Ngwempisi River

There are no industrial polluters along this river. In 1989 the river water had an average COD of 16 mg/l (with peak values up to 45 mg/l), and an average EC of 63 umho/cm. There are 2 water quality monitoring stations along this river.

Ngwavuma River

There are no specific polluters along this river, which flows out into the Pongola River in RSA. The main economic activity in the area is small scale farming. There are 2 water quality monitoring stations along this river.

2.3.4.3 RSA

a. General

Usutu River Basin

The Usutu River basin has an area of 17,035 km^2 (with 8,160 km^2 in Swaziland). There are 5 urban centres in the Usutu River basin in RSA, respectively Piet Retief/Ethandakurhanya, Amsterdam, Sheepmore, Lothair and Chrissiesmeer. There are only 2 industries, a saw mill and a pulp factory in Piet Retief, which occasionally causes water pollution problems downstream in Swaziland. Water quality data of the Mgwempisi River are given in Table 2.5.

Table 2.5 Water quality data of the Mgwempisi River, tributary of the Usutu River, at the Merriekloof Dam (figures indicate 50 percentile values)
Units in mg/l unless otherwise indicated

Parameter	50 percentile value
EC, umhos/cm	106
TDS	38
Fluoride	0.2
Nitrite/Nitrate	0.06
pH	7.5
Sodium	4.0
Calcium	3.0
Chloride	5.0
Magnesium	3.5
Sulphate	5.0
Ammonium	0.04

Pongola River

The Pongola River basin has an area of 11,195 km^2 (with 2,640 km^2 in Swaziland). The Pongola River and its tributaries have their sources in the Eastern Transvaal Highveld (about 2,000 m MSL). It subsequently flows through the Middleveld (about 800 m MSL), intersects the Libombos range at the Pongolapoort Dam, and subsequently flows into the low lands (80 m MSL) of Kwa Zulu and Maputoland, where it joins with Ngwavuna and Usutu Rivers prior to entering Mozambique. The Government of RSA gives high priority to socio-economic development in the low land area.
Average rainfall in the basin is 833 mm/yr, varying from 1,100 mm/yr in the western high lands to 600 mm/yr in the eastern low lands.

There are 2 urban centres in the basin, Pongola and Paulpietersberg. The only industries are a saw mill in Paulpietersberg and a sugar mill in Pongola. There are no significant point sources of water pollution. Agricultural runoff and drainage water is the major potential source of river water quality deterioration, but there are no data which give evidence of water pollution problems.

b. Water use

No quantitative data on the water abstraction from the Usutu River basin are available. The basin area is for about 25% covered with exotic forest. Water is further used for domestic purposes and for the pulp mill in Piet Retief. Currently a study is carried out regarding the transfer of Usutu River water to the Vaal River basin (Ref 20).

The water abstraction from the Pongola River system amounts in 1995 to about 463 Mm^3/yr (360 Mm^3 for irrigation, 55 Mm^3 for afforestation and the remainder for domestic and industrial uses. It is planned to increase the abstraction in 2010 to 698.4 Mm^3/yr (585.9 Mm^3/yr for irrigation and 100.3 Mm^3/yr for afforestation). A flow of 158.5 Mm^3/yr is reserved for ecological purposes and for Mozambique.

2.3.5 Agreements on water sharing

No formal treaties have been signed by RSA and Swaziland regarding sharing of the water resources in the Usutu River basin. RSA has adopted the point of view that compensation water for Swaziland could amount to half of the flow available 80% of the time during the low flow months of July to October. This would yield to about a flow of about 67 Mm^3/yr to Swaziland (Ref 20). It should be assessed how this amount affects the current water use from the Usutu River in Swaziland, amounting to 325 Mm^3/yr.

2.4 Incomati River

2.4.1 Hydrography

The Incomati River drains an area of 46,200 km^2, of which 14,900 km^2 lies in Mozambique, 28,700 km^2 in RSA and 2,600 km^2 in Swaziland. The major tributaries are the Komati and Lomati rivers (in RSA and Swaziland), the Crocodile River (in RSA), and the Sabie River (in RSA and Mozambique). The length of the river in Mozambique is 280 km. River flow data on the Incomati River and its major tributaries, under natural conditions, are (Ref 1,2,5,16,17,19):

- Incomati River (station E-23, Ressano Garcia at the border with RSA)
  MAR (recorded) 2,025 Mm^3 (28 - 4,296)
  (natural MAR 3,680 Mm^3 at river mouth)

- Crocodile River
  MAR 1,446 Mm^3

- Komati River
  MAR 1,438 Mm^3

- Sabie River (station E-30, Machabuine)
  MAR (recorded) 641 Mm^3 (70 - 1,660)
  (natural MAR 762 Mm^3 at RSA border)

- Uanetze River
  MAR 18 Mm^3

- Masintonto River
  MAR 16 Mm^3

The actual flow of the Incomati River at the point of inflow into the ocean is, however, much lower. It is currently estimated at 405 Mm^3/yr, including 400 Mm^3 from the Sabie River.

2.4.2 Dams

a. Corumana Dam in Sabie River (Mozambique)

Operation of this dam started in 1989. Major characteristics are:

Maximum storage capacity	1,380 Mm^3
Dam crest length	3,050 m
Irrigated area	39,000 ha
Power generation capacity	2x15 MW

b. Moamba-Major Dam in Incomati River (Mozambique) - planned

A new dam has been planned in the Incomati River, the Moamba-Major dam. This dam has a discharge capacity of 2,150 million m^3 per year, a power generation capacity of 26.8 MW and the potential for irrigation of 110,000 ha agricultural land.

c. Dams in RSA and Swaziland

In RSA and are the following dams in the Incomati system:

- Edinburgh, Casteel, Acornhoek and Da Gama Dams and 5 smaller dams in the Sabie River sub-basin;
- Injaka Dam (planned) in the Sabie River, with a storage capacity of 123 Mm^3);
- sites for 5 other dams in the Sabie River sub-basin have been identified, with atotal capacity of 551 Mm^3;
- Braam Raabenheimer (or Kwena) Dam and 7 smaller dams in the Crocodile River sub-basin;
- Driekoppies Dam (under construction) in the Lomati River near the Swaziland border (gross storage capacity is 251 Mm^3);
- in the Komati River basin are the following dams:
  - o Nooitgedacht and Vygeboom, with a combined storage capacity of 136.7 Mm^3, and a net draft of 141.3 Mm^3/yr, which is mainly diverted by a transfer canal to the Eastern Transvaal Highveld power stations,
  - o Shiyalongubo, with a storage capacity of 2.3 Mm^3 and a net draft of 4.3 Mm^3/yr,
  - o sites for 5 other dams have been identified (Ref 19).

In Swaziland are the following dams in the Incomati River basin:

- Sand River Dam in the Komati River sub-basin near the border with RSA (storage capacity is 44.1 Mm^3);
- Maguga Dam (planned) near Piggs Peak in the Komati River (gross storage capacity is 332 Mm^3).

All these dams serve primarily for water supply to irrigation schemes.

2.4.3 Irrigation and afforestation

2.4.3.1 Mozambique

There are 33 irrigation schemes in the Incomati River basin with an area of 9,042.3 ha (see Appendix I). The total irrigable land area is about 100,000 ha in the Mozambican part of the river basin.

2.4.3.2 Swaziland

Sand River Dam irrigation scheme (Komati River basin):

Water from the Sand River Dam is used for irrigation of citrus and sugarcane plantations, which drain into the Umbeluzi just before the Mozambican border. The total irrigated area is about 13,000 ha with a water consumption of 181 Mm^3/yr. The irrigable area is about 50,000 ha.
The area under exotic forest is 32,500 ha, in the Highveld region, consuming 33 Mm^3/yr.

2.4.3.2 RSA

Komati/Lomati Rivers

The irrigated area in the Komati River basin is approximately 28,000 ha, with a water consumption of 284 Mm^3/yr. The total irrigable area is 179,000 ha.
The area under exotic forest is 83,800 ha, consuming 71 Mm^3/yr (Ref 19).

Sabie River

In the RSA part of the Sabie River basin the irrigated area is 11,320 ha. The area under exotic forest equals 72,100 ha. The total area of irrigable lands is 170,000 ha and the total area with potential for afforestation is 142,000 ha. The exotic forests are mainly on the western slopes of the basin. The irrigation schemes are mainly in the western Middleveld area. Major crops are banana, citrus, avocado and tobacco (Ref 17).

Crocodile River

The total irrigated area equals 91,000 ha, the largest irrigated area in RSA. The irrigation schemes occur mainly along the Crocodile River and along its tributaries, the Elands, Kaap and White rivers. Major crops are maize, citrus (20,000 ha), tobacco, sugarcane (21,000 ha) and sub-tropical fruits.

The area, planted with exotic forest, equals 172,200 ha, mainly in the western and northern central are of the basin. It is estimated that the current land use causes a reduction of the natural runoff by 20% (Ref 16).

2.4.4 Agreements on water resources sharing

In 1982 a Tripartite Permanent Technical Committee was set up with representatives from Mozambique, RSA and Swaziland. This committee has been working since then and although positive results have been obtained in some areas, not much progress has been achieved towards an agreement on sharing the water resources. In 1991 an agreement was reached, which settles the following points:

- authorization for Driekoppies and Maguga dams;
- guarantee for a minimum daily flow of 2 m^3/s to Mozambique at Ressano Garcia at the Incomati River, until an agreement on the joint use of the water resources is reached;
- supply of 425 Mm^3/yr from the Sabie River to Mozambique for the Corumana Dam;

- any major development schemes in the Sabie basin are subject to approval by Mozambique;
- implementation of a joint study on development of the Incomati water resources.

2.4.5 Environmental aspects

2.4.5.1 Mozambique

a. Water use

The water demands in this river basin in Mozambique are as follows:

Domestic water supply: 15 Mm^3/yr
Control of salt water intrusion: 63 Mm^3/yr
Irrigation: 321.3 Mm^3/yr (theoretically if all existing irrigation schemes are fully used).

The availability of water resources is mainly affected by upstream irrigation schemes, afforestation projects and irregular climatological conditions (droughts), and as a result the Incomati River has dried up completely in Mozambique.
It has been estimated that the natural Mean Annual Runoff of the Sabie basin has been reduced from 762 to 663 Mm^3 due to afforestation projects (Ref 7).
At a current use of about 218 Mm^3/yr (including afforestation) in RSA from the Sabie River, and at a guaranteed supply of 425 Mm^3/yr of Sabie River water to Mozambique, there is little scope for further development of the Sabie River basin water resources in RSA. Moreover a perennial flow is required in the Sabie River for maintaining the eco-systems in the Kruger National Park.

b. Water quality data and sources of pollution

DNA operates 2 water quality monitoring stations, respectively in Ressano Garcia (hydrometric station E-23) and Manhica (hydrometric station E-28). Average results of 1993 are given in Table 2.6.

Table 2.6 Incomati River water analyses results, average data of 1993
Source: DNA

Station	E-23	E-28
Turbidity (NTU)	50	13
EC (umho/cm)	320	440
Chloride (mg/l)	27	80
Nitrate (mg/l)	1.3	0.9
Ammonia (mg/l)	0.1	0.1

Urban centres in the Incomati River basin are Manhica, Palmeira, Mapulanguene, Magude, Moamba and Ressano Garcia. There are 2 sugar mills, both along the main raod from Maputo to Xai-Xai, but only one is currently in operation. It produces about 10,000 t raw sugar per year (capacity is 40,000 t/yr). The mill's sugarcane fields have an area of 2,000 ha. The water abstraction capacity from the Incomati River equals about 10,000 m^3/h for irrigation and mill operation. The mill's effluents are used for irrigation. The molasses is sold.

There are no other industries in the basin area.

c. Corumana Dam

The primary objective of the dam is to provide water for irrigation. However, because of the problems caused by the war, it is now being managed mainly for electrical power generation. Other potential benefits of the system include irrigation, flood control, water supply and fishery. About 15,000 people live in the area around the dam. Management of the dam for electricity supply implies that large volumes of water are released over short periods in order to satisfy peak demands. There are no provisions for control of the released water flows downstream. As a result the periodically released peak flows may cause the following problems in the downstream riverbed:

- river bank erosion and consequential transport of sediments and deposition;
- management of irrigation systems is difficult by the lack of storage capacity of the periodical very high water flows;
- the aquatic life in the river is seriously disturbed by the high flow fluctuations and related variations in the water quality;
- sudden high river water flows cause danger to river water users, especially children.

2.4.5.2 Swaziland

a. Water quality and sources of pollution

The Komati River, flowing from RSA through Swaziland back into RSA, is the main tributary in the Incomati River system in Swaziland. Average river water quality data during 1989 at the bridge in the Mbabane-Piggs Peak road:

EC	78 umhos/cm
pH	7.4
COD	11 mg/l

The major industrial activity is the Havelock Asbestos Mine near the border with RSA. The effluents from the mine with high concentrations of serpentine (containing $MgSO_4$) is stored in ponds where the serpentine settles. The effluent is discharged into the Komati River.

2.4.5.3 RSA

Since the Komati River Basin, the Sabie River Basin and the Crocodile River Basin are considered as separate catchment areas in RSA, are the environmental aspects of these river basins discussed separately

1. Komati River Basin

The main source of the Komati River is near Breyten in RSA at an altitude of about 1,800 m MSL. The river, with a length of 455 km, flows through Swaziland back into RSA where it joins the Crocodile River at Komatipoort just before the Mozambican border. Major tributary of the Komati is the Lomati River, which has its main source near Barberton at an altitude of 1,890 m MSL. The Lomati River has a length of 150 km and a catchment area of 1,520 km^2. The total area of the Komati/Lomati sub-basin is 11,087 km^2. In 1982 the basin had a population of 315,200 persons (Ref 19). The natural MAR of the Komati River, at the point of joining the Crocodile River, is 1,438 Mm^3 (including 364 Mm^3/yr from the Lomati River. The water requirements in the

Komati River basin are as follows:

Purpose	Present requirement (Mm^3/yr)	Future requirement (Mm^3/yr)
	RSA/Swaziland	RSA/Swaziland
Afforestation	71/33	no data
Irrigation	284/181	no data
Urban/industrial/ETH power plants	140/15	161/54
Total	495/229	

The major urban centres in the basin are Carolina, Barberton, Badplaas and Komatipoort (all in RSA), Bulenbu and Piggs Peak (both in Swaziland). In these places are some light service industries. There are no other industries in the basin.

There are coal mines near Breyten and Carolina. Further development of the coal reserves in the basin is planned. Asbestos is mined between Badplaas and Balenbu and also in Swaziland.

There are no significant point sources of pollution in the river basin. Agricultural runoff and drainwater discharge is the major potential source of water pollution.

Major water resource development plans in the basin are the Maguaga Dam in Swaziland and the Driekoppies Dam in RSA (currently under construction).

Average water quality data of the rivers in the Komati River basin are given in Table 2.7. These data indicate that the water quality is still acceptable for its designated uses.

Table 2.7 Average water quality data of the rivers in the Komati River basin (data from water quality monitoring programmes in RSA and Swaziland) Units in mg/l unless otherwise indicated

Parameter	Komati	Sabie	Crocodile
EC, umhos/cm	121	99	157
TDS	89	74	112
pH	7.3	6.9	7.1
Sodium	10	6	10
Magnesium	6	4	7
Calcium	11	6	9
Fluoride	0.1	0.1	0.2
Chloride	10	7	8
Nitrate	0.09	0.16	0.26
Sulphate	5	5	9
Phosphorus	0.016	0.015	0.019
Hardness ($CaCO_3$)	47	31	53
Alkalinity ($CaCO_3$)	47	32	55
Silicium	7.9	6.2	8.3
Potassium	1.1	0.8	1.0
Ammonia	0.1	0.05	0.08
Sodium Adsorption Ratio (meq/l)	0.6	0.6	0.6

2. Sabie River Basin (Ref 17)

a. General

The Sabie River basin has an area of 7,096 km^2, of which 90% lies in RSA. In 1985 the population number was 338,000 (estimated number in 2010 is 691,000).
The natural MAR of the river is 762 Mm^3 (reduced to 633 Mm^3/yr by afforestation). The major tributary is the Sand River with a natural MAR of 145 Mm^3. More than 50% of the basin consists of natural parks, respectively Kruger National Park, Sabi Sand Wildtuin, F.C. Erasmus Natural Reserve and Calcutta Natural Reserve. The elevation of the basin varies from 1,700 m MSL in the west to 200 m MSL in the east, in the Kruger National Park. The average rainfall varies from 1,600 mm/yr in the west to 600 mm/yr in the east.

The Kruger National Park is located in the East Transvaal Lowveld. It has a surface area of about 20,000 km^2.

Current water use in the Sabie River basin is as follows:

- domestic/industrial 9.2 Mm^3/yr
- irrigation 102 Mm^3/yr
- afforestation 106.6 Mm^3/yr
- total 217.8 Mm^3/yr

By increased use and expansion of irrigation it is estimated that the water requirements will increase to 295.8 Mm^3/yr by the year 2010

b. Water quality and sources of pollution

The water quality of the Sabie River is still considered very good, also in view of the quality requirements for the natural parks. Water quality data are given in Tables 2.7 and 2.8. The DWAF impiements a regular water quality monitoring programme at various points in the river basin.

The major urban centres are Mkuhlu, Thulumahashe, Bosbokrand, Sabie and Graskop. There are 6 municipal sewage treatment plants within the basin, discharging totally 3,090 m^3/d of effluent into the rivers.

There are 5 small gold mines in the south-western part of the basin. These mines consume 140 m^3 water per day for drilling and processing. No water pollution problems in relation to mining activities are currently reported. However in the 1920s the mines caused serious damage to the aquatic life in the Sabie River.

There are relatively little industries in the Sabie River basin. In the urban centres are some light industries. In the forest areas are 12 saw mills. In Graskop and Sabie are 3 wood product industries. None of these industries causes water pollution.

A gradual deterioration of the water quality is caused by agricultural runoff and drainage water discharge. This is most clearly shown by a gradual increase of the electrical conductivity.

From the current data it can be concluded that quantitative management is the major issue in the Sabie River basin, since the increasing water requirements for the growing population and for further development of irrigation, put a heavy pressure on the naturally available water resources, which are diminished with about 15% by exotic afforestation.

The diminishing flow of the Sabie River has led to the institution of the Sabie River Working Group. A Kruger National Park River Research Programme was embarked upon in 1988 (Ref 6,7).

3. Crocodile River Basin (Ref 16)

a. General

The Crocodile River basin has an area of 10,326 km^2. The river length is 320 km. The natural MAR of the river is 1,446 Mm^3 (reduced to 1,157 Mm^3 by afforestation). In 1991 the population numbered 423,000 persons, of which 109,000 people live in urban areas and 314,000 in rural areas (estimated population in 2005 is 610,000). About 63.7% of the population lives in Nsikazi District, which with a population density of about 450 per km^2, is much more densely populated than the other areas. Nelspruit, the regional centre, has about 62,000 inhabitants. The Kruger National Park occupies about 20% of the basin area.

The basin is divided in 3 distinct geographical zones: the Highveld in the west (> 1,400 m MSL), the Middleveld (800-1,400 m MSL) and in the east the Lowveld (< 800 m MSL). The average rainfall is 880 mm/yr, 1,660 mm/yr in the west and 500 mm/yr in the east).

The major tributaries to the Crocodile River are the Elands, Kaap and White Rivers.

Water demand for (1985):

- irrigation and afforestation 406.6 Mm^3/yr
- domestic, industrial and mines: 20 Mm^3/yr
- total 426.6 Mm^3/yr

b. Water quality and sources of pollution

The water quality in the Crocodile River is gradually deteriorating as a result of urban effluent discharges and runoff, agricultural runoff, and from industrial and mining activities. In the lower Crocodile fairly high ammonia concentrations have been measured (average of 0.06 mg N/l) and in the Kaap River, tributary to the Crocodile, high arsenic concentrations have been observed, making the water unfit for irrigation.

Water analysis data of the rivers in the Crocodile River basin in RSA are given in Table 2.7 and 2.8.

Table 2.8 Water analysis data of the Crocodile and Sabie rivers
Average values over the period 1983 - 1989 (Ref 6)

Sampling station Parameter	Crocodile X2M17	Crocodile X2M16	Sabie X3M12	Sabie X3M15
Total Dissolved Solids, mg/l	252	296	75	89
EC, umhos/cm	333	398	106	131
Chloride, mg/l	16	22	8	11
Sulphate, mg/l	17	17	5	5
pH	7.6	7.7	7	7.1
Ammonium, mg/l	0.06	0.06	0.01	0.07
Fluoride, mg/l	0.3	0.3	0.1	0.1
Nitrite+Nitrate, mg/l	0.69	0.55	0.3	0.13

In the Crocodile River Basin are 23 industries with a water consumption over 150 m^3/d. These industries include 9 fruit processing plants, 1 sugar mill, 1 vegetable and tobacco processing plant, 1 mineral drinks manufacturer, 6 pulp and paper mills, 1 wood board factory, 1 iron and chromium refinery and 2 manganese refineries. These industries have a total water consumption of 65,275 m^3/d.

The pulp and paper mill in Ngodwana generates 17,000 m^3/d of effluent, which is sprayed over 472 ha grassland. This causes a significant increase of the chloride concentration of the groundwater, and consequently of the Elands River water, to which the groundwater drains off.

The manganese metal company in Nelspruit is considered as the most serious water polluter. It discharges ammonia, manganese, sulphate and borium. The plant has a temporary permit, and it is constructing a wastewater treatment plant. The factory dumps liquid and solid wastes in a quarry, from where leachate with a very high manganese concentration is discharged into the Crocodile River.

Mines, mainly occurring in the Kaap River sub-basin, are another source of water pollution. Currently there are 9 mines in operation (2 asbestos, 5 gold, 1 magnesite and

1 talc). Major water pollutants, discharged by the mines, are arsenic, zinc, chromium and salts. Cyanides, which are used in gold mining, is not included in the current water quality monitoring programmes. Additional risks for water pollution, in relation to the mining industry, old waste dumps, rock heaps and slime dams, from where polluted leachates may flow into the nearby rivers.

Other sources of water pollution in the Crocodile River basin include:

- 30 municipal sewage treatment plants (25,000 m^3 effluent per day), with often high ammonia concentrations;
- urban runoff from the densely populated areas in Ka Ngwane, where inadequate sanitation is prevalent;
- agricultural runoff and drainage water causing a significant increase of the salt concentration (from the middle Crocodile to the lower catchment area the TDS concentration increases from 15 to 36 mg/l and return flows from sugarcane fields with TDS levels of 2,000 to 5,000 mg/l have been reported);
- agricultural activities have also caused water contamination with pesticides and herbicides;
- increase of acidity of river water as a result as acid deposition from the East Transvaal Highveld coal-fired power plants (producing 80% of the electricity production in RSA).

In the past the following water pollution problems have occurred:

- Crocodile River : cessation of flow;
  exotic waterweeds;
  pesticides (near Madelane);
  high ammonia level (from Nelspruit sewage treatment plant;
  high manganese levels.
- Kaap River : high arsenic and sulphate levels from mining.
- Elands River : herbicides;
  spillage of black liquor from pulp mill.
- White River : spillage of oil and grease from wood boar factory.

3 ENVIRONMENTAL AND RIVER BASIN MANAGEMENT FRAMEWORK IN MOZAMBIQUE

3.1 Institutional aspects

3.1.1 Institutional framework for river basin management in Mozambique

The most important institutions in relation to management of river basins and water resources are briefly described below.

a. National Council for Water Affairs (CNA)

The Water Law of 1991 has established the Conselho Nacional de Aguas to act as an inter-ministerial organization to advise the Government of Mozambique on water policies, and as a national steering committee for all water management related issues. Members of CNA are representatives of:

- Ministry of Public Works and Housing (chairman of CNA);
- Ministry of Agriculture and Fisheries;
- Ministry of Mineral Resources and Energy;
- Ministry of Health;
- Ministry for the Coordination of Environmental Affairs;
- Director of DNA (technical secretary of CNA);
- President of the Institute for Rural Development.

The CNA is responsible for policy development and analysis of all large-scale water projects. Other tasks of CNA include:

- direction of river basin management;
- coordination of population-related issues and involvement of the population;
- to ensure compatibility of all activities with established water management policies.

CNA has permanent commissions for:

- legislation;
- international rivers (e.g. proposed "Protocol on shared water course systems in the Southern African Development Community region);
- drainage and irrigation;
- hydro-power.

b. Ministry of Public Works and Housing

The Ministry of Public Works and Housing is responsible for planning and supervising all activities related to public construction works and water resources management. The Ministry's objectives in the area of water resources are to ensure the proper use of surface water and groundwater resources in order to fulfil the requirements of the national economy and to guarantee adequate water supply and sanitation for the population. The main functions of the Ministry in the field of water resources management are to:

- promote inventories and balance studies of water resources and establish an adequate water information system;
- promote funding for water resource development studies and projects;

- promote development of legislation and to supervise its enforcement and implementation;
- execute investments for studies, projects and works;
- promote self-reliance and sustainable development in water supply and sanitation.

c. National Directorate of Water (DNA)

The National Directorate of Water (DNA) was created in 1978. DNA serves as the executive agency under the Ministry of Public Works and Housing. DNA bears the responsibility of managing the water resources in the whole country and coordinating the other sectors with involvement in water management at national, regional and local levels. DNA is responsible for supervision of the urban Water Supply Companies and sanitation. The practical aspects of river management in Mozambique have been delegated to 5 Regional Water Administrations (ARAs). ARA-Sul is responsible for management of the Umbeluzi, Maputo, Incomati, Limpopo and Save River basins. The organizational structure of DNA is as follows:

- Department of Finance, Studies and Planning (DEPI);
- Department of Water Resources (DRH), with the sections:
  - o Hydrology, including water quality management,
  - o Hydrogeology,
  - o Climatology,
  - o Hydrometry,
  - o Computing,
  - o Communications;
- Department of Water and Sanitation (DAS), mainly for urban areas;
- Cabinet for the National Programme for Rural Water Supply (PRONAR);
- Cabinet for the National Programme for Low Cost Sanitation (PNSBS), for rural and peri-urban areas (established under the current re-organization programme).

The Institute for Rural Development (INDER) is responsible for promotion of rural sanitation and water supply programmes.

Currently a re-organisation is being considered which implies transfer of Planning to DRH.

The organization of DNA further comprises (i) the Division of Administration and Finance (RAF), (ii) the Cabinet of the Director, who is assisted by a technical council and a technical collective, and (iii) the Professional Training Centre, responsible for organization and coordination of training programmes up to the middle technical level.

DNA has 187 employees (including PRONAR), consisting of 34 higher level technicians, 44 middle level technicians, 42 lower level technicians and 67 administrative personnel.

d. ARA-Sul

ARA-Sul is responsible for management of the water resources and the related infrastructure in the Umbeluzi, Maputo, Incomati, Limpopo and Save River basins. The infrastructure includes dams, hydro-power systems and hydrometric stations. It is also responsible for distribution of water to the large-scale users, mainly irrigation schemes and the Maputo Water Supply Company. ARA-Sul reports to the Director of DNA. Financial resources for operation of ARA-Sul are provided by the Government. The total number of employees is 265. ARA-Sul is a public institution with legal personality

and it is entitled with administrative, patrimonial and financial autonomy. The main activities of ARA-Sul are:

- water resources assessment, including the hydrometric services, hydrological studies and maintenance of the hydraulic infrastructure;
- water resources management, including river basin development planning, licensing, registration of water demands and uses, and involvement of the water users.

Organograms of DNA and ARA-Sul are contained in Appendix II.

e. Water Companies

The Water Companies are responsible for the urban water supply. Currently there are Water Companies in 12 cities. The Water Companies function under the supervision of DNA.

f. Water quality laboratories and Universities

Two laboratories are currently active in water quality monitoring:

- the Maputo Water Supply Company laboratory (LEAM);
- the National Laboratory of Food and Water Hygiene (Ministry of Health).

The Eduardo Mondlane University carries out research and studies in the field of water resources development, water pollution control and environmental protection.

g. Non Government Organizations (NGOs)

There are about 20, most internationally oriented, NGOs active in rural water and sanitation programmes in Mozambique. A list of NGOs is given below:

Oxfam (Belgium)
Oxfam (USA)
Care International
MOLISV (Italy)
ACAV (Italy)
MCDI (USA)
Water Aid (UK)
Médicos Sem Fronteira
(Spain, France, Switzerland)
Save The Children (USA, UK)
World Vision
World Relief
Federacao Mundial Luterana
Comunidade Mahometana
Corpo Suíco
Helvetas (Switzerland)

3.1.2 International river basin management

Most of the rivers, constituting the major water resources for Mozambique, have their source in the adjoining countries to the west of Mozambique. As such Mozambique is in a quite vulnerable position regarding its water supply in terms of possible reduction by increased water consumption, fluctuations in river flows and pollution due to increased population and economic activities in upstream counties. Especially in Maputo Province there is a very high dependency on water from the cross-border rivers. Severe droughts, such as in 1981-1983 may cause disastrous shortages of water for agriculture, domestic use and industries.

From 1963 negotiations, at a technical level, were held with RSA and Swaziland on water management issues regarding the Maputo, Incomati and Limpopo rivers. This

resulted in a principle agreement on cooperation and exchange of information with the objective to achieve optimum utilisation and protection of the river water resources.

Since 1976 there is an agreement between Mozambique and Swaziland regarding the sharing of Umbeluzi River water.

A Tripartite Permanent Technical Committee (TPTC) between Mozambique, Swaziland and the Republic of South Africa is in existence to resolve differences in the use of waters common to each country. In 1979 it was agreed that the Helsinki Rules should apply to TPTC negotiations. In recent years discussions have however taken place which go beyond the Helsinki principle of equitable and reasonable sharing of water into the principle of best joint utilisation. In most cases this principle would favour RSA since the other 2 countries are less advanced in water resource development and hence have greater difficulty in justifying its share of water (Ref 15). The recent RSA policy for inter-basin transfer of water is an example of water resource development, which may adversely affect the other countries especially during periods of drought.

Another initiative for integrated international river management is taken by the South African Development Community (SADC), which has a general treaty in preparation. RSA has now become a member of SADC (prior to the joining of RSA the association was known under the abbreviation SADCC). River basin management should be included in the general treaty as separate protocols. SADC is preparing an international Action Plan for the Zambezi River System (ZACPLAN), incorporating integrated river basin planning and management including environmental problems and their impacts (Ref 3). A similar plan might be considered for the Umbulezi, Maputo and Incomati rivers.

Recently a draft memorandum has been prepared, joint by Mozambican and South African agencies, for a programme on collaborative research and capacity building for management of the rivers shared by Mozambique and RSA. The goal of the programme is to promote management of rivers and their estuaries for the long term benefit of the population and for protection of the natural heritage of Mozambique and RSA. The programme includes the following projects:

- capacity building for development of expertise for scientific river basin management and of collaborative networks;
- environmental assessment of the status of river systems;
- assessment of environmental water requirements to sustain the quality of the rivers and the estuaries at a desirable level;
- implementation of a research programme focusing at promotion of long term sustainability of the natural environment of the river systems.

Adequate Master Plans for integrated water resource management, particularly for international cooperation and equitable sharing of water between the countries in the international river basins, are urgently needed.

The Limpopo Basin Permanent Technical Committee has been established between Mozambique, Botswana, RSA and Zimbabwe.

Joint Water Commissions between Mozambique and RSA, between Mozambique and Swaziland, and between Mozambique and Zimbabwe still have to be formalized.

3.1.3 Institutional framework for environmental management

The Ministry for the Coordination of Environmental Affairs (MICOA) was established in December 1994. The mandate and tasks of MICOA include:

- to advise on natural resources management;
- enforcement of pollution control and environmental protection regulations;
- coordination, supervision and monitoring of environmental management in Mozambique;
- development of planning and management capabilities in MICOA and the line ministries;
- creation of models of good practices (demonstration projects);
- promotion of public awareness.

MICOA has the function to coordinate and steer all environment-related policies and activities of (i) the other Government Ministries, (ii) regional, provincial and municipal authorities, (iii) specialised institutes, e.g. the National Institute for Rural Development (INDER) and the National Institute for Physical Planning (INPF), (iv) NGOs, such as the Grupo de Trabalho Ambiental (GTA) and professional organizations, such as the Federation of Industrial Entrepreneurs for the Environment (FEMA), and (v) research institutes, e.g. the National Institute for Agricultural Research (INIA).

MICOA will be organized in a relatively small head office in Maputo and provincial directorates with district branches. Regional centres of MICOA will be set up in Xai-Xai (south), Chimoio (central) and Nampula (north). The objectives of the regional centres are:

- research, data collection, surveys and monitoring;
- technical assistance to local bodies and NGOs;
- promotion of awareness;
- conduction of courses and extension;
- inter-sectoral coordination of environmental issues;
- environmental impact assessment studies;
- establishment of demonstration projects.

Priority needs for organizing and strengthening MICOA are:

- financial support for operational expenditure;
- support for investments, e.g. for setting up the regional centres;
- managerial strengthening through technical assistance and possibly by a partnership with a foreign environmental ministry or institution.

The definitive organizational framework of MICOA has not been finalised as yet. MICOA has currently a staff of 91, including 19 university graduates and 12 medium level technicians.

3.2 Legislation

No specific legislation for environmental management in Mozambique has been introduced yet. The Water Law (Lei no.16 of August 3, 1991) is the most relevant law for protection of the quality of inland surface waters and groundwater. The Water Law contains:

- general regulations for management of the inland water resources;
- regulations for water use;
- regulations for protection of the water quality;
- regulations for protection of groundwater resources.

The Water Law has created CNA and established the following institutional framework for river basin management:

- CNA, responsible for inter-sector coordination and decision making;
- DNA, responsible for implementation of policies, regulation and supervision of operations, management of national databases and planning;
- ARAs, responsible for operational management at basin level.

Other legislation which relates to river basin management includes:

- the Land Act;
- Regulations for industrial activities (of 1930, 1945 and 1969);
- Regulations for investments, foreign and national (1984 and 1987);
- Regulations for safety in oil installations (1947, 1961 and 1967);
- Pesticide regulations (1986);
- Decree for protection of soil, flora and fauna (1955);
- Decree for exploitation of quarries (1979);
- Mine law (1986).

Legislation for environmental impact assessment is being drafted.

3.3 Projects and programmes

3.3.1 National Environmental Management Programme (NEMP)

The National Environmental Management Programme has been prepared by the National Environmental Commission (created in 1992) and it has been submitted for Government approval in May 1994 (Ref 11). MICOA was created as a new Ministry in December 1994.

The NEMP is a Government Programme intending to include environmental management and sustainability issues in all activities aiming at national development. The NEMP is a Master Plan for the environment. It includes formulation of a National Environmental Policy, overall Environmental Legislation and an Environmental Strategy. Key targets of the NEMP are:

- mitigation of the country's most serious environmental problems on the basis of better use and knowledge of the available natural resources;
- introduction of an environmental culture in the country's productive and consumptive processes;
- development of national environmental consciousness;
- institutional capacity building.

The long term target of the NEMP is to achieve sustainable socio-economic development.
The NEMP is closely linked with the National Reconstruction Plan (PRN), which focuses on resettlement and re-integration of displaced and remigrating people, and onwards on reconstruction and national development (see 3.3.2).

Specific environmental problems to be addressed under the NEMP include:

- in rural areas:
  - o deforestation,
  - o loss of biodiversity,
  - o degradation of soils and loss of soil productivity,
  - o environmental damage from dams and eutrophication of surface waters,
  - o depletion of water resources;

- in coastal areas:
  - o loss of mangrove forests,
  - o coastal erosion, especially in cities,
  - o coastal water pollution caused by urban wastewater discharges, shipping and polluted river outflows;

- in urban areas:
  - o lack and degradation of sanitation facilities,
  - o inadequate water supply,
  - o inadequate solid waste management,
  - o settlements on inappropriate sites.

The following constraints have been identified with respect to introduction of effective environmental management:

- the current processes of political and economic transformation in the country;
- socio-economic and demographic problems (poverty, unemployment and displaced persons);
- inadequate institutional framework for natural resources management;
- lack of human resources, information/data, environmental education and research;
- inadequate environmental legislation;
- lack of community participation.

The following financial resources for support to implementation of NEMP have been identified:

- World Bank Environmental Support Project (ESP);
- Global Environmental facility;
- UNDP Capacity 21;
- bilateral and multilateral donors.

MICOA plays a central role in execution of the NEMP. It should ensure that all sectoral plans fulfil the principles of sustainable development and comply with the targets of the NEMP.
MICOA can execute specific projects aiming at developing its capacities, and demonstration projects for developing new approaches.
MICOA has the authority and task to address the degradation of Mozambique's natural environment.

MICOA has prepared a NEMP Support Document, July 1995, which contains an action plan for implementation of the NEMP.

NEMP Support Document

In July 1995 MICOA has published a Programme Support Document, which contains a rolling five year NEMP implementation strategy in UNDP/PSD format. The NEMP Support Document contains a framework of projects to be implemented over a rolling period of 5 years, starting in January 1996.

The NEMP describes a large number of activities which target at strengthening the capacities in environmental management skills. A summary is given below.

1. Strengthening the institutional organization of MICOA, with the targets:

   - internal organization and capacity strengthening;
   - preparation for establishment of for Centres for Sustainable Development;
   - technical capacity in pollution control and legislation monitoring concentrated in a Centre of Environmental Monitoring in MICOA;
   - strengthening of provincial staff;
   - internal management of MICOA's environmental information.

2. Policy development, with the targets:

   - establishment of EIA regulations as a policy instrument for environmental management;
   - creation and improvement of environmental legislation nand capacity building in the institutions that develop, administer and enforce such laws;
   - ensuring adherence to and implementation of International Conventions.

3. Natural Resources Management, with the targets;

   - environmental disaster contingency strategy produced;
   - establishment of comprehensive information system to analyze and monitor status of natural resources.

4. Urban management and regional planning, with the targets:

   - creation of basic urban and environmental management capacities of urban municipalities and regional planning skills;
   - assistance in preparation of Municipal Development Plans for the cities of Maputo, Beira, Quelimane, Nampula and Pemba;
   - participation in the preparation of the complementary legislation to the Municipal Law (3/94) and capacity building of municipalities in environmental management;
   - preparation of national policies and strategies on urban environmental management;
   - promotion of appropriate urban development strategies and environmental investment management procedures;
   - assistance in preparation of a Management Plan for the province of Maputo as the framework for the management of natural resources and development investments;
   - elaboration of a sustainable development concept for the province of Nampula, with the involvement of all relevant stakeholders;
   - elaboration of a sustainable development concept for the province of Nampula, with the involvement of all relevant stakeholders.

5. Coastal zone management, with the targets:

   - integrated coastal zone management in Mozambique.

6. Environmental education, with the targets;

   - increased negotiation and dialogue with business community;
   - formal links with NGOs and CBOs (Community Based Organizations);
   - raising public environmental awareness through informal channels;
   - promote the introduction of environmental aspects in the school curricula.

7. Coordination and support of external activities, with the targets:

   - develop capacity to contribute substantially to national environmental policy development;
   - support training of line ministry staff in sustainability and environmental issues;
   - support of the institutions involved with sustainable development in Mozambique.

Financing of NEMP implementation

The total costs of the 5 year programme are USD 38,000,000 of which 18% will be contributed by the Government. For 1996 an amount of USD 5,100,000 has been allocated by the Government and various donors on a total budgeted amount of USD 7,814,000. The UNDP is not able to commit funds past December 1996, which is the end of the present cycle.

Ongoing environmental programmes

Currently there are 49 environment-related projects ongoing in Mozambique.
UNEP gives support in marine issues, research, information systems and biodiversity.
The US Government gives support in implementation of the UN convention on climate change.
The World Bank has 7 programmes in wildlife, coastal zones, national environmental strategies, environmental assessment, urban management, local government reforms and GIS databases.
The African Development Bank has a soft loan programme.
The UNDP and the Governments of Sweden and Norway have given core support in strengthening MICOA, environmental assessment of the Katina P oil disaster, forest and wildlife programmes and support to NEMP.
NORAD gives support to wildlife department, coastal zone management, marine research and gender/environment/sustainable development programmes.
SIDA gives support in environmental impact assessment training.
The European Union supports wildlife management, training, environmental assessment and planning.
The Government of The Netherlands gives support to a social science perspective in a natural resources management training course, zoological research and Maputo coastal protection.
IUCN is involved in identification and development of projects with local institutions.
WWF is involved in Bazaruto Archipelago conservation Maputo game reserve projects.
The Ford Foundation supports a community based natural resource management project.

Ongoing and planned projects as part of NEMP focus on the following subjects:

- strengthening of MICOA's organization and capacities;
- policy development;
- natural resources management;
- urban management and regional planning;
- coastal zone management;
- environmental education;
- coordination and support of external activities.

3.3.2 National Reconstruction Plan

The Government of Mozambique has formulated a National Reconstruction Plan (PRN) for war damage mitigation and development. The programme is implemented in 2 main phases:

- Phase 1 (1994 - 1997): resettlement and re-integration of the population;
- Phase 2 (from 1997 onwards): reconstruction and development.

Priorities of the PRN are:

- re-establishment of agriculture and livestock;
- rehabilitation of local trade;
- restoration of infrastructure;
- water supply;
- basic health services;
- education;
- strengthening of local administration;
- promotion of local economic initiatives.

Development of the rural sector is considered as the best approach to alleviate poverty and to improve living conditions, since the economy of Mozambique depends largely on agriculture.

3.3.3 Projects on water resources

The following projects and programmes on water resources development and management are currently ongoing:

a. Netherlands technical assistance to DNA

The Netherlands Government implements a technical assistance programme on water resources from 1978. The programme includes transfer of expertise, e.g. in the fields of groundwater and surface water hydrology, capacity building, training and institutional strengthening. A new programme on Strategic Integrated Water Management has recently started in cooperation with DNA. A project for strengthening the water resource management capacities of ARA-Sul is in preparation.

b. UNDP programme

The UNDP provides assistance in various projects on water management, including institutional strengthening and development of legislation. The programme also includes a number of small-scale projects

c. World Bank programme (proposed)

c.1 The proposed World Bank programme for water resources management and development includes:

- strengthening of the water companies in the 5 major cities;
- strengthening of ARA-Sul;
- joint regional study on the Incomati basin;
- assistance to PRONAR.

A preparation mission for this programme was made to Mozambique in June 1995.

c.2 Programme for trans-boundary water issues

The World Bank is also considering trans-boundary water issues between Mozambique, Swaziland and RSA. Specific issues in this context are:

- Mozambique and RSA both want to review current river basin management issues regarding their shared water resources for which they may seek financial assistance from the World Bank;
- the RSA Department of Water Affairs and Forestry (DWAF) has conducted a study on the Incomati basin, which could not be entirely completed due to political and financial constraints;
- World Bank funding was obtained for a study on the Usutu basin in Swaziland;
- the TPTC has not compiled yet any major review of the tripartite arrangements for the shared river basins.

Southern Waters Ecological Research and Consulting CC has drafted Terms of Reference for a study on the status of water resources developments (current and planned) in RSA and Swaziland and their potential impacts on Mozambique (August 1995).

d. Swiss Government programme

The Swiss Government supports the Department of Water and Sanitation (DAS) and the Training Centre of DNA.

e. Italian Government Programme

The Italian Government is providing assistance in an Integrated Rural Development Programme in the Umbeluzi River basin. Furthermore the Italian Government has prepared Terms of Reference for feasibility study on Integrated Development in the Incomati-Sabie River basins.

f. Proposal for a collaborative research and capacity building programme for the management of the shared rivers of Mozambique and RSA

The programme is initiated by the Rivers Research Liaison Committee (with representatives of MICOA and the Kruger National Park Rivers Research Programme). The major components are: capacity building for river management and research,environmental assessment of the river systems and of environmental water requirements, and development of a research programme.

g. Proposal for development of a conceptual framework for the development of the Pongola River system downstream of Pongolapoort

This programme has been proposed by the Institute of Natural Resources (University of Natal) to the Development Bank of Southern Africa. The proposal aims at formulation of a detailed programme for the socio-economic development and conservation of the natural and human resources of the Maputo River basin in the area downstream of the Pongolapoort Dam. Sofar 3 meetings have been held, attended by representatives from Mozambique, Swaziland and RSA, to discuss this proposal.

h. Others

PRONAR and DNA receive support and co-financing from various other sources, including the Danish Government and UNICEF. The African Development Bank finances rehabilitation of the Massingir Dam in the Limpopo River basin and some small-scale projects. UNESCO also has given technical assistance to DNA in the period 1981-1992.

4 REGIONAL INTEGRATED RIVER BASIN MANAGEMENT PLANNING

4.1 Need for regional integrated river basin management planning

The current pressures on the available water resources in the Umbulezi, Maputo and Incomati river basins, with respect to increasing use of the resources and aggravating impacts on the quality of the water resources and the eco-systems in the basins, urge that immediate measures are taken for integrated water resources development planning in the 3 basins. The need is further stressed because the river basins are shared by 3 different countries, all of them having plans for further development of the water resources in their area of the basins. Regional integrated river basin management planning is hence needed to assess and coordinate jointly the water needs and the development plans of the countries involved. Regional planning should in the first place target at (i) agreements on equitable sharing in the water resources between the 3 countries, (ii) sustainable use of the water and (iii) protection of the water quality and the eco-systems, which are strongly interlinked with the status of the water resources.

The development of integrated planning, with agreements on water use, is especially an urgent need for Mozambique, since as the downstream user of the river waters, it is in the most vulnerable position with respect to ensuring its water supply requirements.

Integrated river basin management planning for the 3 river basins, and the successful implementation of the evolving plans, can only be achieved by effective cooperation between the 3 countries sharing the basins, respectively Mozambique, RSA and Swaziland. Therefore it is proposed that the existing Tripartite Permanent Technical Committee for the river basins, shared by the 3 countries, be upgraded and strengthened to a permanent Southern African River Basin Management Board (SRBMB) in which the national or provincial governments are represented at the highest administrative level. The major objective of the RRBMB would be to formulate and define plans, which should enhance equitable sharing in the water resources between the 3 countries, sustainable use of the water resources and protection or improvement of the environment and ecosystems in the river basins. Subsequently the SRBMB would be responsible for overall supervision and coordination of the implementation of the plans.

There are currently already various proposals and initiative for developing river basin management at an international level, see Section 3.3.3. These proposals target at formulation of socio-economic development plans, environmental assessment, capacity building and institutional strengthening. It is urgently needed that these proposals are evaluated by a centralized committee of experts and policy makers, in order to reform the proposals in such a way that the evolving programmes respond to the most urgent needs and effect the highest possible efficiency and benefits. It is recommended that the proposed SRBMB will be equipped for this purpose.

4.2 Needs for institutional development

For development of regional integrated river basin management planning extensive institutional strengthening is required, at the tripartite, regional cooperation level and at the national levels. Furthermore it is required that the different countries develop comprehensive plans for their areas in the basins, which would serve as a basis for developing the regional plans.

Regional integrated planning for the 3 river basins should be institutionalised at 2 levels:

- at the international level by establishing a permanent Southern African River Basin Management Board (SRBMB) with representatives of the national (or provincial) governments from the 3 countries involved;
- at the national level establishment of river basin management authorities to be responsible for overall management of the areas of the river basins in the different countries.

4.2.1 Southern African River Basin Management Board

The tasks for the SRBMB will be to:

- formulate targets, standards, policies and regulations for regional river basin management, focusing on sustainable use of the resources;
- inventory and assess the water resources in terms of quantities, quality, current use and trends;
- negotiate and establish agreements regarding sharing of the basins water resources between the 3 countries;
- assess proposal for projects and studies related to water resources and environmental management in the river basins, and prepare recommendations for reformulation and implementation;
- assess national plans in terms equity (priority needs), sustainability and technical/economic feasibility;
- direct a proactive regional water resources monitoring programme with respect to:
  - o control and evaluation of water use practices on the basis of mutual agreements and the actual situation in a particular year (annual fluctuations in availability of usable water quantities),
  - o monitoring of water quality and hydrometric data,
  - o sources of water pollution and environmental degradation,
  - o status of natural resources and ecosystems,
  - o management of databases and information exchange,
  - o preparation of annual reports,
  - o identification of activities which adversely affect the water resources and the quality of the environment,
  - o proposals for actions to mitigate such adverse activities,
  - o identification of violations of agreements and regulations, and proposals for actions to address or penalise such violations;
- coordinate and supervise all projects related to water resource development and environmental management in the river basins;
- develop or update integrated regional river basin management plans;
- develop action plans for response to emergencies, e.g. severe droughts and floods.

The SRBMB is composed of representatives of the following national or provincial institutions from the 3 countries:

- Ministry of Foreign Affairs: negotiations, agreements and legal aspects;
- Ministry of Planning: financial/economic aspects;
- Ministry of Agriculture: agricultural aspects and irrigation;
- Ministry of Environment: environmental and ecological aspects;
- Ministry of Energy: hydropower issues;
- Water Resources Management Authority: water needs and development plans.

The SRBMB will have a permanent office in one of the countries, possibly attached to one of the national water management authorities, with the following staff:

- permanent secretary;
- technical officers to develop, supervise, coordinate and evaluate monitoring programmes;
- database and information exchange managers.

4.2.2 National River Basin Management Authorities

In the Mozambican parts of the 3 water basins ARA-Sul is responsible for management of the water resources, under the supervision of the Ministry of Public Works and Housing and DNA. The activities of ARA-Sul are mainly confined to distribution of the water to the gross users (e.g. Maputo Water Supply Company and irrigation schemes) and maintenance of the infrastructure for water storage, transportation and hydrometric stations.

The tasks and capacities of ARA-Sul have to be expanded and strengthened significantly for being developed into an integrated water basin management agency, with responsibility for all related tasks. For this purpose ARA-Sul should have capabilities and capacities to:

- monitor water resources quality (surface water and ground water);
- maintain databases regarding all quantitative and qualitative aspects of the water resources and the inter-related ecological and land resources;
- prepare plans for sustainable use of the water resources;
- assess development plans in the river basins on environmental impacts and sustainability;
- identify and assess sources of water pollution, land degradation and loss of natural and ecological resources and to prepare plans for mitigation of such sources and for further environmental improvement;
- implement the plans;
- enforce regulations regarding water resource management and environmental protection;
- develop action plans for response to emergencies, e.g. severe droughts, floods, forest fires and breakdown of infrastructure.

In the areas where the needed capacities and capabilities cannot be developed at the short term, ARA-Sul can draw the required expertises from other institutions and private firms.

4.3 Integrated river basin management planning in Mozambique

It has been noted that the Government of Mozambique should make an early effort in preparing justifiable and feasible plans for development in its parts of the 3 river basins, primarily for determining the volumes of water it needs to abstract from the 3 rivers for wholesome rural and urban development in the Province of Maputo, in which province the 3 river basins are located. If the Government does not have ready-made plans for these purposes, it will weaken its cause in reaching agreements on water resource distribution with the other 2 countries. Other reasons for accelerating the development of the needed plans are:

- rural development is considered as a primary instrument in the development of Mozambique as a whole, with approximately 80% of the population depending on agriculture for its living;
- the direct vicinity of the city of Maputo provides a good market for rural products and a port for export of the products, and in addition healthy rural development will reduce the population pressure on the city.

Consequently in developing integrated river basin management in the 3 basins in Maputo Province, and subsequently in Mozambique as a whole, the following targets should be attained:

- assessment of water needs for implementation of the river basin development plans;
- formulation of an integrated development plan for the river basin areas in Maputo Province;
- institutional development for joint regional river basin management and for local river basin management, with strengthening of the Mozambican component of the TPTC;
- execution of the integrated river basin management plan in Maputo Province.

Four projects, aiming at fulfilling these targets, are described in the following sections.

4.3.1 **Project 1** - Determination of water requirements for development of the river basins in Maputo Province and for the water supply of Maputo City

Objective/output

Determination of the water requirements for a selected development scenario, in order to support the cause of the Government of Mozambique in negotiations with the other riparian countries on distribution of the water resources in the river basins.

Methodology

Different scenarios for rural, urban and industrial development and environmental protection and rehabilitation in Maputo Province and Maputo City are elaborated. The water requirements for each scenario are assessed and compared with the currently available water resources. The scenarios should target at poverty alleviation, improvement of living conditions, infrastructure, public utilities and health, and sustainable development of the natural and ecological resources. Subsequently a scenario is selected, which will be used as an policy instrument in negotiations on water distribution with the other countries.

Project duration: 6 months

Executing agency: DNA, City of Maputo, Provincial Government

Project staffing requirements (local and expatriate)

Experts in the fields of water resources, agronomy, forestry, urban and land use planning, socio-economic planning and management of ecological and natural resources.

Project funding: Bilateral/multilateral (UNDP)

4.3.2 **Project 2** - Development of an integrated development plan for the rural area in Maputo Province

Objective/output

Feasibility studies, resulting in development of an integrated plan on the basis of the scenario selected in project sub 4.3.1, are carried out. The plan should entail optimum (sustainable) use and exploitation of the natural and ecological resources, rehabilitation of degraded resources (if feasible) and improvement of income, employment opportunities and living conditions.

Methodology

Initially the project is carried out by means of a number of feasibility studies regarding optimum and sustainable use of the available resources in the area. Study objects are for example:

- optimization of the use of the water resources by interlinking the river basins by canals, use of the Maputo River for urban water supply, artificial recharge during periods with excess river discharge and improvement/rehabilitation of soil water retention capacities;
- land use planning;
- feasible development of agriculture and livestock, taking in account market opportunities, selection of the most suitable lands, protection of natural resources (buffer zones) and a combination of forestry with extensive grazing;
- rural development with settlement of farmers, improvement of living conditions, creation of employment opportunities, extension, training and pilot projects;
- development of hydropower, mineral resources, fishery and products from ecosystems;
- regional urban centre development;
- institutional development for local administration, management and monitoring;
- protection and rehabilitation of natural resources and ecosystems, e.g. reforestation and rehabilitation of estuary areas;
- development of services, health care, utilities, housing and infrastructure.

Subsequently the results of the feasibility studies are elaborated into a plan for integrated development of the area.

Project duration: 24 months

Executing agency: DNA, Provincial Administration

Project staffing requirements (local and expatriate)

Experts in the fields of water resources, geology, soil sciences, agronomy, forestry, urban and land use planning, socio-economic planning and management of ecological and natural resources.

Project funding: Bilateral

4.3.3 **Project 3** - Institutional development for regional integrated water resources management planning and for strengthening the water resource management organization in Maputo Province

Objective/output

A Southern African River Basin Management Board (SRBMB) with representatives of the 3 riparian countries is to be set up, with a permanent office in one of the countries, possibly attached to one of the national water management authorities. The main functions of the Board are water resources planning on the basis of agreements between the 3 countries and management of the natural resources in the river basins according to the principles of sustainability and protection of the environment and ecosystems (component 3.A).

The water resources management organization in Maputo Provinces, ARA-Sul, is to be strengthened in order to be better equipped for its tasks in integrated river basin management (component 3.B).

Methodology

Component 3.A: The tasks of the SRBMB are defined and detailed in terms of needs for authority rights, funds, staff, office space, equipment etc. It is assessed whether the RRBMB can be set up within an existing regional organization for international river basin management, e.g. the Southern African Development Community (SADC) with its subsidiary Environmental and Land Management Sector (ELMS), based in Lesotho.

Subsequently the SRBMB is set up and made operational according to the earlier established objectives and needs. Immediate activities of the SRBMB in this context are:

- organization of the central office;
- development of integrated quantitative and qualitative monitoring programmes;
- setting up a database and an information system;
- assessment of the water needs in the 3 countries within the 3 river basins;
- assessment of current plans for water resource development in the 3 basins;
- development of protocols for negotiations, policy development, project approval and regional planning.

Component 3.B: Strengthening the capacities and capabilities of ARA-Sul is carried out simultaneously.

Project duration: 24 months

Executing agency: National and Provincial Governments, Water Management Authorities, DNA, ARA-Sul

Project staffing requirements (local and expatriate)

Experts in the fields of water resources management and monitoring, database management, institutional development

Project funding: Multilateral (World Bank, African Development Bank)

4.3.4 **Project 4** - Execution of the integrated development plan for the rural area in Maputo Province

Objective/output

The project, formulated in project sub 4.3.2, is executed.

Methodology

The project is carried out in 2 phases:

Component 4.A: Detailed design and project planning. This will result in a number of sub-projects, which to some extent, can be tendered and carried out as separate projects.
Sub-projects may include:

- setting up of monitoring and management systems and databases (also included to some extent in project 3;
- setting up of agricultural schemes and irrigation systems;
- conservation of natural and ecological resources and designation of buffer areas;
- systems for optimization of the use of water resources;
- reforestation of deforested areas;
- housing and settling of small farmers;
- infrastructure, services and utilities;
- upgrading of urban centres in the rural ares;
- development of small-scale industries and other employment opportunities;
- exploitation of mineral resources.

Component 4.B: Execution of the projects preceded by tendering procedures.

Project duration: 6 years

Executing agency: DNA, Provincial Government, ARA-sul

Project staffing requirements (local and expatriate)

Experts in the fields of water resources, geology, soil sciences, agronomy, forestry, urban and land use planning, socio-economic planning, management of ecological and natural resources and environmental management.

Project funding: Bilateral, multilateral (World Bank, African Development Bank)

4.3.5 **Time schedule for project implementation**

The overall programme is carried over a period of 7 years. A time schedule is shown in Figure 4.1.

Figure 4.1 Time schedule for implementation of the programme for regional integrated river basin management planning and integrated rural development in Maputo Province

Year Project	1	2	3	4	5	6	7
1	xxx						
2	xxxx	xxxxxx	xx				
3.A 3.B	xx	xxxxxx xxxxxx	xxxx				
4.A 4.B		xxx	xxxxxx xxx	xxx xxxxxx	xxxxxx	xxxxxx	xxxxxx

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   Umbeluzi, Incomati, Limpopo, Buzi and Pungoe Basins
   Secretaria de Estado de Hidraulica Agricola
   SOGREAH Ingenierie, Hidrogest
   April 1993

6. Preliminary water quality guidelines for the Kruger National Park rivers
   Programme report no. 1
   Kruger National Park River Research Programme
   June 1991

7. Kruger National Park river research programme
   Second phase: Programme description
   Foundation for Research Development, Pretoria
   August 1991

8. Provincial Towns Water Sector Study, Draft Final Report
   Part C - Technical Aspects, Volume I
   International Bank for Reconstruction and Development, International Development Association
   DHV Consultants, Consultec, Fernando Braz de Oliveira
   1993

9. Abatement of the water pollution of the Infulene Basin
   J.C.L. van Buuren, J. van der Heide
   Technical University Delft, Eduardo Mondlane University
   February 1995

10. Consedracoes sobre a mineralizaco das aguas de alguns rios de Mocambique
    (Considerations regarding the mineralization of water in some rivers in Mozambique)
    Jan Suschka, DNA
    1983

11. National Environmental Management Programme
May 1994

12. Environmental impact assessment of the proposed distillery at Simunye Sugar Estate, Swaziland
Final Report
CSIR, Pretoria, RSA
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13. "Ensuring our future". Swaziland National Report on Environment and Development
Prepared for UNCED 1992
Ministry for Natural Resources and Energy
June 1991

14. Diminishing freshwater resources in the Kingdom of Swaziland
From: Environmental management in developing countries, Volume 1,1994
Institute for Scientific Cooperation, Tübingen, Germany

15. Sub-Saharan Africa Hydrological Assessment SADCC Countries
Country report: Swaziland
World Bank, United Nations Development Programme
Sir M MacDonald and Partners Ltd. (UK) and Hidroprojecto Consultores de Hidraulica e Salubridade, SA (Portugal)
December 1990

16. Water Quality Management Series
Crocodile River Catchment Eastern Transvaal - Water Quality Situation Assessment
Department of Water Affairs and Forestry
Pretoria, February 1995

17. Water Resources Planning of the Sabie River Catchment (10 Volumes)
Department of Water Affairs and Forestry
Chunnett, Fourie and Partners Consulting Engineers
Pretoria, March 1990

18. Phongolo Rivier - Opvanggebiedstudie (*River basin study*)
Department of Water Affairs
December 1986

19. Komati River Development
Feasibility Study for the First Phase Development of the Water Resources of the Komati River Basin - Driekoppies and Maguga Dams
Joint Permanent Technical Committee for the Governments of the Kingdom of Swaziland and the Republic of South Africa
Henry Olivier and Associates/Chunnett, Fourie and Partners
February 1987

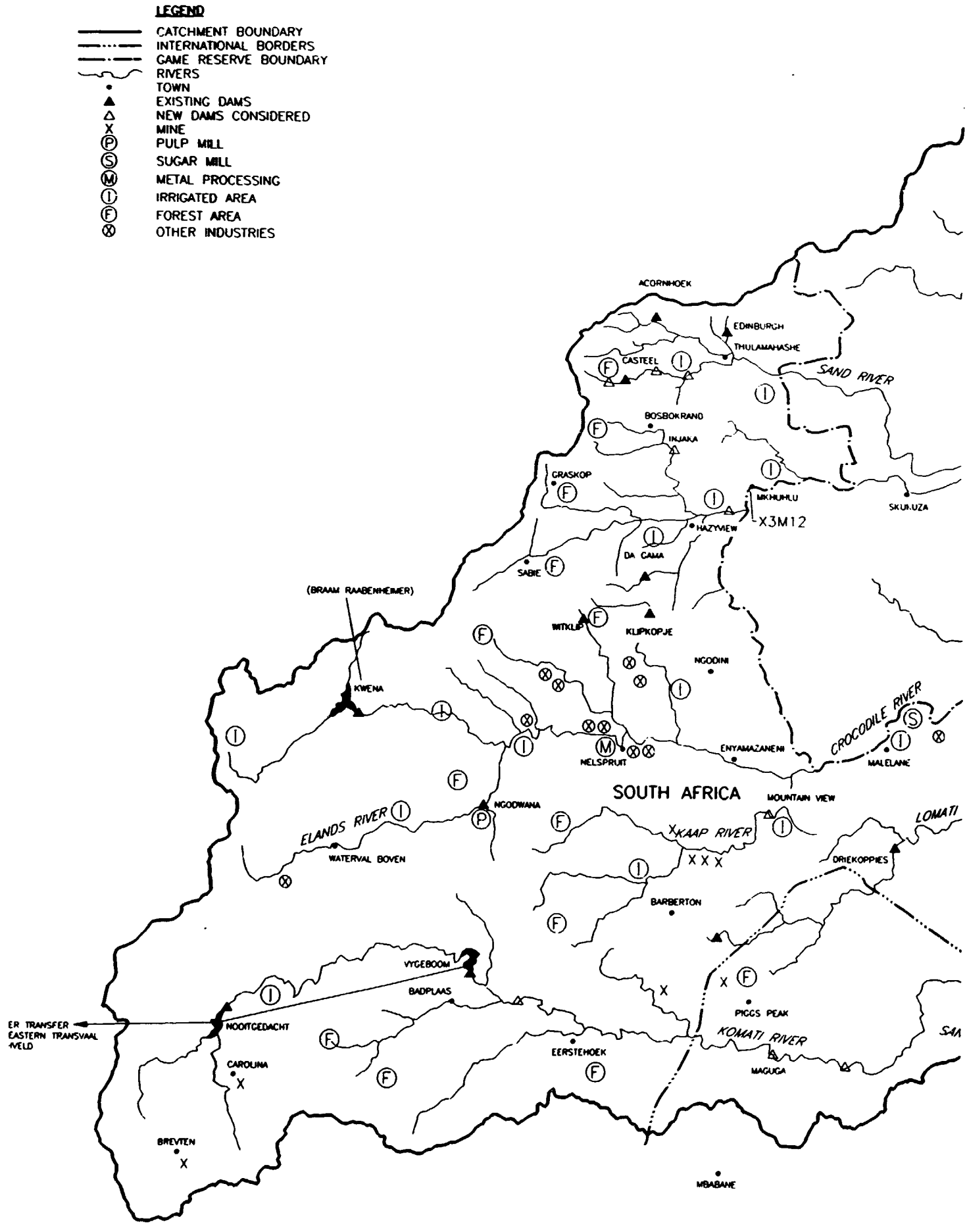
20. Usutu-Vaal Government Water Scheme - Usutu-Vaal Transfer Reconnaissance Study (Concept report)
Department of Water Affairs and Forestry
July 1995

APPENDIX I

Maps of river basins

I.1 Umbeluzi and Maputo River Basins

I.2 Incomati River Basin


LEGEND
CATCHMENT BOUNDARY
INTERNATIONAL BORDERS
GAME RESERVE BOUNDARY
RIVERS
TOWN
EXISTING DAMS
NEW DAMS CONSIDERED
MINE
PULP MILL
SUGAR MILL
METAL PROCESSING
IRRIGATED AREA
FOREST AREA
OTHER INDUSTRIES
ACORNHOEK
EDINBURGH
THULAMAHASHE
CASTEEL
SAND RIVER
BOSBOKRAND
INJAKA
GRASKOP
MKHUHLU
SKUKUZA
X3M12
HAZYVIEW
DA GAMA
SABIE
(BRAAM RAABENHEIMER)
WITKLIP
KLIPKOPJE
NGODINI
KWENA
CROCODILE RIVER
NELSPRUIT
ENYAMAZANENI
MALELANE
SOUTH AFRICA
MOUNTAIN VIEW
ELANDS RIVER
NGODWANA
KAAP RIVER
LOMATI
WATERVAL BOVEN
DRIEKOPPIES
BARBERTON
VYGEBOOM
BADPLAAS
PIGGS PEAK
KOMATI RIVER
NOOITGEDACHT
EERSTEHOEK
CAROLINA
MAGUGA
BREVTEN
MBABANE

SEC 1

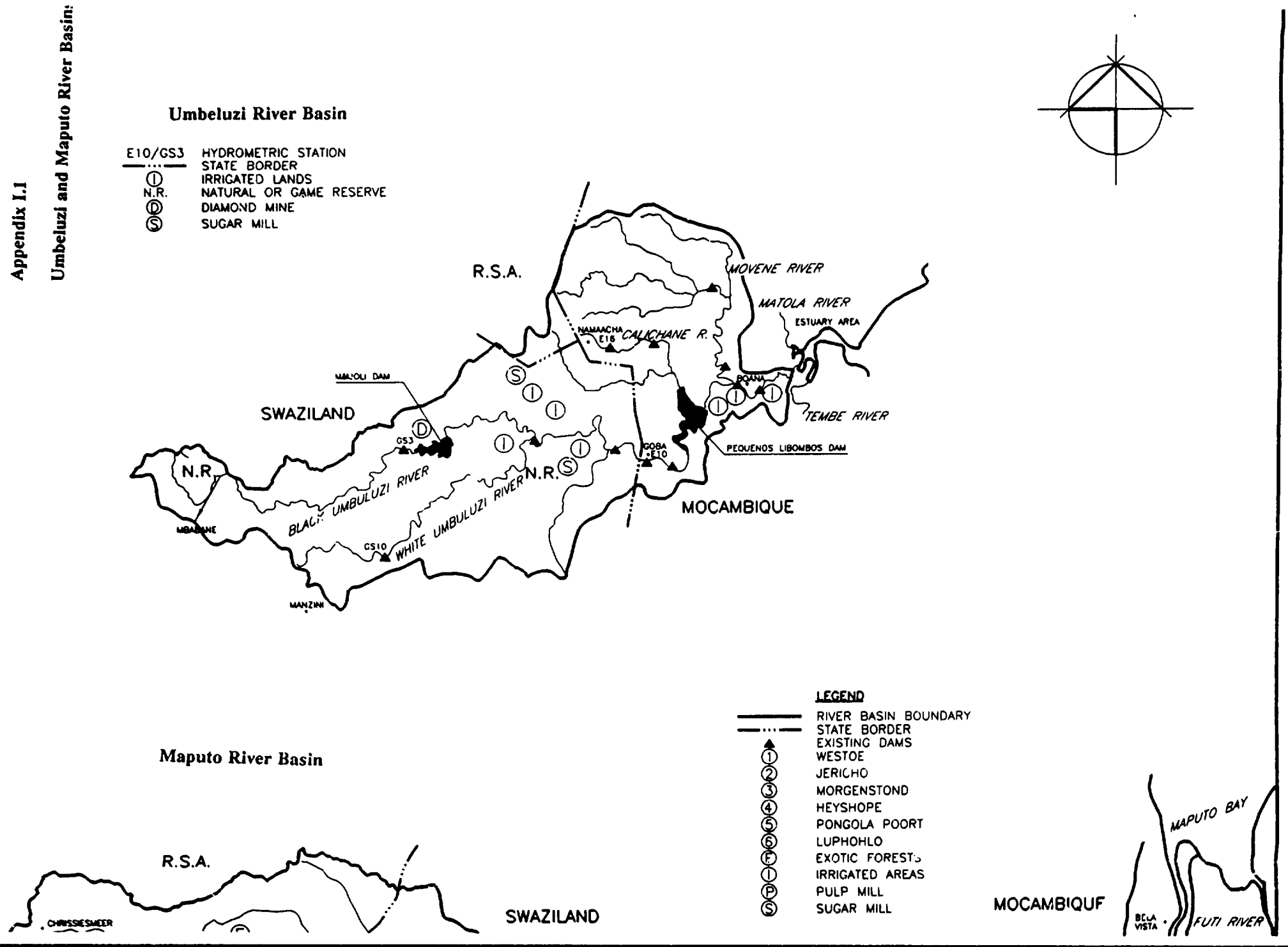
Appendix I.2

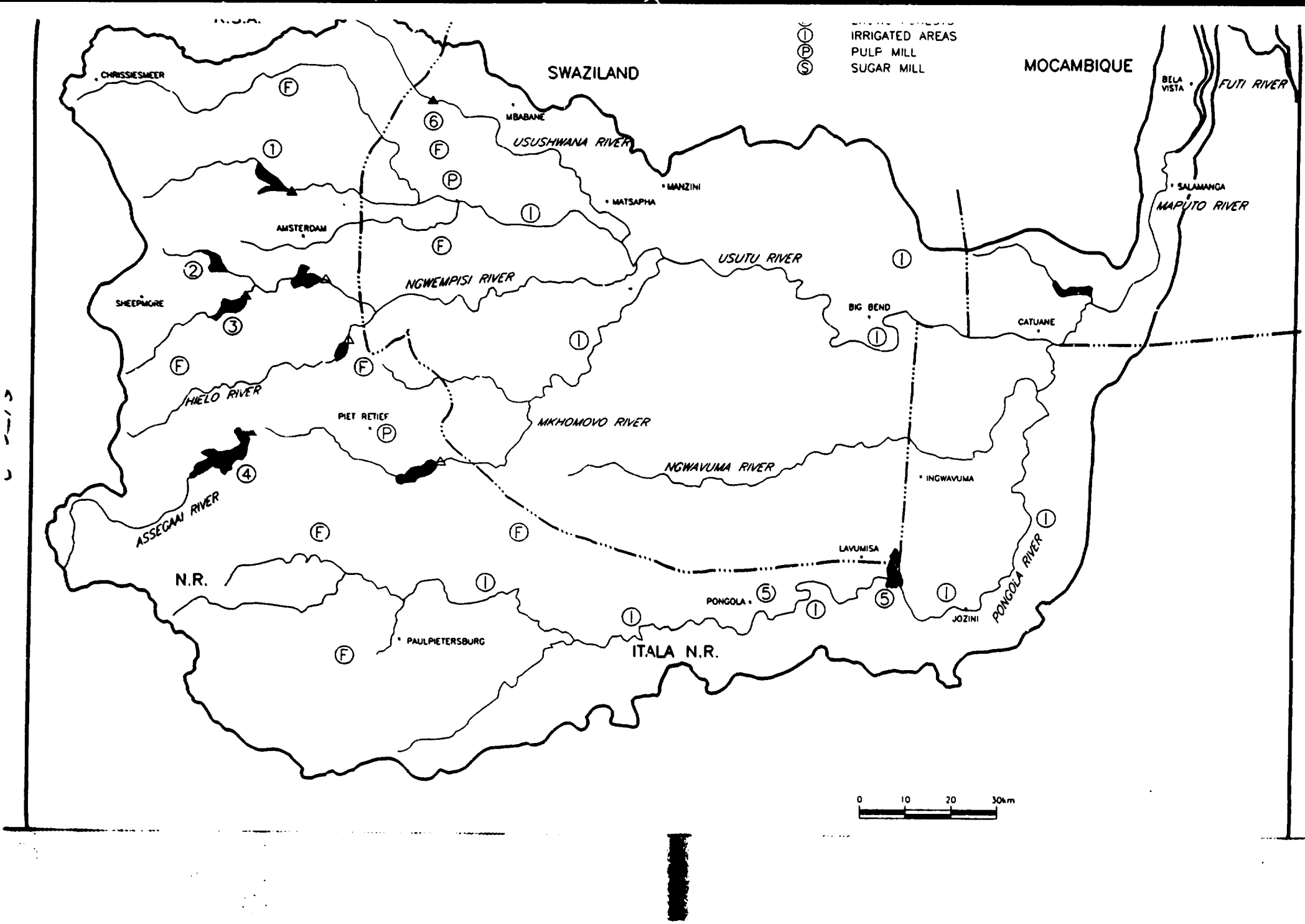
Incomati River Basin

SER 2

Appendix I.1

Umbeluzi and Maputo River Basin




IRRIGATED AREAS
PULP MILL
SUGAR MILL
SWAZILAND
MOCAMBIQUE
CHRISSIESMEER
MBABANE
USUSHWANA RIVER
MANZINI
MATSAPHA
BELA VISTA
FUTI RIVER
SALAMANGA
MAPUTO RIVER
AMSTERDAM
NGWEMPISI RIVER
USUTU RIVER
SHEEPMORE
BIG BEND
CATUANE
HIELO RIVER
PIET RETIEF
MKHOMOVO RIVER
NGWAVUMA RIVER
INGWAVUMA
ASSEGAAI RIVER
LAVUMISA
N.R.
PONGOLA
JOZINI
PONGOLA RIVER
PAULPIETERSBURG
ITALA N.R.
0 10 20 30km

APPENDIX II

Data on irrigation schemes in the Umbeluzi and Incomati river basins

INFORMAÇÃO REFERENTE A ACTIVIDADE AGRÍCOLA NAS BACIA DE UMBELUZI, SABIE-INCOMATI E LIMPOPO.

NOME DO UTENTE	BACIA	LOCALIZAÇÃO	CULTURA	AREA DE CULTIVO (Ha)
SEMENTES DE MOÇAMBIQUE Lda	UMBELUZI	UMBELUZI	MILHO	135.0
SEMENTES DE MOÇAMBIQUE Lda	UMBELUZI	UMBELUZI	ARROZ	24.0
SEMENTES DE MOÇAMBIQUE Lda	UMBELUZI	UMBELUZI	HORTICOLAS	25.0
SEMENTES DE MOÇAMBIQUE Lda	UMBELUZI	UMBELUZI	F. UMEMBA	26.0
SEMENTES DE MOÇAMBIQUE Lda	UMBELUZI	UMBELUZI	F.MANTEIGA	17.0
PROJECTO CITRINOS DE TINANGUENE	SABIE-INCOMATI		CITRINOS	500.0
U.G.A.	SABIE-INCOMATI	DAIMANE-SABIE	MILHO	24.0
U.G.A.	SABIE-INCOMATI	DAIMANE-SABIE	TOMATE	7.0
U.G.A.	SABIE-INCOMATI	DAIMANE-SABIE	REPOLHO	5.0
U.G.A.	SABIE-INCOMATI	DAIMANE-SABIE	CEBOLA	6.0
U.G.A.	SABIE-INCOMATI	DAIMANE-SABIE	ALHO	6.0
U.G.A.	SABIE-INCOMATI	DAIMANE-SABIE	BATATA	1.5
CARLOS MASSILANE COSSA	SABIE-INCOMATI	VALHA	TOMATE	16.0
CARLOS MASSILANE COSSA	SABIE-INCOMATI	VALHA	CEBOLA	6.0
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	MILHO	15.0
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	AMENDOIN	12.0
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	PIMENTO	0.5
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	TOMATE	12.0
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	REPOLHO	5.0
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	CEBOLA	10.0
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI	CHAVANE-CORUMANA MD	FEIJAO VERDE	1.0
JACINTO MANUEL CHIBURE	SABIE-INCOMATI	CHICUAVATE- SABIE	MILHO	3.0
JACINTO MANUEL CHIBURE	SABIE-INCOMATI	CHICUAVATE- SABIE	TOMATE	2.0
JACINTO MANUEL CHIBURE	SABIE-INCOMATI	CHICUAVATE- SABIE	REPOLHO	2.0
JACINTO MANUEL CHIBURE	SABIE-INCOMATI	CHICUAVATE- SABIE	PEPINO	1.0
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	PIMENTO	0.2
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	TOMATE	0.5
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	FEIJAO VERDE	0.6
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	MILHO	0.3
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	TOMATE	0.6
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	CEBOLA	1.0
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	ALHO	0.5
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	FEIJAO VERDE	0.3
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	MILHO	2.3
EZEQUIEL MBATSANE	SABIE-INCOMATI	MISSÃO	TOMATE	1.0
PROJECTO MAKALAWANE	LIMPOPO	MAKALAWANE	FEIJAO/MILHO	100.0
COMPANHIA AGRACOLA JOAO F.SANTOS	LIMPOPO	MACARRETANE	ALGODAO	650.0
COMPANHIA AGRACOLA JOAO F.SANTOS	LIMPOPO	MACARRETANE	MILHO	50.0
LONACO-CHOKWE	LIMPOPO	MACARRETANE	ALGODAO	420.0
LONACO-CHOKWE	LIMPOPO	MACARRETANE	MILHO	150.0
SIREMO	LIMPOPO	MACARRETANE	ARROZ	19150.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	300.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	225.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	325.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	300.0

INFORMAÇÃO REFERENTE A ACTIVIDADE AGRÍCOLA NAS BACIA DE UMBELUZI, SABIE-INCOMATI E LIMPOPO.

NOME DO UTENTE	BACIA	LOCALIZAÇÃO	CULTURA	AREA DE CULTIVO (Ha)
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	225.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	325.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	300.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	225.0
SISTEMA DE REG. DO BAIXO LIMPOPO	LIMPOPO	XAI-XAI	ARROZ	325.0
MARAGRA	SABIE-INCOMATI	MANHIÇA	CANA D'ACUCAR	7250.0
MARAGRA	SABIE-INCOMATI	MANHIÇA	ARROZ	1000.0
MARAGRA	SABIE-INCOMATI	MANHIÇA	MILHO	150.0
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	MILHO	1.5
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	FEIJAO	1.0
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	CITRINOS	10.0
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	GIRASSOL/TRIGO	4.0
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	BATATA-DOCE	8.0
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	TOMATE/COUVE	4.0
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	UMBELUZI	MANGUEIRAS	7.0
LONACO PROJECTO UMBELUZI	UMBELUZI	MASSACA I		0.0
QUINTA DO BOM PASTOR	UMBELUZI	UMPALA	HORTICOLAS	1.0

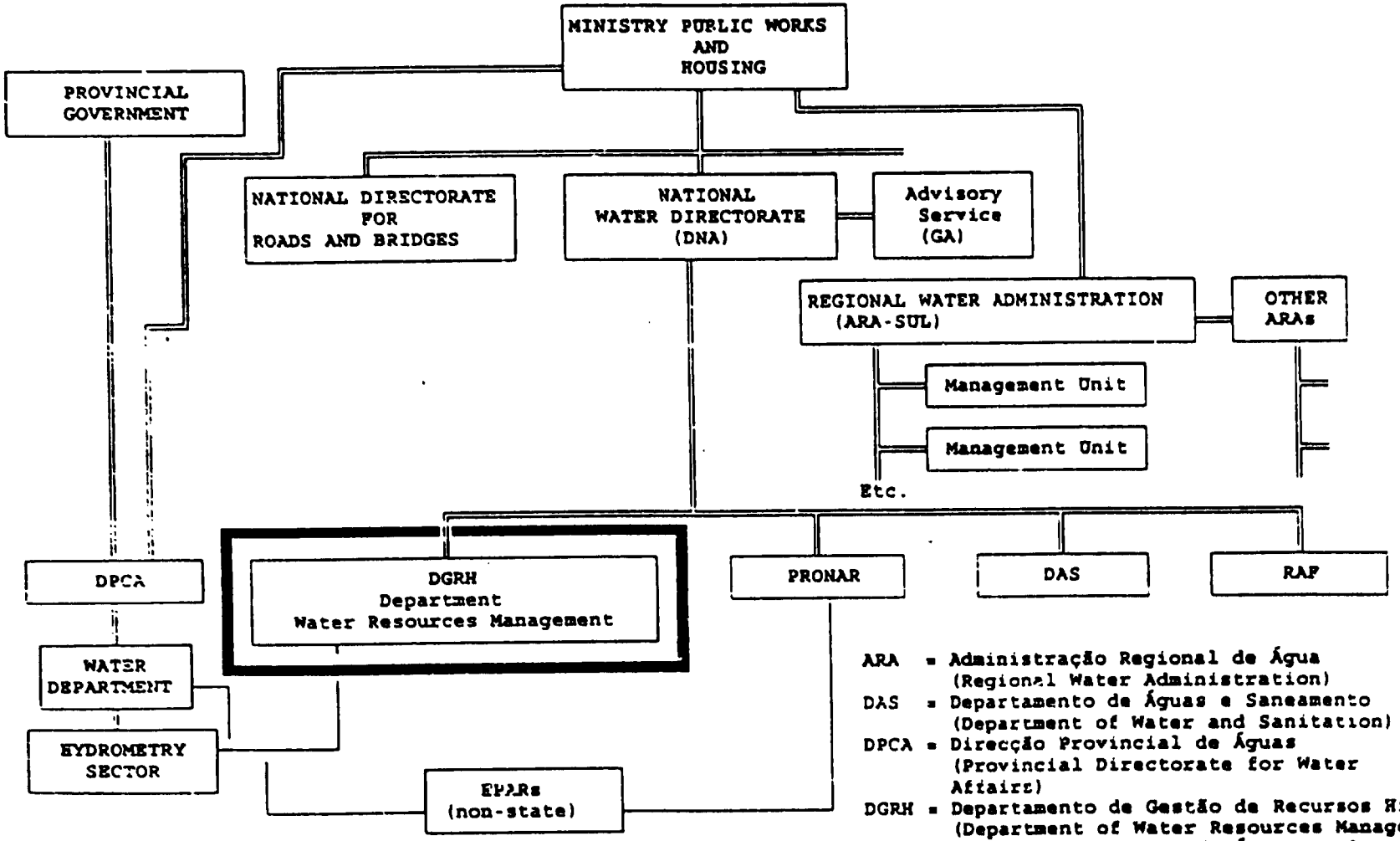
INFORMAÇÃO REFERENTE A USO DE PRODUCTOS QUIMICOS NA AGRICULTURA, NAS BACIAS DE UMBELUZI, SABIE-INCOMATI E LIMPOPO.

NOME DO UTENTE	BACIA	PESTICIDA USADO	FERTILIZANTE USADO
SEMENTES DE MOÇAMBIQUE Lda	UMBELUZI		
PROJECTO CITRINOS DE TIMANGUENE	SABIE-INCOMATI		
U.G.A.	SABIE-INCOMATI	MANCOM EC	N.P.K.
U.G.A.	SABIE-INCOMATI	DIMETOATO	
U.G.A.	SABIE-INCOMATI	METAMIDOTOS	
U.G.A.	SABIE-INCOMATI	DICLOROS (?)	
U.G.A.	SABIE-INCOMATI	MALANTIÃO (?)	
CARLOS MASSILANE COSSA	SABIE-INCOMATI	SINBCS (?)	S/REF
CARLOS MASSILANE COSSA	SABIE-INCOMATI	AZKSDRIN (?)	
CARLOS MASSILANE COSSA	SABIE-INCOMATI	BIDONIL	
CARLOS MASSILANE COSSA	SABIE-INCOMATI	MANGOZEBE	
CARLOS MASSILANE COSSA	SABIE-INCOMATI	TIODAN	
JOSE FERNANDO FABIAO MUNDLOVO	SABIE-INCOMATI		
JACINTO MANUEL CHIBURE	SABIE-INCOMATI		
EZEQUIEL MBATSANE	SABIE-INCOMATI		
MANAGRA	SABIE-INCOMATI	SENCOR	UREIA
MANAGRA	SABIE-INCOMATI	ROUNDUL	SUPERFOSFATO
MANAGRA	SABIE-INCOMATI	REDONIL	CLOR. POTÁSSIO
MANAGRA	SABIE-INCOMATI	BASUDIBE	
MANAGRA	SABIE-INCOMATI	POLIRON	
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	CIPERMATRINA	NPK
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	PERFEKTION	NPK
ESTACAO AGRARIA DO UMBELUZI	UMBELUZI	CINBUS	UREIA
LONACO PROJECTO UMBELUZI	UMBELUZI	MINERAL OIS	N.P.K.
LONACO PROJECTO UMBELUZI	UMBELUZI	MANCOVER	UREIA
LONACO PROJECTO UMBELUZI	UMBELUZI	BENLATE	POTASSIUM
LONACO PROJECTO UMBELUZI	UMBELUZI	OFIRNOL	PHOSPHATE
LONACO PROJECTO UMBELUZI	UMBELUZI	PICARIOL	
QUINTA DO BOM PASTOR	UMBELUZI	NUVACRON	ADUBO COMPOSTO
QUINTA DO BOM PASTOR	UMBELUZI	SAYTROID	SULFATO DE AMÓNIO
QUINTA DO BOM PASTOR	UMBELUZI	MORESTAN	UREIA
QUINTA DO BOM PASTOR	UMBELUZI	CUPRAVIT	

APPENDIX III

Organograms of DNA and ARA-Sul

ORGANISATION CHART FOR WATER INSTITUTIONS



ORGANISATION CHART FOR ARA-Sul