Government of the Republic of Mozambique
Government of the Republic of Zimbabwe
Swedish International Development Cooperation Agency (Sida)

DEVELOPMENT OF THE PUNGWE RIVER BASIN JOINT INTEGRATED WATER RESOURCES MANAGEMENT STRATEGY

THE PUNGWE RIVER MONOGRAPH

MAIN REPORT

FINAL REPORT
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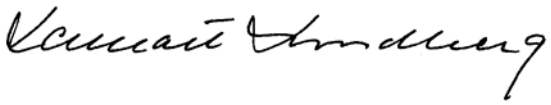

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Preface

The Pungwe River Basin Joint Integrated Water Resources Management Strategy (IWRMS), the Pungwe Project in short, is a co-operative effort by the Governments of Zimbabwe and Mozambique to create a framework for the sustainable and equitable management, development and conservation of the water resources of the Pungwe River basin, with the objective of increasing the derived social and economic benefits for the people living in the basin. A key element in the development of this strategy by the Project lies in building capacity for its implementation and upgrading, to facilitate effective participatory management by both the authorities and stakeholders. The Pungwe River is a shared watercourse between the two countries.

The Pungwe Project is financed by the Swedish International Development Co-operation Agency (Sida), through an agreement with Zimbabwe and Mozambique.

The project is implemented under the auspices of the Department of Water Development (DWD), in the Ministry of Rural Resources, Water Development and Irrigation (MRRWD&I), Zimbabwe, and the National Directorate of Water (DNA), in the Ministry of Public Works and Housing, Mozambique, on behalf of the two governments. The implementing agencies are the Zimbabwe National Water Authority (ZINWA) through the Save Catchment Manager's Office, and the Regional Water Administration of Central Mozambique (ARA-Centro), respectively.

The Pungwe project commenced in February 2002 and is being implemented in four phases, viz:

Phase 0 – Inception Phase

Phase 1 – Monograph Phase

Phase 2 – Scenario Development Phase

Phase 3 – Joint IWRM Strategy Phase

During the monograph phase a large effort by the Consultant together with the implementing agencies in Zimbabwe and Mozambique was directed towards improving the knowledge base for the development of the water resources of the basin through a number of sector studies. The sector studies describe the present situation in the basin with regards to water resources, environment and pollution, water demand, infrastructure and socio-economy.

This main report is the result of all sector studies. It makes an introduction to the Pungwe River basin and the basis for water resources management in the river basin. The main report aims to give the reader an overview of the current situation in the Pungwe River basin without going into too many details. For the interested reader, all data and information are presented in the twelve annexes produced within the Pungwe Project:

Annex I Sector study on: **Surface Water Resources**

Annex II Sector study on: **Hydrometric Networks**

Annex III Sector study on: **Hydrological Data Quality & Modelling**

Annex IV Sector study on: **Groundwater Resources**

Annex V Sector study on: **Dams and other Hydraulic Works**

Annex VI Sector study on: **Water Quality and Sediment transport**

Annex VII Sector study on: **Water Demand for Water Supply & Sanitation**

Annex VIII Sector study on: **Water Demand for Irrigation and Forestry**

Annex IX Sector study on: **Fisheries**

Annex X Sector study on: **Conservation Areas, Wildlife and Tourism**

Annex XI Sector study on: **Infrastructure**

Annex XII Sector study on: **Socio-economy**

1 The Natural Environment

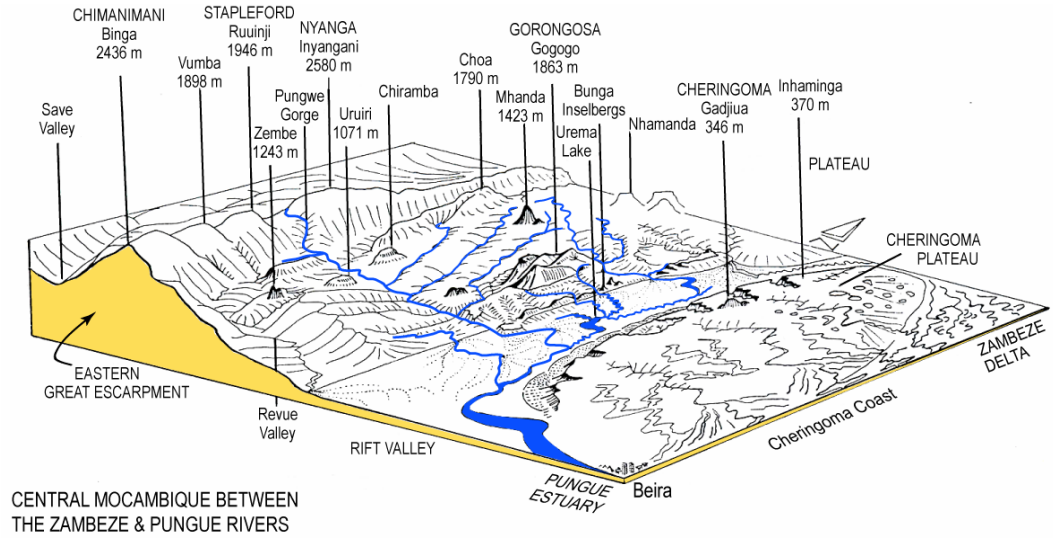
1.1 Geography

The Pungwe River is born in Eastern Highlands in Zimbabwe and flows eastwards through the Mozambican provinces of Manica and Sofala on its way to the Indian Ocean at Beira. The river is 400 kilometres long and drains a total catchment area of some 31 151 km^2 of which 1 461 km^2 (4.7%) is within Zimbabwean territory and 29 690 km^2 (95.3%) is within Mozambique. The main tributaries of the Pungwe River from the source to the mouth are the Honde, Nhazonia, Txatora, Vunduzi, Nhandungue, Urema and Muda rivers.

The Pungwe River:

- **Shared by Zimbabwe and Mozambique**
- **400 km long**
- **Drains 31 151 km^2 of which 5% is located in Zimbabwe**

The most upstream part of the Pungwe River, in the area of Pungwe Falls in Zimbabwe, has an altitude of about 1 500 above m.a.sl, with high peaks up to 2 500 m. Eastwards of the mountains, the river flows through a plateau at 1 000 – 300 m altitude, down to the confluence with the Vunduzi River. From here and downstream, the plateau falls rather rapidly to an altitude of less than 100 m. The lower basin is situated just a few meters above sea level and the plains are often flooded during the rainy season. Seawater intrusion in the Pungwe River reaches about 80-100 km from the river mouth during high tide in the Indian Ocean.

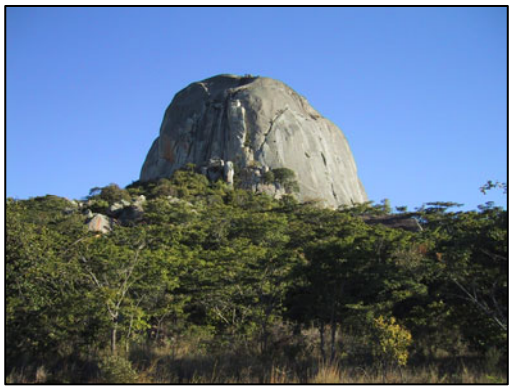


Outline of the topography in the Pungwe River basin
(Source: TINLEY, K. 1977 - Framework of Gorongosa System, University of Pretoria)

The Pungwe River basin

The Pungwe River basin has a high agricultural potential, as there is rather little arable land in use and the forest, classified as deciduous or semi-deciduous Miombo forest, is not very dense. In the low altitude parts of the basin, the vegetation is savannah or prairie. The Gorongosa National Park, one of the largest national parks in Southern Africa, is situated within the north-eastern part of the Pungwe Basin.

Granite and gneisses are predominant in the upper Zimbabwean basin. The massive granite weathers to bare domes, which gives rocky scenery. The Mozambique part of Pungwe River basin can be roughly characterised into the upland Basement Complex and the lowland Sedimentary Basin. The Basement Complex covers the western part of the central region and consists of mountains, upland and middle plateaus. An inselberg-landscape is common on the plateaus where the rocks can be deeply weathered. The Sedimentary Basin with mainly sandstones is situated in the Sena plains and Cheringoma Plateau, split by the N-S oriented Chire-Urema Graben, which is a continuation of the Eastern African Rift System.



In the Zimbabwean part of the Pungwe River Basin the massive granite weathers to bare domes

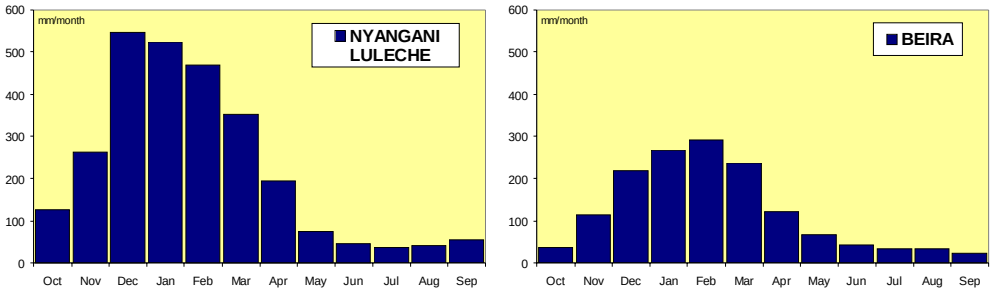
The typical red clayey soil of the western part of the river basin may used to make bricks

The western parts of the basin consist of argillaceous red soils of a considerable depth. In the mountainous areas, the soils are shallower, but can reach larger depths in the valleys. The soils of the region below the plateau are more varying and are classified as clayey – sandy fluvial dark soils, fertile fluvial soils or shallow soils without agricultural potential.

1.2 Climate

The Pungwe River basin stretches over two climate types. The western part has a humid mountainous climate. In this region, the mean annual rainfall may be above 2 000 mm, and the temperature is significantly lower than in the surrounding, non-mountainous areas.

In the eastern region, near Beira, the climate is classified as tropical humid, with a temperature variation from 22 ^{o}C in July to 29 ^{o}C in January. Here, the average rainfall varies from 300 mm in February to 20 mm in September. Rainfall is distinctly seasonal with a pronounced concentration during the warm season November-April. Normally very little precipitation falls from June to October.



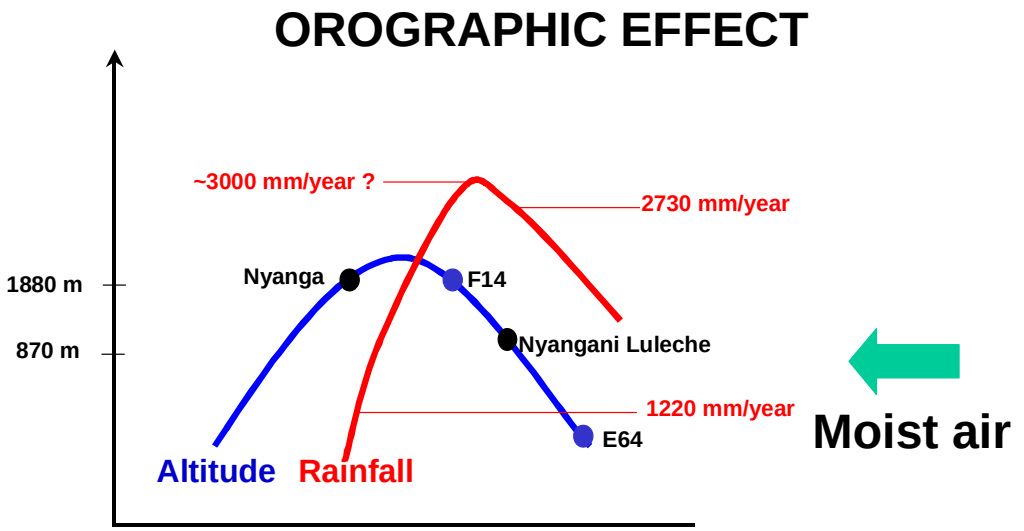
Rainfall differs much between the upper Zimbabwean part (Nyangani Luleche) and the lower basin (Beira)

In large, the Pungwe is a perennial river with a low degree of development as concerns abstractions, diversions and regulation. The large temporal variation in precipitation in the region leads, however, to great annual variations in the Pungwe flows. Both flood and drought periods are experienced. Since major dams are lacking, the negative impacts of these events are difficult to control and mitigate.

The high rainfall during January and February often causes flooding in the lower river basin

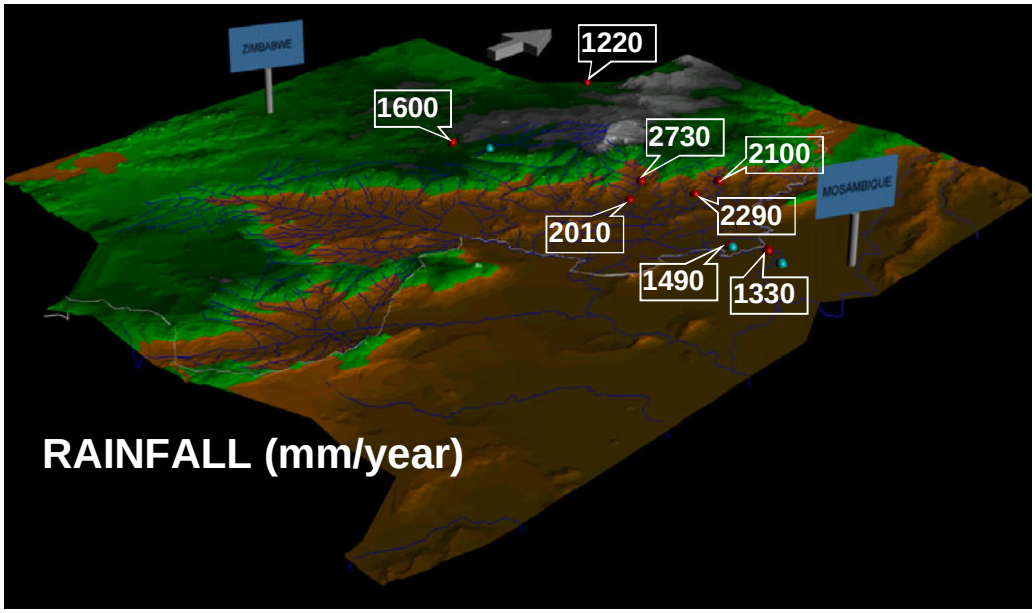
The spatial distribution of rainfall over the Pungwe River basin gives also distinct differences in the availability of the water resources. Although, only covering some 5% of the area the Zimbabwean part is estimated to produce between 25-30% of the natural runoff. The reason for this is that the change in generated runoff is very rapid when moving from the western Mozambican parts up to the mountainous areas in Zimbabwe.

The dramatic rise in altitude towards the Eastern Highlands creates an orographic effect, i.e. the humid air from the Indian Ocean is forced to rise, cools down and falls out as rainfall. The rainfall rises rapidly on the eastern slopes and even more rapidly decreases on the western slopes that are located in the so-called rain shadow. A similar effect also occurs at the Gorongosa Mountains that are known to receive much rainfall.



Principle illustration of the orographic effect in the Eastern Highlands in the upper parts of the Pungwe River basin. Blue dots indicate flow stations and black dots rainfall gauges.

Because of this phenomenon the change in rainfall goes from 1 300-1 400 mm/year at the border up to 2 700 mm/year on the eastern slopes and down to 1 200 mm/year on the western slopes of the Eastern Highlands.



The rainfall dramatically changes in the upper parts of the Pungwe River basin. Red bullets denote rainfall stations

1.3 Flora and fauna

Main vegetation and habitats

At broad level 17 vegetation types (including mangroves) can be mapped in the Pungwe Basin of which Miombo woodland is dominant covering approximately 50% of the basin. Vegetation types of conservation concern that are directly reliant on regular water flow are as follows:

- The seasonally-inundated Gorongosa *tandos* that links the Zambezi Valley with the Pungwe system in the south via the Urema trough (Rift Valley);
- The seasonally inundated grasslands of the lower Pungwe/Buzi floodplains comprising approximately 4 500 km^2 of wetlands;
- The estuarine mangroves.

These wetlands are of critical importance providing a myriad of habitats for fauna some of which are endemic and/or threatened. Many smaller but important vegetation types/habitats are dependent on rivers or streams, for instance Riverine Forest and Montane/Sub-montane vleis and dambos.

Unique ecosystems

The considerable elevation of the Eastern Highlands, where Pungwe rises, coupled with high rainfall creates microclimates and ecosystems that are unique in Zimbabwe. Unlike the rest of Zimbabwe, a light drizzle that is locally known as *guti*, occurs here regularly in the dry season. The relatively low temperatures that prevail at the higher elevations reduce evapotranspiration losses. These factors have the effect of preventing much of the soil surface from drying out completely, thereby maintaining green foliage on many plant species in the dry season. The forests and montane grasslands that are supported by this locally increased precipitation contain many items of flora and fauna that are not found elsewhere in Zimbabwe.

This region embraces Zimbabwe's highest and most reliable rainfall area and is consequently suited to intensive land-use, particularly afforestation and horticulture. Much of the original vegetation and associated biodiversity in these very limited types of habitats has consequently been drastically reduced because of these areas (especially the montane grasslands and the lowland forests and woodlands) having been converted to agricultural usage.

Specially Protected Species likely to be encountered in the Pungwe River basin:

- **Fire lily: Grasslands and at lip of Pungwe Falls**
- **Nyanga fireball: Forests on edge of escarpment from Mount Nyangani south towards Mtarazi Falls**
- **Flame lily: Forest margin among bracken and woodland on the highveld**
- **The tree ferns: The Pungwe Gorge/Nyanga National Park**
- **Orchids: Miombo woodlands and forests, especially along rivers; + vleis, bogs and montane grasslands**
- **Cycads: Nyanga National Park/ Pungwe Gorge/Gorongo Mountain**

The Urema Lake and the floodplains in the Gorongosa National Park show a stark difference in the appearance between wet and dry seasons. During the wet season, vast areas are flooded and floating pastures and conspicuous flowering water lilies appear. There is a widespread, lush, verdant growth. In contrast, during the dry season, there is an absence of surface water except in the rivers and lake. Grasses shrivel and turn brown.

Mangrove communities occur on the inter-riverine islands and mudflats of the Pungwe-Buzi estuary. At least eleven mangrove tree species occur within the estuary of which eight are true mangrove species and four are mangrove associate.

Alien vegetation

Alien vegetation is mainly located in the upper basin area where certain commercially grown trees are posing threats to the ecosystems in the upland areas by invading them with wind-born seeds and suppressing the indigenous vegetation. In Zimbabwe about 53 km^2 is covered with the two principal species Black Wattle and Mexican Pine. Australian Blackwood is also becoming established at various sites within the Rhodes Nyanga National Park, but it tends to remain in small slowly expanding clusters.

In Mozambique, the Manica Province has the largest area of exotic tree plantations in Mozambique. These areas covers today approximately 11 km^2 and are mainly located in the southern districts of the province. The main species are Pinus and Eucalyptus.

Protected conservation areas

The two main protected conservation areas within the Pungwe Basin are *Gorongosa National Park* in Mozambique, covering 20% of the Pungwe Basin, and *Nyanga National Park* in Zimbabwe occupying less than 1% of the basin. In Mozambique, *coutadas* (controlled hunting areas) occupy a further 20% of the basin.

Gorongosa National Park, the "flagship" conservation area in Mozambique has a total area of 5 370 km^2. It was created in 1960. The park is wholly located within the Urema trough. Several rivers flow into the Park from adjacent higher ground resulting in the extensive wetlands that provide variety of habitats for wildlife. Lying at the centre of Gorongosa National Park is Lake Urema, which is the intermediate recipient of almost all the Urema catchment drainage, which then passes on down the Urema River to the Pungwe River. The timing of water flow on to the floodplain and its eventual departure are crucial to maintaining the Gorongosa floodplain in a condition that supports varied, and potentially abundant, wildlife. An insufficient volume of water from the catchment or too rapid an outflow will result in a drier floodplain and subsequent changes in its habitats and fauna.

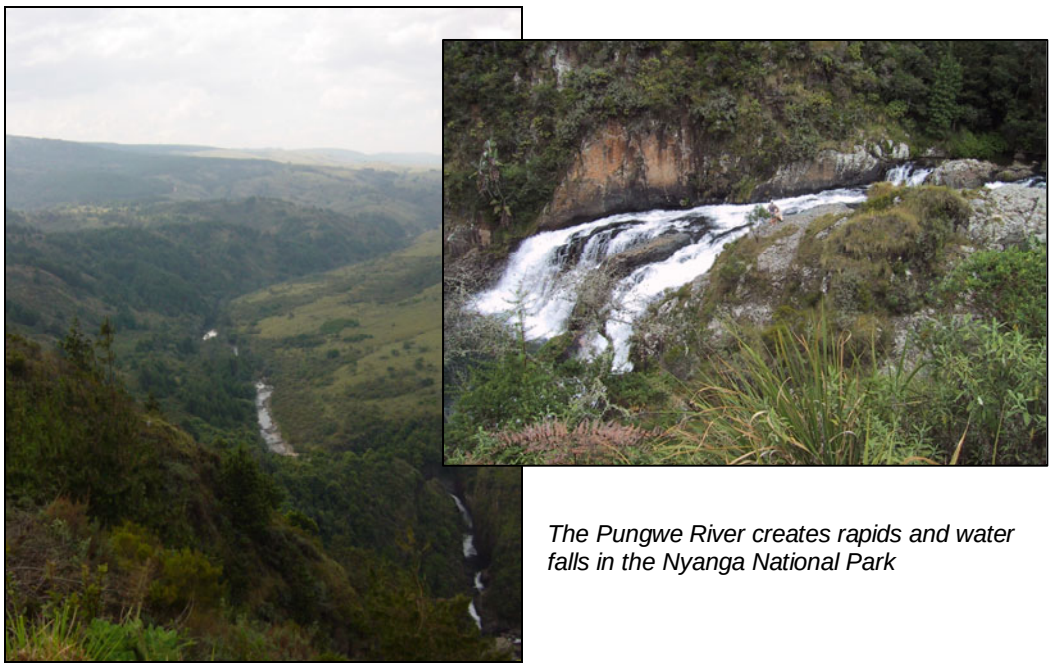
The Gorongosa National Park:

- **Straddles a section of the southern end of the Great Rift Valley of East Africa**
- **Entirely within the Pungwe River basin**
- **Covers 5 370 km^2**
- **Created in 1960**
- **Forty-six mammals species have been recorded in the park**
- **Hosts about 200 bird species**

The ecological richness and biodiversity of Gorongosa National park were recognized by explorers from the outside world more than a century ago, although foreign hunters had been there at least 300 years before that, and local people must have been well aware of the floodplain's significance for large wild animals long before. In the 1970s the park's floodplain supported the most notable concentration of large wild mammals known in Mozambique.

The park was famous in African conservation circles. Before the country's independence from Portugal in 1975, the park was visited each year by thousands of tourists from Rhodesia (now Zimbabwe) and South Africa, and by sport hunters from Europe and North America.

Unfortunately the Gorongosa Park was severely damaged during the civil war when soldiers occupied the park and hunted for rations and for ivory. When a cease-fire agreement was signed in October 1992, the soldiers were demobilized civilians and came back to find what was left to hunt. Since 1997 the Government of Mozambique has been restoring the park with support from the African Development Bank (ADB) through Gestão dos Recursos Florestais e Faunisticos Project - the GERFFA Project (the Management of Forest and Wildlife Resources Project).



The Pungwe River creates rapids and water falls in the Nyanga National Park

Nyanga National Park is located on the Eastern Highlands of Zimbabwe and currently covers an area of 330 km^2 with more than 50% of the Park occurring within the Pungwe catchment. The Park includes Mt. Nyangani, the highest peak in Zimbabwe (2592 m.a.sl.) and the Mtarazi Falls, the highest waterfall in the country (762 m).

The wetlands and the montane grasslands of the area support a variety of birds. Large mammal species include klipspringer, kudu, sable, blue duiker (Zimbabwe's smallest antelope) and the Samango monkey (the Eastern Highlands is only area where this species of monkey occurs in Zimbabwe).

The Nyanga region is one of Zimbabwe premier holiday destinations and offers a wide range of accommodation facilities for anglers, birdwatchers and hikers including quality hotels, bed and breakfast, self catering facilities as well as camping sites in the National Park.

Wildlife

Large mammals are mainly restricted to Protected Conservation Areas. Forty-six mammals have been recorded in Gorongosa National Park although four species are believed to be locally extinct (White Rhino, Cheetah, Roan and Tsessebe). Prior to the armed conflict (1980 to 1992) the park's floodplain supported more than five tons animal biomass per km^2 (mainly large ungulates).

Lions and elephants are today common in the Gorongosa National Park in Mozambique

Most of the large mammals common for southern Africa exist in the Gorongosa Park, including for instance carnivores such as Lion, Spotted Hyena, Leopard and herbivores such as African elephant, Black Rhinoceros, Hippopotamus, Zebra, Greater Kudu, Waterbuck, Wildebeest and Cape Buffalo.

The most important area for aquatic birds outside of the national parks is the lower Pungwe/Buzi floodplains that support several bird species with threatened global concern status including the Wattled Cranes, Woolynecked Stork, Saddlebilled stork and Caspian tern. Of special interest is the Wattled Crane, a globally endangered resident of sub-Saharan Africa.

The Nile Crocodile, Monitor Lizard and Python are amongst the more common larger reptiles of in the Pungwe basin. The only known endemic vertebrates in the Pungwe Basin are the Pungwe Worm Snake and three fish species (the Gorongosa Kneria, the Pungwe Chiselmouth and the Beira Killifish).

There are some rare and vulnerable species of fish in the Pungwe River. These species are mainly found in the upper reaches of the river. Cold-water species dominates the upper parts of the river where the water is mostly clear and of low productivity. Warm-water and marine fish species become more common in the lower reaches of the Pungwe.

The fish fauna of the lower reaches of the flood plain is dominated by marine and brackish water species. The Beira estuary is also a habitat for juvenile and sub-adult shrimps although there are no data available to enable an assessment of the importance of the estuary as a nursery for the shrimp stocks along the coast and on the Sofala Bank.

Shrimps are common in the Pungwe River estuary and may be caught even 75 km upstream the river mouth at the EN 6 Pungwe Bridge

2 Socio-Economic Conditions

Water resources play a strategic role in the development of communities. Their sound management or lack of it has a profound impact on poverty, community health and equity in the distribution of wealth. For sustainable development, the management of water resources requires gender mainstreaming through the incorporation of women's as well as men's concerns and experiences in any planned actions, including policy and legislation. This approach will enhance the creation of wealth in general while ensuring that women and men benefit equally.

Women play an important role in water management

Economic activities in the Pungwe Basin are largely based on agricultural production, small-scale and commercial livestock production, wildlife and forestry resources utilisation, and fishing. Agriculture is dominated by subsistence dry land farming and irrigated cash crop production. With the exception of the large-scale commercial tea and forestry plantations in Zimbabwe, and Mafambisse Sugar Estate in the Pungwe Estuary in Mozambique, the majority of the basin population relies on subsistence agriculture for its livelihood.

The abundant water supplies in the basin, good soils and rich ecosystems that depend on water provide a good basis for social and economic development, provided wise water management is practised.

2.1 Demography

As at year 2003, the Pungwe Basin had an estimated total population of 1 199 567 of which 8% in Zimbabwe. Projections of population growth show that in twenty years (2023), the total population of the Pungwe Basin will have grown to about two million people, i.e. approximately doubled.

Demographic analysis shows that the male population is higher in the cities compared to rural areas. Some rural districts in Sofala Province such as Dondo, Inhaminga and Muanza show higher male populations than female. This is probably due to their proximity to the metropolitan area of Beira/Dondo and the Mafambisse Sugar Refinery that offer opportunities for male employment.

Population in the Pungwe River basin 2003:

- **Zimbabwe 95 869 (8%)**
- **Mozambique 1 103 698 (92%)**
- **TOTAL 1 199 567**

The generally higher female population in the rural areas could be due to urban as well as cross-border migration. The latter occurring in Mozambique during the struggle for independence and the civil war that followed soon after. Internal migration may be due to male migration to the cities in search of formal and informal employment. The women who have remained in the rural areas are responsible for food production and general family upkeep.

In Mozambique, there is a growing tendency for households to migrate from the large urban areas such as the cities of Beira/Dondo and Chimoio to other districts situated along the Beira Corridor, which have conditions suitable for farming. In many cases the movement involves part of the family, usually wives. The income from agricultural production supplements that earned through formal or informal employment by the male members of the family who remain in the city.

Another observed migration pattern is related to the movement of people within or to other districts in search of employment in the large cities or to find markets for crops. In the districts of Nhamatanda in Mozambique and Mutasa in Zimbabwe, floods have often resulted in migration of people to other neighbouring districts. In Zimbabwe the resettlement exercise under the land distribution programme has also led to population migration.

In the Pungwe River basin women have generally remained in the rural areas and are responsible for food production and general family upkeep

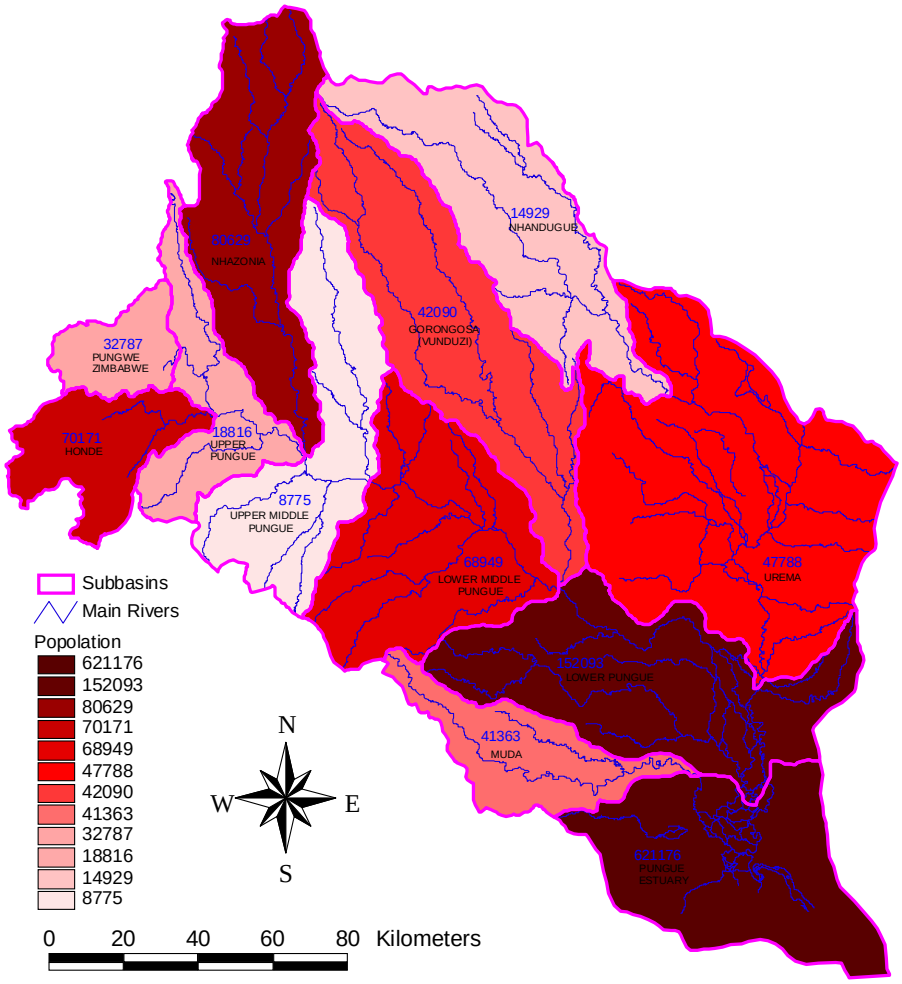
2.2 Settlements

Settlements in the Pungwe Basin consist of rural village communities, a few scattered urban centres, small towns and growth points, as well as commercial farms. The City of Beira (400 000) in Mozambique is the main urban and industrial centre.

There are no major industrial towns on the Zimbabwean side of the basin, with the exception of Hauna growth point, a hub for commercial activity in the Honde Valley. In Mozambique, Chimoio (170 000) is just outside the catchment boundary. Other towns with some importance are Gondola (190 000), Nhamatanda (140 000) and Gorongosa (80 000) but most of the population is in suburban areas with little distinction from the surrounding rural areas.

The city of Beira at the Pungwe Estuary

Population



Population in the major subbasins of the Pungwe River basin

Administratively, the basin covers parts of Sofala and Manica provinces in Mozambique, and a large part of Mutasa Rural District in Zimbabwe, as well as Nyanga National Park. A small portion of the basin in Zimbabwe falls in Nyanga Rural District.

Settlements are concentrated along the river valleys, floodplains and zones with agriculturally suitable soils, as well as in the proximity of existing infrastructure such as roads and administrative centres or posts.

2.3 Health

In Mozambique five out of the eleven districts in the basin are served by a district hospital. The number of health centres and health post is somewhat larger, with Sofala Province being better served than Manica. Consequently, serious illnesses and injuries are therefore considerably underprovided for. In Zimbabwe, access to health facilities is comparatively good. However, the provision of health services is deteriorating due to the shortage of drugs and qualified health personnel.

The most common diseases in the Pungwe Basin in Mozambique, diarrhoea and cholera, are related to access to safe drinking water. National statistics show that children up to the age of 4 years are the most vulnerable group. The City of Beira, Nhamatande and Manica districts are the most affected by cholera.

In general the major problem concerning health in Mozambique is related to the following factors:

- access to services and the quality thereof;
- access to clean water and adequate sanitation;
- lack of education on disease prevention;
- low literacy levels;
- poverty and its link with poor diet and nutrition.

The main diseases in the Pungwe Basin in Zimbabwe are STDs, respiratory infections, Diarrhoea, HIV/AIDS and cholera. Access to safe water has improved over the years due to the construction of several pipelines that supply treated water to villages. There is, however, no data on the number of cases of these diseases. Infections and death are likely to be on the increase due to the deterioration of health services. Zimbabwe has an extensive health network that lacks adequate resources to function effectively.

Sanitation facilities in the basin are still generally basic, and largely based on the pit latrine or open bush. Coverage is variable, with more facilities in Zimbabwe compared to Mozambique. Major constraints in the provision of sanitation are poverty and lack of education.

The National Water Policy (PNA, 1995) of Mozambique provides the legal and institutional framework for the creation of conditions for implementing sustainable interventions in the water and sanitation sectors. However, progress in increasing access to safe water in the rural areas continues to be slow. In Zimbabwe, the rural water supply programme has made significant inroads in the provision safe drinking water in the basin. Regrettably the impetus experienced in the 1980s has now waned due to diminishing resources.

2.4 HIV/AIDS

The HIV/AIDS pandemic is adding considerable pressure to already stressed health services in the basin. It is estimated that about 20% of the population are HIV positive at present.

In Zimbabwe the prevalence of HIV and related illness in Zimbabwe was on the increase over the previous years. In Mozambique, it is estimated that between 1990 and the year 2000 the rate of HIV infection in the central region of the country rose from 3% to 16.5%. It was higher in the southern region at 13.2% compared to the northern region of the country that registered an infection rate of 5.7%. Manica and Sofala provinces were respectively rated in the first and third place in the country for HIV prevalence, with rates of 21.1% and 18.7% respectively (Ministry of Health, 2002).

In 2000, 45 000 people died from of HIV related illnesses in Mozambique. About 33 300 or 74% of those deaths occurred in the central region. It is estimated that in 2001 the number of deaths in Mozambique increased to 57 000, with 38 900 or 68% occurring in the central region.

HIV/AIDS in the Pungwe River basin:

- **About 20% of the population are HIV positive**
- **By 2010 projected life expectancy is estimated to drop to 36.5 years of age**

Women and children are the most affected by the AIDS pandemic. In Mozambique, women between the ages of 15 and 29 have a higher HIV infection rate. It is estimated that in 2000 there were 60 000 cases of new orphans due to maternal deaths from AIDS, 43.7% of which occurred in the central region (ditto in 2002). It should be noted that some of these orphans are also HIV positive, while others are HIV negative. Notwithstanding, all of them require special care.

If the present trend in infection incidences continues, HIV/AIDS will have a major impact on population dynamics in the Pungwe Basin. According to the Ministry of Health and Child Welfare of Zimbabwe, a child who is born now has a 50% chance of dying from AIDS at some stage of his life. The life expectancy in Zimbabwe, which had increased before the advent of HIV/AIDS is now in decline. It is anticipated that it will reach 45 years of age in the not too distant future. In Mozambique it is predicted that life expectancy will drop from 43.5 years of age in 1999 to 36.5 in 2010. It is estimated that in the absence of HIV/AIDS, the life expectancy would be 50.3 years in 2010.

2.5 Education

In Mozambique, the formal education network is still developing, with remote areas poorly served. In comparison, 90% of the children in Zimbabwe attend primary school. Manicaland Province, in which the basin in Zimbabwe is located, has one of the highest educated populations in the country. These education disparities between the basin countries will need to be addressed to ensure equitable development in the long term.

The number of schools under the National Education System in Sofala and Manica Provinces are 360 primary schools and 10 secondary schools. Unfortunately the number of Level 1 schools (1st to 5th Grade) is still much higher than Level 2 (6th and 7th Grade). As a consequence, a large number of pupils complete Level 1 of primary school without progressing to Level 2 to complete the primary school level. The failure rate in Level 1 and Level 2 varies between 60% and 70%. The dropout rate, particularly among girls, is of major concern to the government and its partners who have designed specific programmes to reduce it, with special attention on female students.

A similar situation exists for Level 2 graduates, where an inadequate number and sparse distribution of schools restrict entry into Lower Secondary level. The few secondary schools are normally located in the district capitals. Consequently, students from outlying areas are at a disadvantage, since they are usually unable to secure resources to cover the expenses of attending school away from their homes.

Many pupils in the Mozambican part of the Pungwe River basin do not complete the primary school level

Young 12th grade graduates, who have not received training in primary school education, staff most primary schools in the rural areas. To address the teaching staff shortage, the Ministry of Education is implementing short training courses for these teachers, with the assistance of partners such as UNICEF, GTZ and others, or using funds from the State budget.

The Pungwe Basin in Zimbabwe has 41 primary schools and 14 secondary schools. Of the 14 secondary schools, four offer 'A' level. Each ward in the basin has a primary school. At present there are no plans to build additional schools. About 90% of the children attend primary school. The rest do not attend school for religious reasons or due to poverty. Members of the Apostolic Church discourage their children from attending school, with girls being the most affected. In most cases the school attendance rate is 100% in the first term, while dropouts occur during the course of the year. To boost household incomes, some children are required to carry out farming activities such as tea picking on the plantations to the detriment of their education.

The Ministry of Education in Zimbabwe has qualified teaching personnel, although in recent years it is becoming increasingly difficult to retain experienced staff. Despite staffing problems, the pass rate is very high. Many students reach secondary school and a reasonable number progresses to 'A' level.

2.6 Gender and poverty

While gender concerns men and women, the role played by women as managers of natural resources, domestic and income-generating activities should receive special attention. Development strategies and poverty alleviation programmes invariably falter in their initial stages because of their failure to explicitly refer to gender. The success of these strategies lays in managing conflicting gender interests in the face of limited resources and varied entitlements. The collection of water is mainly a female activity. 95% of the people involved in transporting water are women and girls. On average, the female members of a household do four trips per day for seven days of the weak, to carry 20 to 25 litres of water (a 20 to 25 litre bucket/tin is the most commonly used container for carrying water).

95% of the people involved in transporting water are women and girls

In Zimbabwe, although representation in the decision-making bodies such as the Save Catchment Council and the Pungwe Sub-Catchment Council favour men, the few women who are on those committees continue to play a key role in water management issues. The water sector in Mozambique recommends that women be included on the water committees chosen by the communities to ensure the correct management and maintenance of the water sources. There is therefore scope for the Project to build on these initiatives and policies to promote the participation of women in water management.

Poverty continues to be a scourge in sub-Saharan Africa. Poverty is widespread in both countries especially in the rural areas. About 75% of the rural households have income levels that fall below a level that satisfies basic needs. For Manica and Sofala Province, the minimum monthly consumption needs per capita were calculated to be about US$ 6 in the rural areas and US$ 10 in the urban areas. Water and other resources derived there from can provide the key to the sustainable eradication of poverty.

The majority of the rural households in the Pungwe River basin have income levels that fall below a level that satisfies basic needs.

National statistics indicate that Sofala Province has the highest rate of poverty at 88% in Mozambique. In the rural areas the rate of poverty is estimated to be 92%. The poverty levels in urban and rural areas in Manica Province are much lower compared to national levels. In Manica Province 63% of the rural population is considered poor. This is most likely due to the prevailing climate and fertile soils that are suitable for agricultural production coupled with opportunities for vibrant trade with neighbouring Zimbabwe.

In Zimbabwe poverty is widespread and increasing. About 61% of households have a per capita income below a level that sufficiently satisfies basic needs. High poverty levels are more accentuated in the rural areas, with 75% of rural categorised as poor, compared to 39% of urban households. Honde Valley has a mixture of rich and poor households. Compared to other parts of Zimbabwe, Honde Valley has an abundance of water resources and fertile land that provide numerous sources of income through agriculture.

2.7 Main economic activities

The highest proportion (~65%) of the population in the Mozambican part of the Pungwe River basin practice agriculture, forestry and fisheries in the urban and rural communities. The main activity in the rural areas is agriculture (~90%). It is worth noting that around ~40% of people living in the urban areas are involved in the agricultural, forestry or fisheries. In most cases, these are people living in the cities whose main occupation is that of rural farmer, using land in the green areas of the cities and in districts located along the Beira Corridor and in Pungwe Basin. Commerce and finance are the second largest sectors in Mozambique in both urban and rural areas.

Economic activities in the Pungwe Basin in Zimbabwe are almost entirely based on agriculture due to the rural nature of the basin's communities. The main sub-sectors include large-scale commercial tea, coffee and forestry plantations, and small-scale irrigation for a variety of crops, including tea, coffee, fruit and vegetables. Nyanga National Park plays a major role in the basin's tourist activities.

The average monthly income accrued by the small-scale rural farming in Mozambique is estimated to US$37 for maize, US$43 for bananas, US$113 for cotton and US$125 for sesame. The income earned from employment is in average US$59 to US$86.

Agriculture

Land use patterns in the Pungwe Basin are strongly influenced by agro-ecological conditions and distribution of the natural resources. Agricultural sub-sectors in the basin areas consist of the small-scale traditional farming and the large-scale commercial operations. The former is largely subsistent with production mainly focusing on food crops, fruit and vegetables for sale.

In Zimbabwe the small-scale sector also grows tea and coffee in the highlands for sale. It practices irrigation and dry-land cropping due to the presence of numerous perennial streams. The large-scale sector comprises commercial tea and coffee plantations, fruit and vegetables.

Small-scale traditional farming focusing on food crops, fruit and vegetables for sale is common in the Pungwe River basin

There are three agricultural zones in Mozambique as follows:

- The Upper Pungwe, including the Nhandungue Valley in the north, the Nhacangara and Messambedze valleys in Catandica area, and the Mavuzi valley in the southwest.
- The Middle Pungwe, which covers Gondola, Macossa, Chimoio, and Gorongosa plateaus, as well as parts of Upper Muda system.
- The Lower Pungwe, in the flood plain, comprising Bué-Maria, Metuchira, Muda, Mecubedze, and Dondo, where large sugar cane plantations are located. The region has been designated as a priority for future agricultural development.

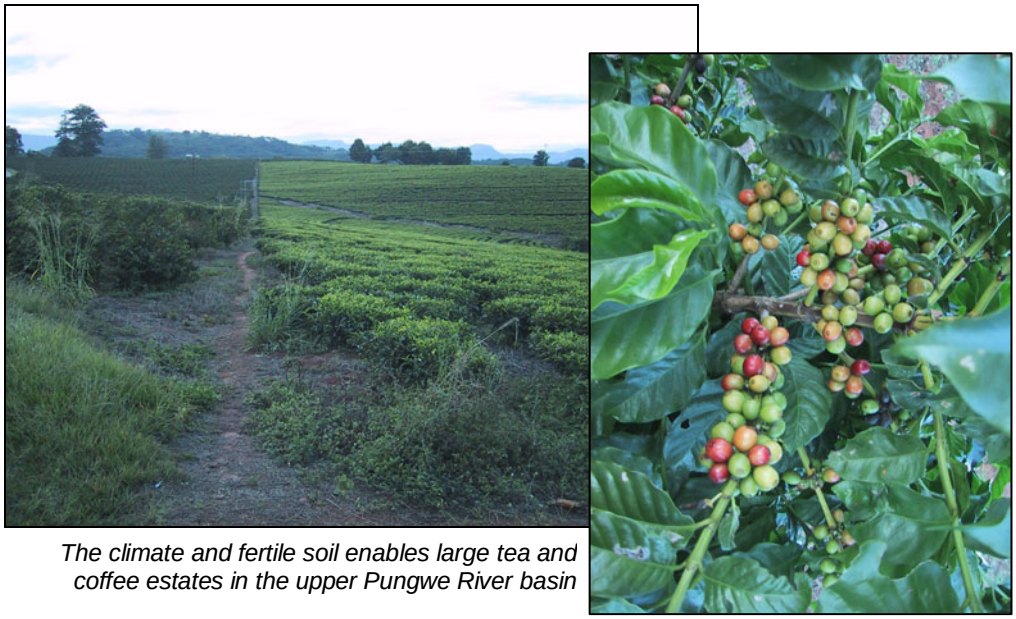
Current arable land equipped for irrigated agriculture in Mozambique accounts for approximate 8 758 ha. Irrigated crops consist of sugar cane, maize, tobacco, sunflower, Irish potatoes, a variety of vegetables and fruit. Most of the equipped and irrigated area in Sofala province is currently used for sugar cane production. 8 093 ha out of the existing equipped land is used for irrigated sugar cane production, the plantations belonging to Açucareira de Moçambique, Mafambisse. Flood irrigation is the main type of irrigation practiced. Water is fed from dams into the channels either by gravity or diesel powered pumping systems. A smaller proportion of irrigated land is equipped with sprinkler irrigation systems, mainly for sugar cane plantations.

Sugar cane stands for more than 95% of the irrigated crop in the Pungwe basin in Mozambique

Since the first roads were built into the northern portion of the Pungwe Valley and the adjacent Honde Valley in Zimbabwe, the agricultural uniqueness of this high rainfall subtropical lowland became evident. As a result large-scale coffee and tea estates have developed in the area.

New crops such as cotton and burley tobacco were also successfully introduced, but the latter is no longer grown in the Pungwe River basin. Groundnut production was also popular but this has also been displaced by continuous maize. Maize is now grown on probably 90% of all the arable land, but bananas are the major export crop to the towns, competing with sugar cane for space along damp waterways. A limited amount of cocoyams are grown for home consumption.

Mangos are another major fruit crop, as well as pawpaw (papaya) trees. There is a good potential for citrus with the aid of irrigation on the Hauna plain. Excellent guavas grow wild between Hauna and the Ruda River, and are not yet subject to fruit fly stinging.



The climate and fertile soil enables large tea and coffee estates in the upper Pungwe River basin

Livestock

The population of cattle in the Pungwe basin in Mozambique is 4.5% of the national head. Small ruminants account for 5.4% of the national flock as at year 2000. The swine population in the basin is 6.4% of the nation-wide. Individual families hold more than 75% of the basin's livestock population.

Honde Valley is not suitable for livestock production due to lack of grazing land, and only few families have animals. The Honde Valley Dairy Milk Scheme, the only such project in the area, was initiated in 1985 with 150 members from three wards participating. Currently, only 26 are active members. They supply fresh milk, sour milk and yoghurt to Hauna Development Unit.

In total, at year 2000, the livestock population was 25 500 cattle, 45 800 ruminants, 12 000 swine and 508 000 poultry.

Forestry

The commercial forestry in the Pungwe River basin is mainly concentrated to the upper Zimbabwean parts. The Stapleford Forest Estate near Penhalonga is the principal Forest Commission property within the Pungwe Basin in Zimbabwe. It was formerly a privately owned property that was bought many years ago by the Forestry Commission who planted up the high plateau area to pines. In the sub-tropical Nyamkwarara Valley section other pines were also planted. The John Meikle Research Station is located on the rim of the Nyamkwarara Valley, where it serves as the Forest Commission's seed breeding and production centre.

Much of Erin Forest Estate in Nyanga district is officially part of the Rhodes Nyanga National Park, but it is on indefinite lease to the Forestry Commission for commercial timber production at a very nominal rental.

Large forestry estates dominate parts of the Pungwe River basin in Zimbabwe

Fishery

There is small-scale fishing going on along most of the Pungwe River but data on fish catches are not available. Some fish is sold on local markets but most of the fisheries are likely to be at a subsistence level. During times of floods fishing efforts increase dramatically and the marketing of fish is likely to provide a significant income to those involved. Based on the information from other tropical rives one can calculate the fisheries productivity of the Pungwe River flood plain (4 500 km^2) to be in the range of 4 to 6 tones per km^2 or about 20 000 tones. This is probably far above what is fished today.

Fishery in the Pungwe Estuary is an important source of income

Tourism

Tourism in Zimbabwe is much more developed compared to Mozambique. This situation is due to the long period of armed conflict in Mozambique during which there was an almost total absence of tourism. Within the Mozambican portion of the Pungwe Basin the Beira area the most developed with regards to tourism: 757 guest beds are registered with the Ministry of Tourism for the Beira area out of a total of 1 297 beds for the entire Pungwe Basin area.

In the Eastern Highlands of Zimbabwe, there are several hotels, inns and lodges of international and local repute. The pristine nature of Nyanga National Park, with its natural woodland and beautiful scenery of the Pungwe Falls and Gorge, under normal times attracts thousands of local, regional and foreign tourists. The spectacular view of Honde Valley is a favourite attraction for visitors to the area.

The Gorongosa National Parks are the main tourist attraction in Mozambique. However, until full restoration of the park is achieved the number of guest beds remains low.

2.8 Infrastructure

Water Supply and Sanitation

The urban area of Beira/Dondo is supplied by a modern water supply system with full treatment facilities. The intake point on the Pungwe River for raw water supply is located approximately 75 km upstream from the river mouth. Despite the relatively long distance from the mouth, tidal influence periodically results in seawater intrusion during low flows.

The Beira water supply intake and treatment plant are located 75 km upstream the river mouth

The water supply system caters for about 19% of the total population of Beira and Dondo, through house connections, yard connections and public stand posts. The main water consumer is the domestic sector. Non-domestic use, which is largely associated with industries and institutions, accounts for 30% of total domestic consumption. At present, the network is run-down due to lack of maintenance. Since 1999 the system has been operated under a management contract with Águas de Moçambique, a private company with a concession valid until 2013.

The City of Mutare is located outside the Pungwe Basin, in the Odzi River catchment. It is, however, supplied by Pungwe River water through an elaborate inter-catchment transfer facility. The intake is built upstream the Pungwe Falls and is designed to abstract maximum 0.7 m^3/s.

Water Supply for the basin's rural areas comprises small piped systems serving small towns, growth points, commercial plantations, service centres and some villages, as well as direct abstractions from the rivers by riparian village communities not connected to developed installations. The Pungwe Basin in Mozambique contains 6 small piped systems at Nhamatanda, Muanza, Gorongosa, Gondola, Macossa and Barue. The pipeline schemes at Gorongosa, Gondola and Barue are supplied from surface water, with the rest depending on groundwater. Most of these water supply systems are in poor condition, and operate at below design capacity. Some are not even operational at present and are normally not metered.

In general the proportion of the basin population in Mozambique supplied by piped systems or any other formal water scheme is small

Sanitation facilities for the catchment in general are based on pit latrines for rural villages and septic tanks in the more urbanised areas such as Hauna in Zimbabwe. An exception is the City of Beira, which has sanitation systems for storm water and wastewater. However, the public sewerage system only covers 3% of the population, with the majority of users in the main urban area connected to septic tanks. The peri-urban area is not served by any water borne wastewater system, nor is it connected to the water supply system. People tend to defecate in open air. In 2003 overall coverage is estimated at 46%.

Energy

The main electricity supply infrastructure in Mozambique is under the management of EDM – Electricidade de Moçambique. The major electricity sources are Cahora Bassa Dam on the Zambezi River and the Chicamba and Mavuzi Dam and hydropower stations on the Revué River (Buzi River basin). There are also a number of thermal power stations.

Most of the inhabitants in the Pungwe Basin in Mozambique live in rural areas where no electricity is available. People use fuel wood for their energy needs, increasing enormously the problem of deforestation.

Fuel wood is by far the largest energy source in Zimbabwe, particularly in rural areas. The Pungwe Basin in Zimbabwe has no thermal or hydropower generation plants. Its electricity is supplied from the national grid, receiving power from Kariba Hydroelectric Scheme, Hwange thermal power station and other smaller plants. The future development plans include a potential small-scale hydroelectricity site on the Duru River, with a capacity of 2.3 MW.

Roads

Roads in Mozambique are managed by ANE – Administração Nacional de Estradas. The roads are classified into primary, secondary and tertiary roads. There are also non-classified roads (vicinity roads). In the Pungwe Basin in Manica Province, there are about 900 km of classified roads, almost all usable all year round. More than 50% of these classified roads are tar roads. In the Sofala Province, there are about 2,865 km of classified roads, of which about 500 km are tar roads. In Sofala, many roads are vulnerable to floods, including the very important EN 6 that links the Port of Beira to Zimbabwe.

In Zimbabwe, the Department of Roads and the District Development Fund administer the road network. The network in the basin is well developed, with major centres accessible by surfaced roads, all weather gravel roads or minor roads and tracks.

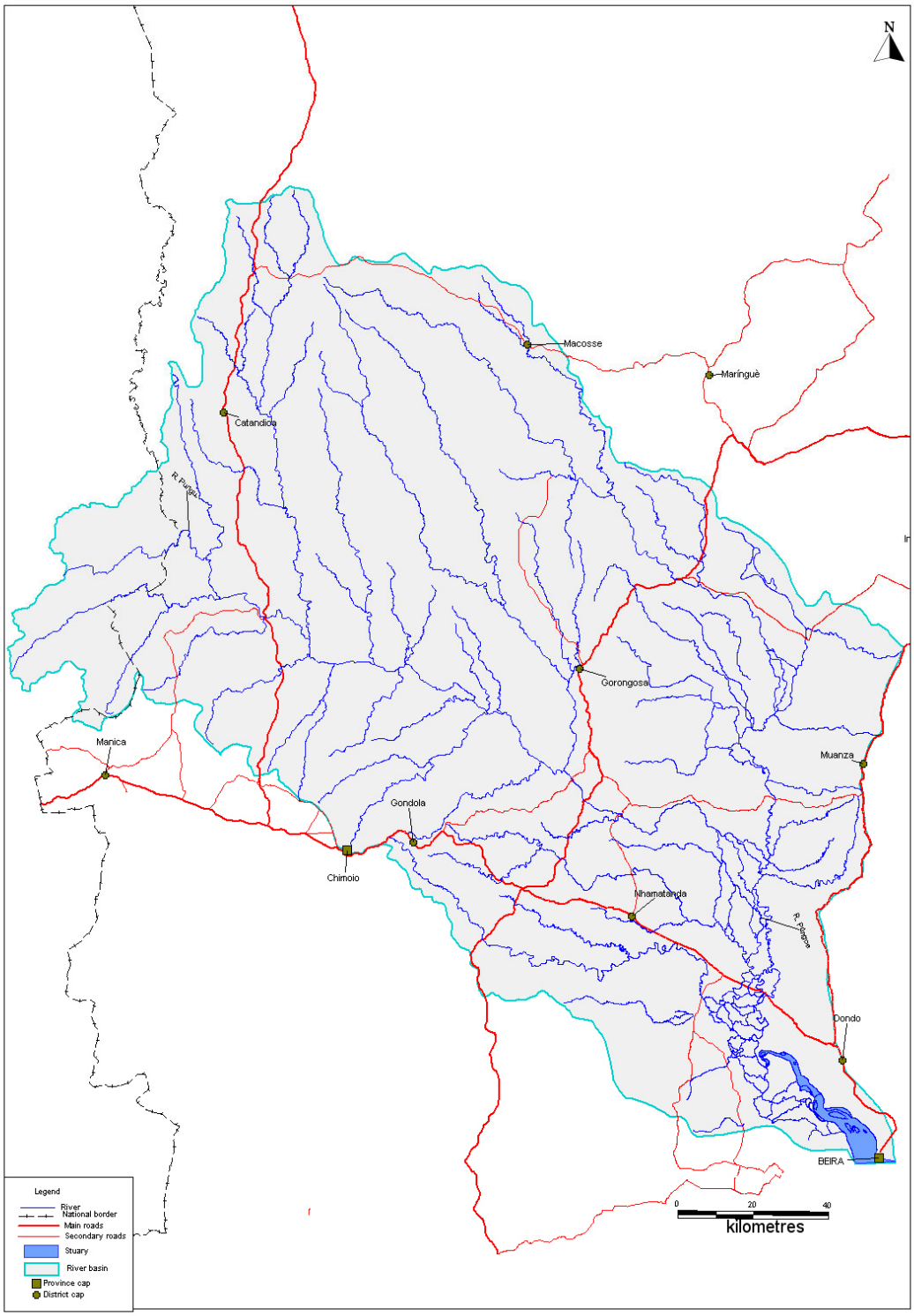
Railways

In terms of railways, it is important to refer the railway line that links the Port of Beira to Zimbabwe (Beira-Machipanda-Mutare). This line is presently suffering in terms of decrease in cargo transported, possibly due to the problems affecting the Zimbabwe economy. The other important railway line, Beira-Dondo-Sena-Moatize, is only inside the basin in the initial section, after which it borders the basin to the East.

The sole harbour in the Pungwe Basin is the Port of Beira. It is a very important infrastructure, serving the national and international interests, particularly Zimbabwe, Malawi and Zambia. About 60% of the cargo traffic to and from Zimbabwe.

Telecommunications

The telecommunications networks in Mozambique, both fixed and mobile, are quite limited in extension, practically covering only Beira, Dondo and towns along the Beira Corridor. Also in the Zimbabwe part of the basin the coverage is very limited.



Main road network in the Pungwe River basin

3 Water Resources Management

3.1 The enabling environment

In the new globalised world, water is considered a natural resource to be shared equitably. This requires cooperation, under a framework of inter-dependence and joint management by riparian states. The legal framework for the management of international rivers by Zimbabwe and Mozambique is addressed in global and regional conventions and declarations, mainly:

- The United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses, 1997.
- The Revised Protocol on Shared Watercourses in the SADC, 2000.

Zimbabwe and Mozambique share five international rivers viz the Pungwe, Buzi, Sabi, Zambezi and Limpopo, with Mozambique being the lower riparian state in all cases. Application of the principles outlined in the above legal documents is of paramount importance for the use and protection of watercourses as well as the larger issue of beneficial cooperation between the two countries. The Revised Protocol obliges member states to apply it to "future" agreements without adjustment. (Article 6(3)). Principles embodied in international protocol require to be ratified by participating states to become national laws.

Mozambique and Zimbabwe established the *Joint Water Commission* in Harare in December 2002. In terms of Article 1(2), the objective of the Commission is to

> "...*act as technical adviser to the Parties on matters relating to the conservation, development and utilisation of the water resources of common (bilateral) interest to the Parties and to perform such other functions pertaining to the conservation, development and utilisation of such resources as the Parties may from time to time agree to assign to the Commission*".

From Article 3 (1), the functions of the Commission are to *advise* the parties on measures and arrangements to determine potentially available water, existing utilisation levels, reasonable demand, relevant data and information, criteria for conservation, allocation and sustainable utilisation and prevention of pollution of the water resources of common water resources.

The national legal frameworks for water management are given the Water Act Lei no 16 from 1991 in Mozambique and in the Water Act Chapter 20:24-25 from 1998 in Zimbabwe.

Water Sector of Mozambique

The principal institutions involved in the management of water resources in Mozambique are:

- the National Water Council (NWC);
- the Ministry of Public Works and Housing (MPW&H);
- the National Directorate of Water (DNA in Portuguese), and;
- the Regional Water Administrations (ARAs in Portuguese).

The NWC integrates all Ministries responsible for water-related issues, and acts as a consulting body of the Council of Ministers. It meets ordinarily every three months under the chairmanship of the Minister of Public Works and Housing. The Council is assisted by a Technical Committee and Secretariat, which is chaired and administered by the National Director of Water.

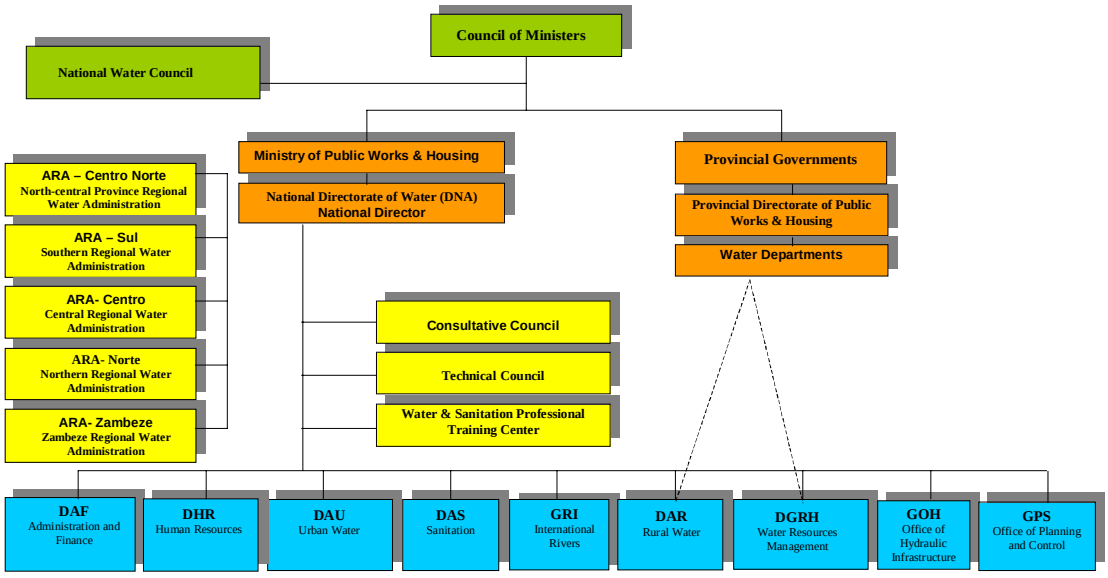
Zimbabwe/Mozambique national water laws:

Mozambique: Water Act Lei no. 16/91

Zimbabwe: Water Act (Chap 20:24) No.31/98

National Water Authority Act (Chap 20:25) No. 11/98

Other important regional authorities associated with water management are the Provincial Directorates of Public Works and Housing (DPOPH in Portuguese). These government entities implement ministerial policy at provincial level. Regarding water issues, they are responsible for the promotion and supervision of urban and rural water supply and sanitation schemes, through their water departments.



Institutional Structure of Water Resources Management in Mozambique

The highest government authority in the Pungwe Basin is the Provincial Governments of Sofala and Manica Provinces.

The DNA is the main Mozambican institution responsible for the planning and management of the water sector. Its statutory mandate is outlined below.

1. *To formulate policies governing water resources development, drinking water supply and sanitation.*
2. *To create and manage the inventory of water resources and water requirements in order to ensure their perpetual balance at the national, regional and river basin level.*
3. *To promote investments in water related studies and development projects, and to supervise the construction of primary hydraulic works such as dams.*
4. *To manage and maintain existing primary hydraulic works in order to ensure their correct operation.*
5. *To promote the formulation of legislation on water related issues regarding the use, protection and quality of water, as well as international river waters, and to supervise its application.*

The Water Law of Mozambique, which was promulgated in 1991, adopted the principle of decentralisation in water resources management, particularly at the operational level. This was to be implemented through the creation of Regional Water Administrations (ARAs), organised on the basis of one or more contiguous river basins. In 1991, five ARAs were legally created, including ARA-Centro, which is responsible for the water resources administration of the Save, Buzi and Pungwe basins, as well as all other minor river basins between the Save and the Zambezi River basins.

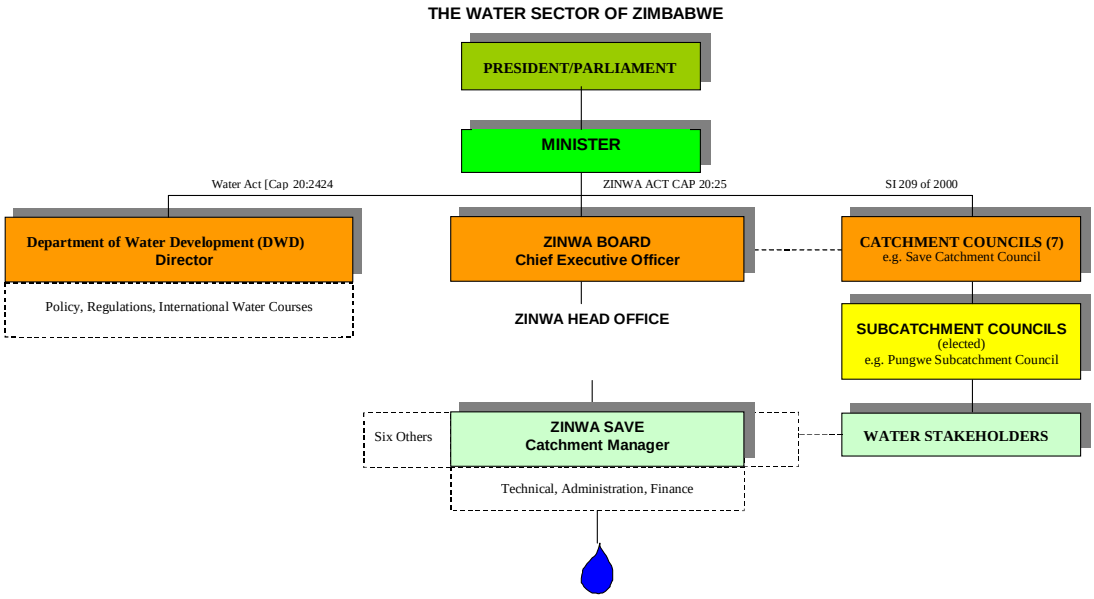
ARA-Centro was made operational in1998 and has its head office in Beira. ARA-Centro is responsible for the following functions within its area of jurisdiction:

- *The formulation, implementation and review of the hydrologic plans of the basins inside its area of jurisdiction.*
- *The administration and control of public waters within its area of jurisdiction.*
- *The creation and maintenance of a register of users.*
- *Collection of water taxes and fines.*
- *The licensing of water uses, and effluent discharges including monitoring thereof.*
- *The approval and supervision of new hydraulic infrastructures.*
- *The planning, design and construction of hydraulic works, as well as their operation and maintenance.*
- *The design operation and maintenance of the hydrometeorological network.*
- *The implementation of flood control programmes.*

Water Sector of Zimbabwe

All surface and groundwater in Zimbabwe is vested in the State President. With the exception of primary water use, all other uses of water must be approved by the State.

The Department of Water Development (DWD), the Zimbabwe National Water Authority (ZINWA) and seven catchment councils are the statutory bodies entrusted with the sustainable management of water resources. All these fall under the umbrella of the Ministry of Rural Resources and Water Development.



Institutional Structure of Water Resources Management in Zimbabwe

For the purposes of the management of water resources, Zimbabwe is divided into seven catchments, which are predominately based on the major river basins in Zimbabwe, viz Save, Runde, Mzingwane, Mazowe, Sanyati, Gwayi and Manyame. Although not part of the Save River basin the management of the Pungwe River basin falls under the Save Catchment.

The Department of Water Development is established in terms of the Water Act Chapter [20:24] No 31/98. Its principal role is to assist the Minister of Rural Resources, Irrigation and Water Development in carrying out the statutory functions listed below.

- *The development of water policies, laws and regulations, and general directions to guide the orderly and integrated planning of the nation's water resources to ensure their optimum development, utilisation and protection.*
- *To ensure the availability of water to all citizens for primary purposes with due regard to environmental requirements.*
- *To ensure the equitable and efficient allocation of available water to all users.*

In addition to assisting the Minister on the above functions, DWD has been given the following mandate:

- *to give effect to any international water agreements to which Zimbabwe is party;*
- *to fix the criteria for water allocation and the issue of permits by Catchment Councils.*

The Water Act empowers the Minister to declare River Systems, better known as catchments, which then fall under the control of a catchment council and the general technical supervision of the Zimbabwe National Water Authority.

The chief accounting officer for the Ministry of Rural Resources, Irrigation and Water Development is the Permanent Secretary, to whom the three directors of Rural Resources, Irrigation and Water Development are responsible. The Director of Water Development is responsible for all water affairs, supported by a complement of seven staff members.

The Zimbabwe National Water Authority (ZINWA) was established in terms of the ZINWA Act Chapter 20:25 No 11/98. Its main functions are:

- *To advise the Minister on the formulation of national policies and standards on all matters related to water.*
- *To exploit, manage and conserve the nation's water resources in order to ensure security of supply, and to facilitate equitable access to water by all sectors, and its efficient utilisation, while minimising the impacts of drought, floods and other hazards.*
- *To provide specialist advice and technical assistance to local authorities and catchment councils in matters concerning the development, management and environmental protection of water resources.*
- *To provide design and construction services for new water works, and to operate and maintain water supply facilities owned or managed by ZINWA.*
- *To carry out hydrological and geographical surveys, including water related research, for the purposes of planning, development and exploitation of water resources, and to publish results thereof.*
- *To give effect to the joint management of international water resources, as determined by the Minister.*

The main source of funding for ZINWA's operation are fees revenues accruing from the sale of water from rivers and water supply facilities owned or managed by ZINWA, charges related to pollution control programmes and fees charged for technical assistance, personnel, training, information and other services to government departments, local authorities, catchment councils, in connection with the exploitation, development, management and distribution of water resources.

ZINWA's requirements for financing capital expenditure for the development of water resources infrastructure are the responsibility of the Central Government through the Public Sector Investment Programme (PSIP).

ZINWA's Head Office is based in Harare. Each ZINWA Catchment Office is headed by a Catchment Manager, who is normally a qualified water professional. The Catchment Manager has been established in terms of the Water Act Chapter [20:24], with the following statutory functions conferred upon the post.

- *The management and administration of the affairs of the catchment council.*
- *Assuming the functions of the catchment council, subject to appropriate delegation.*

The Catchment Manager performs his duties under the direction of the catchment council, and under supervision by ZINWA. The Catchment Manager's office provides technical and secretarial services to the respective catchment councils. It also supplies raw and clear water to farmers, mines, towns, growth points and other community settlements.

The Catchment Manager for ZINWA Save, which is responsible for the Pungwe River basin, has its office in Mutare.

A catchment council (CC) is established by a statutory instrument under the Water Act, through the declaration of a River System by the Minister, and in consultation with ZINWA. Seven CCs have so far been established through Statutory Instrument (SI) 209 of 2000. A catchment council is constituted from members of its subcatchment councils. The principal functions of a catchment council are:

- *To prepare a Catchment Outline Plan (COP) for its river system in conjunction with ZINWA, for approval by the Minister.*
- *To determine and grant water use permits under criteria set by DWD.*
- *To regulate and supervise the exercise of rights to, and use of water in respect of its river system.*
- *To ensure proper compliance with the Act and to supervise subcatchment councils.*

A sub-catchment council (SCC) is established by the Minister through a statutory instrument under the Water Act, for any part of a declared river system that falls under a CC. It is composed of elected representatives of the stakeholder groups in its area. The existing SCC's were established under SI 47 of 2000, Water (sub-catchment councils) Regulations for the seven declared river systems in Zimbabwe, replacing the former River Boards.

The sub-catchment council is the operational arm of the Catchment Council. Its main function is to regulate and supervise the exercise of rights to water within the area for which it was established. It also performs any other functions that may be conferred upon it in terms of the Water Act. The sub-catchment council is funded from levies imposed on permit holders, as well as fees for any services rendered by it.

The Pungwe Sub-Catchment Council's main activity is to collect water levies for water permits

Stakeholders in the Pungwe River Basin

The notion that stakeholders should have a say in the management of the water resources on which they depend is one of the building blocks of the concept of integrated water resources management. The concept of integrated water resources management, and consequently that of stakeholder participation, has found its way into the national water policies and water laws of many countries, also into those of Zimbabwe and Mozambique.

In Zimbabwe the concept of the role of stakeholders in important decision-making regarding water resources management has been incorporated into the Water Act of 1998 with the Catchment Councils, made up of stakeholders, being the ultimate decision-makers on the attribution of water permits in the basin.

In Mozambique the Water Law of 1991 provided for a limited role of stakeholders. The main form in which stakeholder participation would take place was in the Basin Committees. These Basin Committees were given a consultative role only. The emphasis was very much on the decision-making role of statutory governance, in the form of the regional water administrations or ARAs. Stakeholders were given a limited role in the management board of the ARAs though. In practice, these management boards were never created.

Stakeholders in the Pungwe River basin can be classified into three different categories:

1. Government institutions that have responsibility for natural resources management related to water (agriculture, mining, environment, etc.) or are otherwise directly involved with water (health). This group can include some higher level government institutions for as far as they have a stake in managing water-related natural resources in the basin;
2. Water users. This group includes all water users in the basin, essentially all people living in the basin, but represented by the institutions or individuals that are the direct managers of the water they use. This includes water supply companies, commercial farms, agriculture cooperatives, etc.;
3. Civic organizations or non-governmental organizations. This includes associations of farmers, environmental groups, general development-oriented NGOs, etc.

A recent inventory in the Mozambican part of the Pungwe River basin has identified some 150 stakeholders, the majority being water users. In Zimbabwe about 100 water users are registered at the Pungwe Sub-Catchment Council as water permit holders.

3.2 Water resources

Monitoring network

The hydrometric networks are fundamental tools for the sound planning and efficient integrated management of river basin water resources. Hydrometric networks collect data on a daily or continuous basis, required for planning and management purposes.

In Mozambique, rainfall data is collected mainly by INAM (The Meteorological institute) and DNA and its affiliate institutions (hydrometry sectors and, more recently, the ARAs). Stream flow data is collected by DNA and its sister bodies. To date, the digital data archives managed by DNA are not yet entirely reliable.

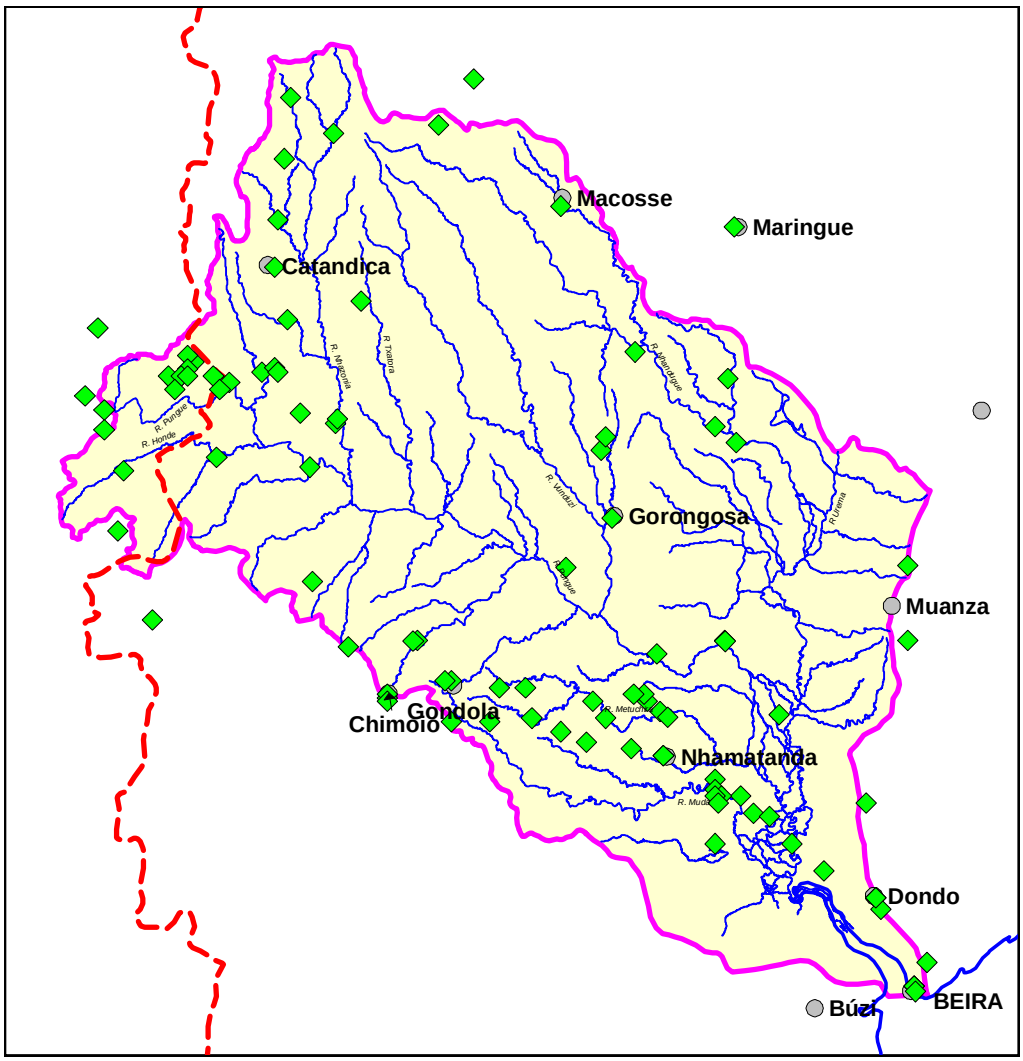
The number of identified rainfall stations with available data in the Pungwe River basin is in total 95:

- 77 stations in Mozambique
- 18 stations in Zimbabwe

Several of these stations, however, only have data for a few years or have a lot of gaps in the measurements. Most stations have not been in operation since the start of the civil war. The large majority of the stations were established along the main roads – EN6 from Beira to Zimbabwe, EN102 from Chimoio to Tete, EN1 through Gorongosa.

Since the establishment of ARA-Centro rainfall stations have been reinstalled in central Mozambique. In the period 1999-2002, nine rainfall stations were put into operation in or close to the Pungwe River basin (P 96 Dondo, P 1272 Metuchira, P 93 Vila Manica, P 375 Pungwe Sul, P 1273 Nhazonia, P 862 Catandica, P 502 Macossa, P 373 Chitengo, P 812 Gorongosa). These stations are essential for the future update of the water resources in the river basin and to monitor changes in the climate. The stations are further a prerequisite for the future use of hydrological models for flood warnings. In Zimbabwe all 18 rainfall stations are presently in operation.

Rainfall gauges are important to monitor the available water resources and possible changes in the climate



All rainfall stations (present and historic) within the Pungwe River basin

According to the DNA files, there are totally 33 stations in Mozambique for Pungwe that have been given a reference number, although some of them have no details and it is not sure they have ever were completely installed. In Zimbabwe four flow stations exist within the Pungwe River basin. In total, the number of stations with available data is 22 stations in Mozambique and 4 stations in Zimbabwe. Most flow records from Mozambique are within the period from 1960 to 1980. Very few stations have any data at all before 1955 or after the early 1980s. Six of the Mozambican stations are presently active, in terms of having an observer and water level records made more or less regularly. In Zimbabwe, three of the four stations are in operation.

In Zimbabwe the collection, processing and management of rainfall and river flow data respectively fall under the auspices of the Department of Meteorological Services (Met Office) and the Zimbabwe National Water Authority (ZINWA).

F14 Pungwe Falls

New station at Bué Maria

River flow gauges utilise the relation between flows and water levels to enable continuous monitoring

All runoff stations (present and historic) within the Pungwe River basin

In Mozambique, ARA-Centro faces severe difficulties to run the hydrometeorological network under their area of jurisdiction, even with the present limited number of rainfall and runoff stations in operation. The main problems are the economical constraints and the limited number of trained staff.

A data quality analysis indicated that the F14 Pungwe Falls, E64 Pungwe Fronteira and E65 Pungue Sul stations have the most reliable records on river flow in the Pungwe River. Also F22 Katiyo, E72 Nhazonia and E81 Urema have fairly reliable records. The reliability, however, varies considerably for observed mean annual runoff, daily data and peaks. The rainfall records in the Pungwe River basin are in general of good quality.

Data on evaporation exist from nine stations, three in Zimbabwe and six in Mozambique in the Pungwe River basin. The data are results from daily observations with evaporation pans.

Surface Water Resources

Surface water is the main source of water in southern Africa. A sound and sustainable development of the water use and allocation in the Pungwe River basin is only possible if it is known how much surface water is totally available and how the surface water resources vary temporally and spatially.

New updates on the surface water resources of the Pungwe River have been calculated through hydrological models (Pitman and HBV). Based on the hydrological years 1960-80, the results from the modelling showed that:

- Although the relatively small catchment area in Zimbabwe, the country generates 28% of the runoff in the Pungwe River basin. A total of almost 4200 million m^3 water is generated annually as natural runoff in the Pungwe River basin. The majority of the runoff occurs during the rainy season between November and April, while the driest month normally is October.

- During the driest month October the flow in the Pungwe River at the border between Mozambique and Zimbabwe is normally 16.7 million m^3, which can be compared with the present maximum water outtake from Pungwe for Mutare City, 1.8 million m^3/month. The normal October flows just upstream of the intake to Beira Water Supply are 46.4 million m^3/month.

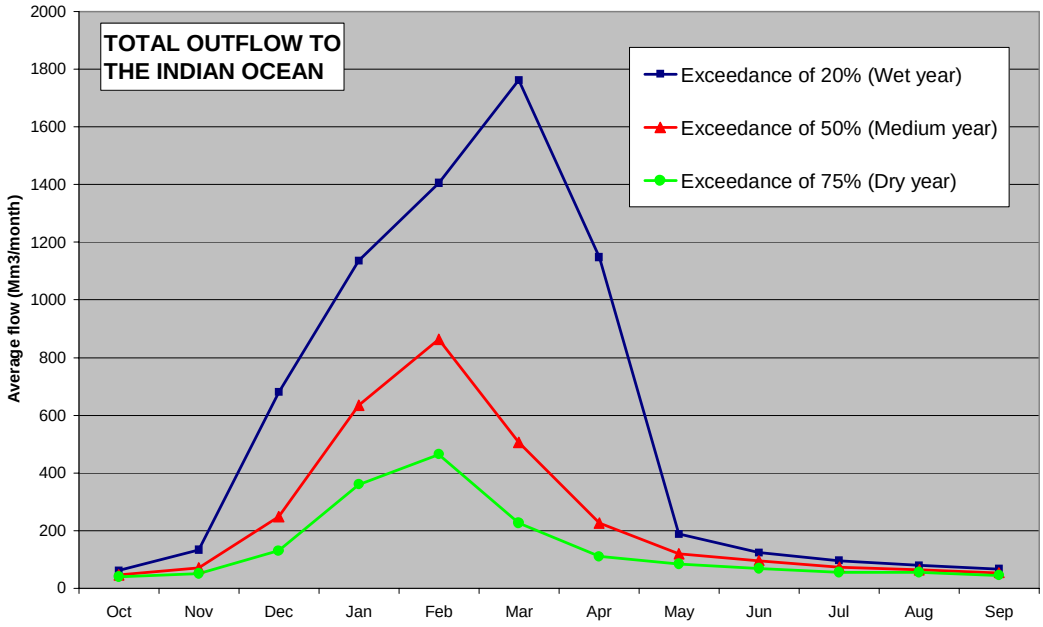
A model simulation with limited rainfall input data based on the hydrological years 1954-2002 showed that during the very extreme 1991-92 seasons the lowest monthly flow was estimated to only 4.4 million m^3/month at the border. The corresponding value for Beira Water intake was 9.4 million m^3/month.

A climatic analysis of the obtained values on available surface water indicated that the obtained values are reasonable. A judgement of the reliability of the calculated surface water statistics were also made by comparison with long rainfall records at Nyangani Luleche and Chimoio as well by comparison with simulated natural runoff for the longer period 1954-2002. The conclusion is that the mean annual runoff and rainfall estimated for the different subbasins of the Pungwe River are considered as good and reliable for the period Oct 1960 to Sep 1981. However, since the 21-year calculation period may be slightly wetter than the long-term average the given mean annual runoff (MAR) may be slightly overestimated (5-15%) compared to the long-term true value.

Point	Area (km^2)	Natural MAR (million m^3/year)	Natural MAR (mm/year)	Percentage of total
Zimbabwe	*1463*	*1191*	*814*	*28%*
Mozambique	*29687*	*3004*	*101*	*72%*
Total	***31150***	***4195***	***135***	**-**

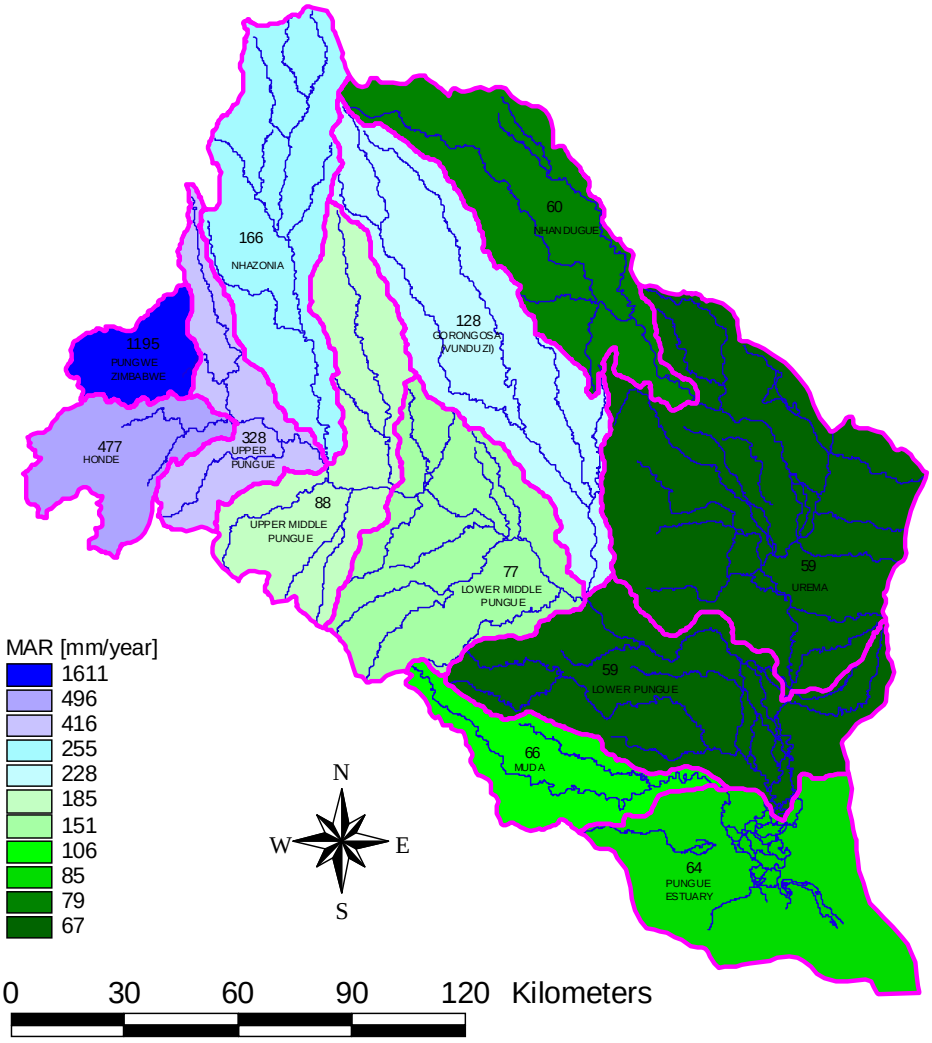
Distribution of surface water availability in Mozambique and Zimbabwe for the Pungwe River basin based on the hydrological years 1960-80. The long-term available water resources are judged to be 5-15% lower than the values given in the table.

The extreme flows based on the hydrological years 1960-80 are less reliable mainly because of the relatively short calculation period. It should be considered for future development options that the given estimated extreme low flows are probably overestimated.



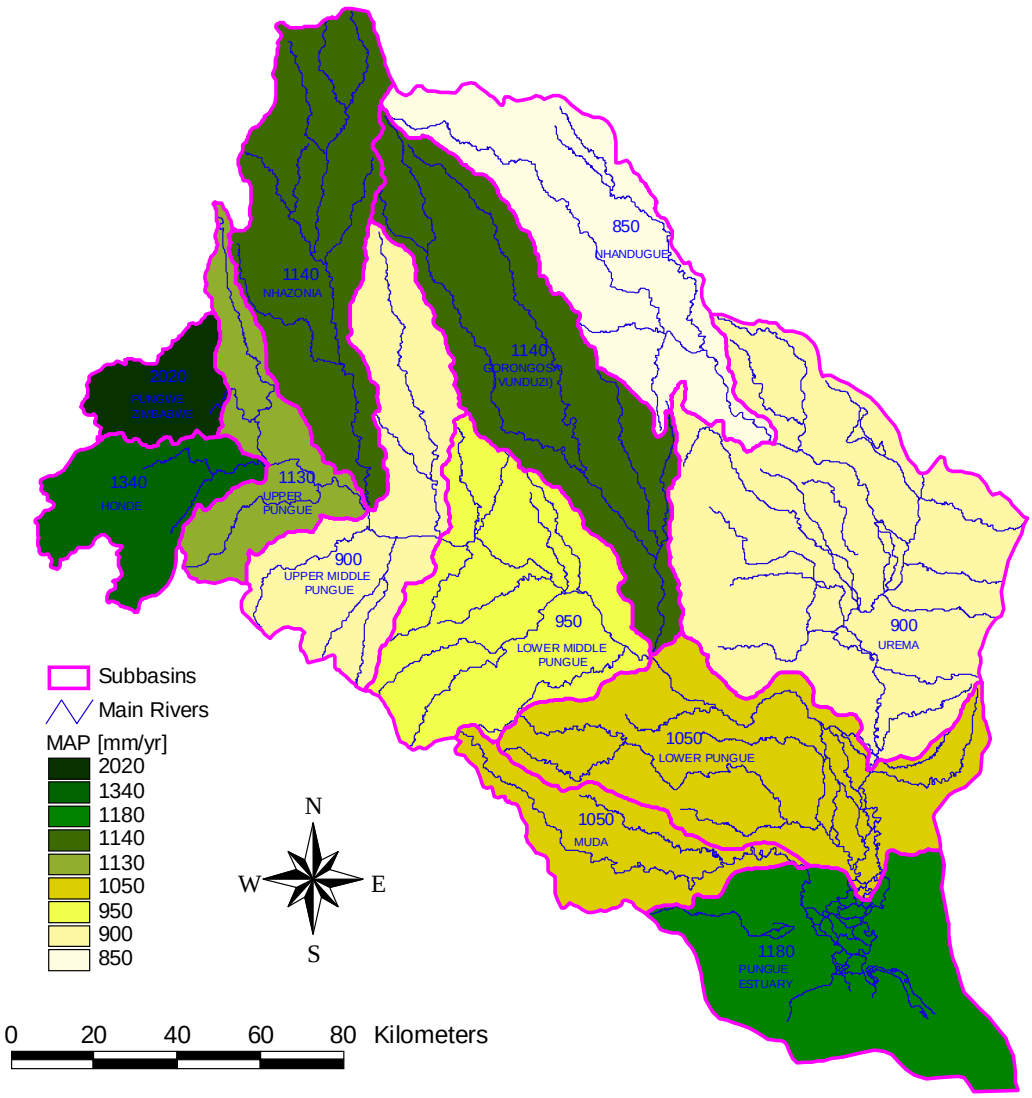
Monthly distributions of natural runoff at the river mouth based on the period 1960-80

Mean Annual Runoff

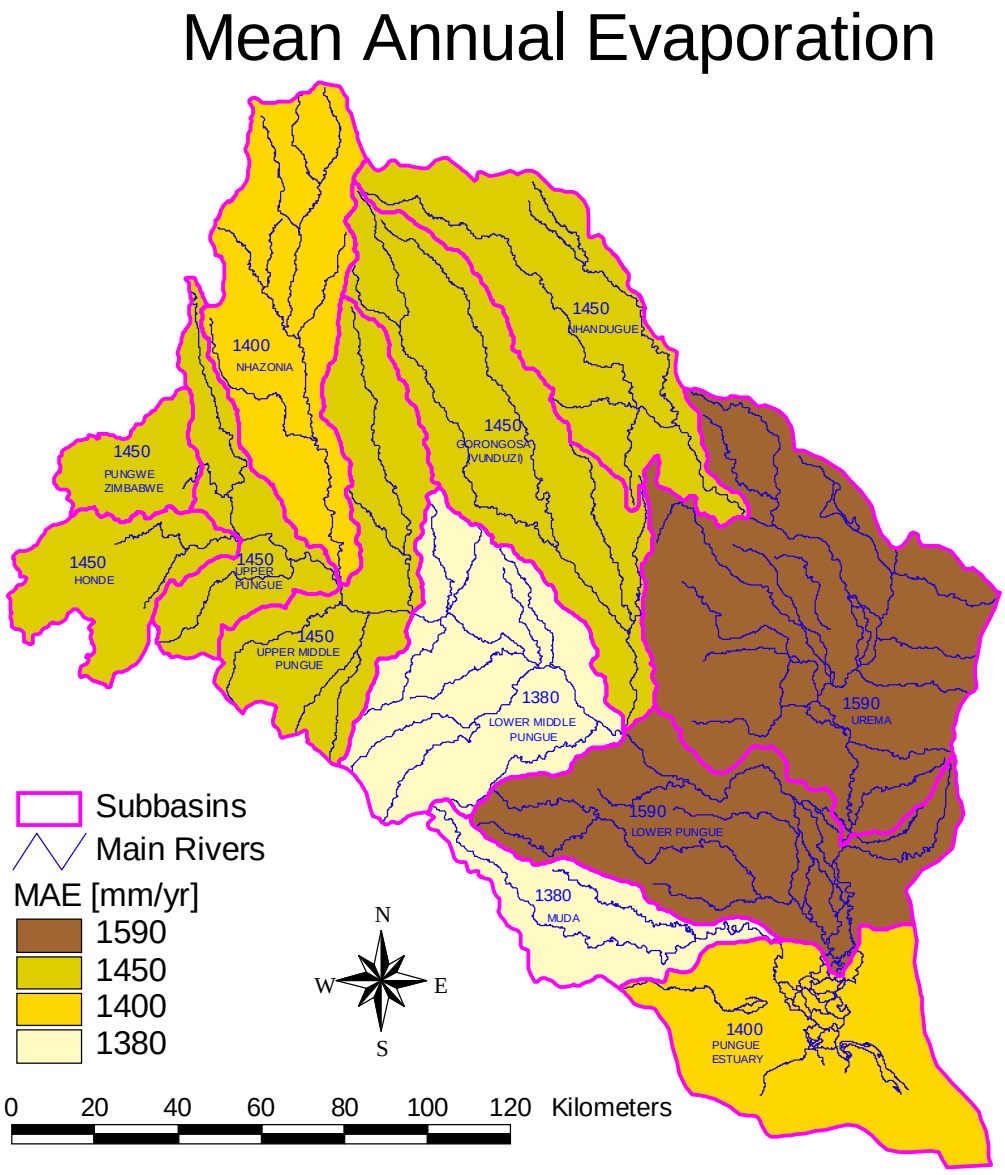


Mean annual runoff (MAR) expressed in mm/year for the subbasins of the Pungwe based on the period 1960-80

Mean Annual Precipitation



Mean annual precipitation (MAP) expressed in mm/year for the subbasins of the Pungwe based on the years 1960-80



Mean annual potential evaporation (MAE) expressed in mm/year for the sub-basins of the Pungwe

Groundwater Resources

Groundwater sources in the Pungwe Basin have been mapped to a reconnaissance level during the Pungwe project. The main objectives were to assess the potential for utilisation of groundwater on a sustainable basis.

The suitability assessment was made for sustainable municipal water supply. The reason for including the "utilisation for municipal supply" in the objectives is that this puts high demand on water quality and quantity and therefore indicates a strict platform for judgment as to what is "high", "moderate" and "low" in terms of groundwater potential. It should be mentioned that areas that were classified as "moderate" therefore could be suitable for other purposes, such as rural water supply with lower demand on quantity.

Groundwater is common for water supply in the rural areas

The selected approach was to utilise all available digital data in a GIS environment, which made it possible to make assumptions and simulations of the way different physical parameters affect groundwater recharge and possibilities for groundwater extraction. The available data sets of parameters included:

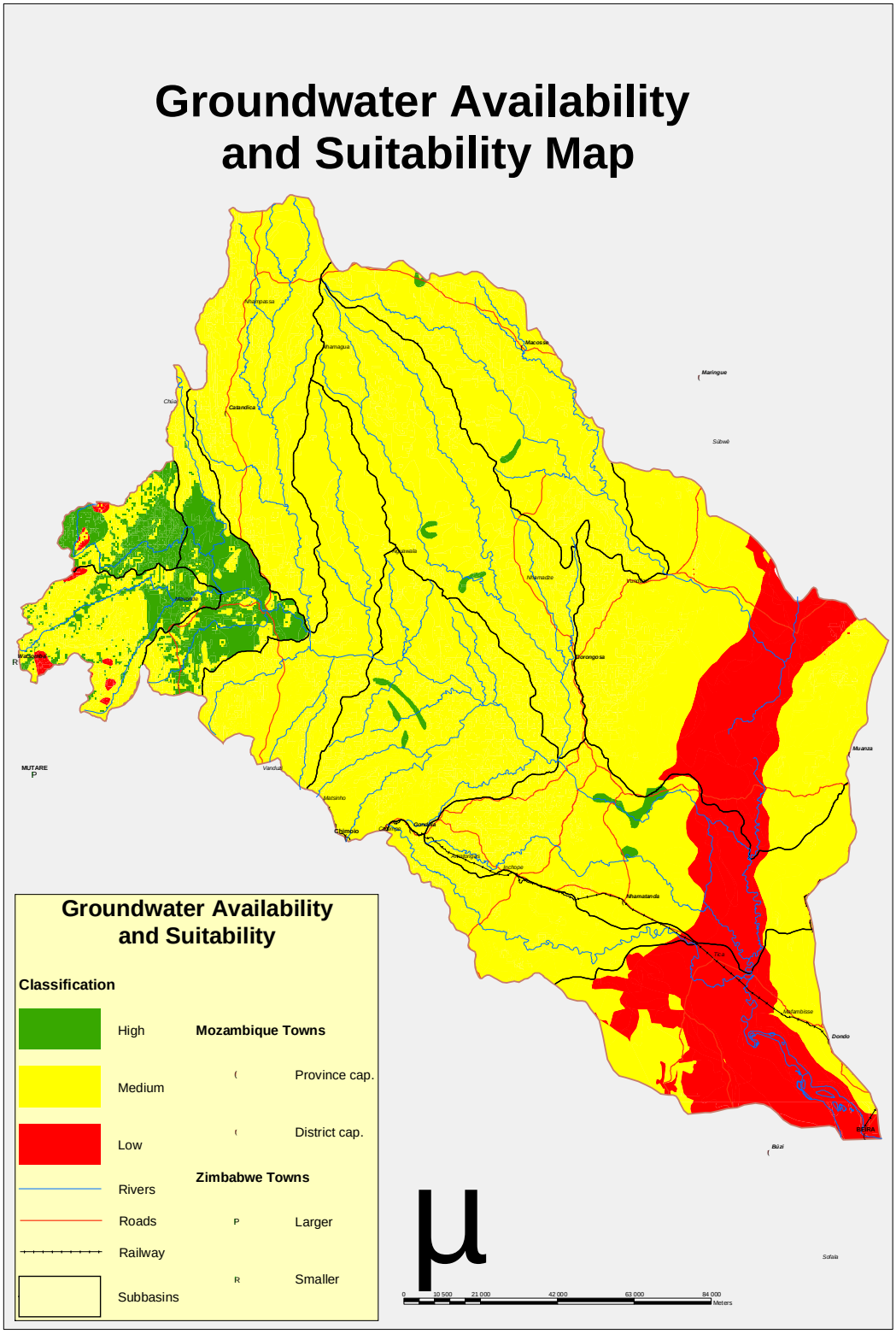
- Catchment outlines and surface hydrology
- Geology and hydrogeology
- Slope
- Soils
- Groundwater quality

A rating and weighting methodology was used. The aim with the classification through rating of parameters and weighting of the different hydrogeological categories was to assess (in three steps):

- The magnitude of the groundwater recharge on a long-term sustainable basis.
- The short-term abstraction potential, governed by the aquifer characteristics.
- The long-term groundwater suitability for domestic water supply, governed by groundwater recharge and abstraction potential, but also by groundwater quality.

The results indicate that large areas of the river basin have moderate or low groundwater potential and very few areas show evidence of high groundwater potential. It is only in parts of the Upper Pungwe and in relatively small areas in the central parts of the river basin that high groundwater potential was found. The suitability mapping shows the general picture for the basin. Small local areas with good potential may occur. The most interesting small areas to investigate are likely to be close to the rivers where induced infiltration through the riverbanks would contribute considerably to the groundwater quality and quantity.

In the modelling work, it was difficult to take into consideration the fact that some of the low-potential areas would benefit by the actual abstraction of groundwater. This abstraction would create a cone of depression and greater distance to groundwater that would promote infiltration to groundwater, which then might change the classification of that area as being more suitable. Furthermore, it is known from interviews and from field measurements that groundwater quality can vary considerably over short distances. Not much of this is known in detail and was difficult to take into consideration in the suitability mapping conducted.



Groundwater availability and suitability for the Pungwe River Basin

3.3 Water demand

Water supply demand

The current water demand from the Beira/Dondo water supply, which includes the Mutua and Mafambisse areas, is estimated at 25 339 m^3/day. Water demand is expected to increase to 74 640 m^3/day in 2023

The City of Mutare is located outside the Pungwe Basin, in the Odzi catchment. It is, however, supplied by Pungwe River water through an elaborate inter-catchment transfer facility. The quantities transferred are limited to a maximum of 0.7 m^3/s by the provisions of a water permit and system design. In addition, on 27th September 1995, it was agreed in a meeting of the Mozambique and Zimbabwe Ministers responsible for Water Affairs that water could be abstracted from the Pungwe River to supply the city of Mutare (located outside of the Pungwe Basin), with an upper limit of 1 m^3/s. Furthermore Mutare city has a second source of water from the Odzani Dams, in the Odzi Catchment. Consequently, a fixed abstraction of 60 480 m^3/day by Mutare City has been adopted as water demand from the Pungwe River. The Mutasa Rural District also draws water from the Pungwe pipeline to supply villages along its route.

Water supply demand 2003:		
Urban:	**Beira/Dondo**	**25 339 m^3/day**
	Mutare	**60 480 m^3/day**
Rural:	**Mozambique**	**10 306 m^3/day**
	Zimbabwe	**1 962 m^3/day**
TOTAL	**98 087 m^3/day or 35.8 million m^3/year**	

Water supply for the basin's rural areas comprises small piped systems and manual pumps serving small towns, growth points, commercial plantations, service centres and some villages, as well as direct abstractions from the rivers by riparian village communities not connected to developed installations.

The Pungwe Basin in Mozambique contains six small piped systems at Nhamatanda, Muanza, Gorongosa, Gondola, Macossa and Barue. The pipeline schemes at Gorongosa, Gondola and Catandica are supplied from surface water, with the rest depending on groundwater. Most of these water supply systems are in poor condition, and operate at below design capacity. Some are not even operational at present.

The proportion of the basin population in Mozambique supplied by piped systems or any other formal water scheme is small. Current water demand from piped schemes has been estimated based on the assumption that 40% of the population is served by reticulated piped systems for small towns, and stand posts for rural areas. This gives an estimated current water demand of 10 306 m^3/day in Mozambique, including the informal direct abstraction (2 022 m^3/day).

For the Pungwe Basin in the rural areas of Mozambique, preliminary estimates indicate a water demand of approximately 24 049 m^3/day in 2023.

The Pungwe Basin in Zimbabwe has a total of seven small to medium sized piped water systems at Hauna, Sachisuko, Honde Army, Zindi, Samanga, Mpotedzi and Sahumani. In addition there are other smaller un-metered water supply schemes that serve a number of villages and schools.

The estimated current water demand for small piped systems and undeveloped supplies in the Pungwe Basin in Zimbabwe is approximately 1 962 m^3/day, of which 428 m^3/day is from piped abstractions and 1 534 m^3/day from informal direct abstractions. The figures exclude diversion to the City of Mutare.

As a conclusion, the current urban and rural water demand in the Pungwe Basin is estimated at 98 087 m^3/day. The situation could change in the future with the rehabilitation of existing water supply installations and the development of new small piped systems in Mozambique, as well as the potential development of new industries, both in Zimbabwe and Mozambique.

Water supply for industry and mining

Industrial and mining development in the Pungwe Basin in general is very low. The primary economic activity is agriculture. Industrial activity in the basin is concentrated in Beira. The city of Mutare, which is outside the catchment, but draws water from the Pungwe Basin, also has a thriving industrial sector. Water demand for these centres has been included under urban water supply.

Outside Beira, Mafambisse Sugar Estate is the only large industry in the catchment directly supplied by the Pungwe River. For the rest of the basin, industrial activity is limited to small-scale service industries in the small towns and growth points that have presently no significant impact on water demand. They are supplied from existing piped schemes or boreholes. Their water demand is included under domestic consumption for each centre.

Informal gold panners on the upper Nyamakwarara River carry out mining activities. In Mozambique, a Malaysian-Australian company is prospecting for gold using modern techniques and gravitation methods. Current water

demand from mining activities is insignificant since almost all the water is returned to the main channel.

Irrigation and forestry water demand

In Mozambique, *alien tree plantations* cover an area of approximately 2 496 ha near the City of Gondola in the district of Gondola. It is estimated that indirect water utilisation is in the order of about 7.5 to 10.0 million m^3 per year. In Zimbabwe, alien tree plantations cover an area of approximately 5 254 ha, which results in an indirect abstraction of between 15.8 and 21.0 million m^3 per year.

In 1975, the population of *livestock* was estimated 45 190 cattle, 46 194 small ruminants, and 19 559 swine. This resulted in an estimated water abstraction of approximately 7 x 10^5 m^3 per annum. By year 2000 the animal population had decreased to 23 513 cattle, 45 769 small ruminants, 11 990 swine and 507 523 poultry, with an associated reduction of water consumption to 4.47 x 10^5 m^3 per annum.

Irrigation and forestry demand 2003:		
Forestry:	**Mozambique**	**7.5-10 million m^3/year**
	Mutare	**16-21 million m^3/year**
Livestock:	**Mozambique**	**0.5 million m^3/year**
	Zimbabwe	**-**
Irrigation:	**Mozambique**	**84-190 million m^3/year**
	Zimbabwe	**38 million m^3/year**
TOTAL	**146 - 260 million m^3/year**	

An area of 8 798 ha is currently equipped with irrigation infrastructure, from which 8 310 ha are being *irrigated*. By far the largest portion of irrigated land, measuring 8 133 ha, is under Mafambisse sugar plantation in the district of Dondo, Province of Beira. The irrigation sector has an annual consumption ranging from 189.5 x 10^6 m^3 per annum in the driest years to 83.95 x 10^6 m^3 in the wettest years. The average water annual consumption for the irrigation sector is approximately 122 x 10^6 m^3.

The irrigated agriculture in Zimbabwe with an estimated area of 2 120 ha results in a maximum annual water abstraction of approximately 37.8 x 10^6 m^3

Following the present development trends in Mozambique, it is expected future growth on all three sectors. For the livestock sector it is expected a

development up to the year 2025 in an animal population that would result in a water consumption of around 6 million m^3 per year.

It is difficult to estimate growths for both the agriculture and forest sectors. In terms of potential, there are a total of 244 000 ha of agricultural soils for irrigated agriculture. If all the area would be used, it would result in a yearly average abstraction on the order of 3 400 million m^3. If similar trends would be adopted for the forest sector, i.e. a development in the order of 200 000 ha, that would result in an indirect annual withdrawal in the order of 800 million m^3.

The total amount for all three sectors would sum up to a figure on the order of 4 200 million m^3 which is slightly more than all the available water in the catchment. However, this situation is not really critical because the estimates correspond to the full development of the existing potential and not to effective proposed developments.

Total water resources contra demand in the Pungwe River:	
Long-term available surface water:	**3 600-4 000 million m^3/year**
Total water supply demand 2003:	**36 million m^3/year**
Total water supply demand 2023:	**60 million m^3/year**
Total irrigation demand 2003:	**146-260 million m^3/year**
Total irrigation demand if all potential areas are irrigated:	**4 200 million m^3/year**

3.4 Hydraulic structures

The Pungwe River can be considered a natural river because there are few abstractions, diversions or regulation structures in its catchment. The present hydraulic infrastructures do not have any significant influence on the natural flow regime.

The largest hydraulic installation in the Mozambique part of the Pungwe Basin is the intake and pumping station of Mafambisse Sugar Estate, with an abstraction capacity of 7.4 m^3/s. The pumping station supplies the Mafambisse Company as well as the Beira Water Supply System.

No other large hydraulic installations, such as flood control works, exist in the basin. However, there is a large number of hand-pump based rural water supply systems. District towns usually have small piped water supply systems.

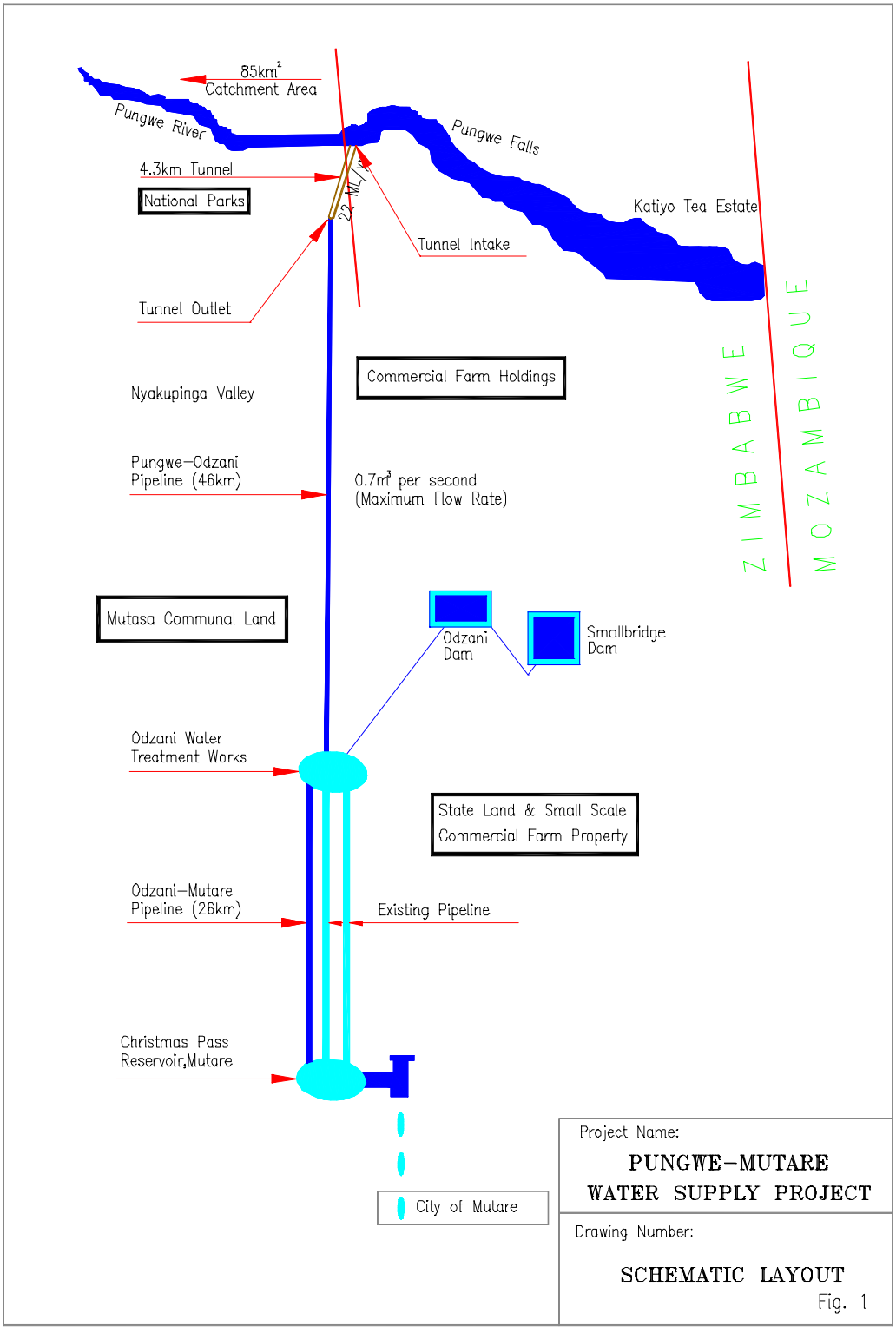
The intake and pumping station of Mafambisse Sugar Estate is the largest hydraulic installation in the Pungwe River

On the Mozambican side, 19 small dams have been identified, mainly for irrigation. There are six pumping systems and some intakes directly off-river or from reservoirs. Approval for the construction of three new small dams in the Nhamatanda and Gorongosa districts has been given. The design has been completed and the process of construction is expected to start within short. DNA is also planning to rehabilitate and build other small dams in the Pungwe.

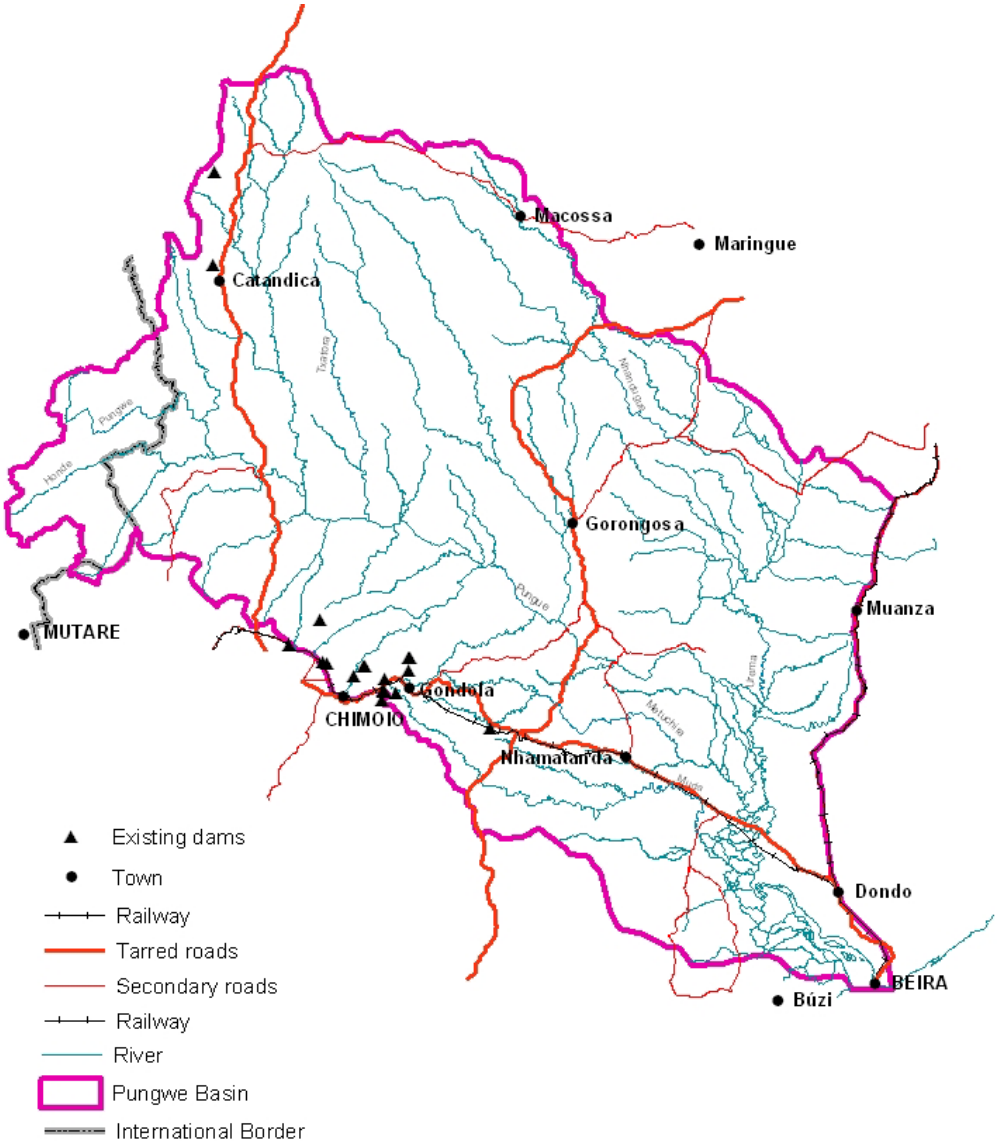
In Zimbabwe, during the pre-independence era, there was virtually no formal development of water supply in the communal areas, until the advent of the war for Independence. Water schemes, based on the twin tank system and pressure filter, were hurriedly installed to service the so-called Keeps (makeshift camps where all villagers were detained under a curfew system, as part of the Rhodesian war strategy).

A total of seven small-scale off-river irrigation schemes have been developed on tributaries of the Pungwe River, in the Honde Valley, under the STABEX Coffee Research and Training Trust (SCORT). These are gravity schemes, which exploit the existence of rapids and falls on the perennial rivers to transfer water to downstream irrigable areas by means of pipelines. The objective of the schemes is to promote small-scale coffee growing by the locals. Climatic conditions and the existence of perennial streams are ideal for coffee growing.

The largest scheme on the Pungwe River in Zimbabwe is the one that supplies water to the city of Mutare, through a diversion tunnel and pipeline. The intake weir has a maximum capacity of 0.7 m^3/s. while the tunnel to supply the city of Mutare is designed for flows up to 1.2 m^3/s.



Schematic layout of Pungwe-Mutare Water Supply Scheme



Existing small dams in the Pungwe River basin

3.5 Water quality and sediment transport

Background geology and soils, vegetation and human settlements have an influence on ambient water quality. The associated uses of land and water for domestic, mining, industrial, transportation and agricultural purposes alter the natural state of water quality. Consequently, there is a need to appreciate the dynamics of human settlements in the context of their polluting potential in order to fully characterise the basin's water quality.

The Pungwe basin is predominantly rural. Settlements are concentrated along the river valleys, in zones with agriculturally suitable soils, the floodplain, and in the proximity of existing infrastructure such as roads and administrative centres. The cities of Beira and Dondo in Mozambique are the main urban and industrial centres in the basin. The general settlement pattern in the basin's rural areas is a mixture of large-scale agricultural, forestry and plantation enterprises, as well as communal and largely subsistence farming communities. The Pungwe River rises in the Nyanga Mountain, flowing through Nyanga National Park where settlements are prohibited and ecological conditions are virtually pristine. On exit from the national park, it traverses predominantly subsistence farming land until it enters the Indian Ocean at Beira. The Nyamakwarara River, a minor tributary, traverses alluvial gold mining areas where informal operations are generating heavy pollutants in the river system.

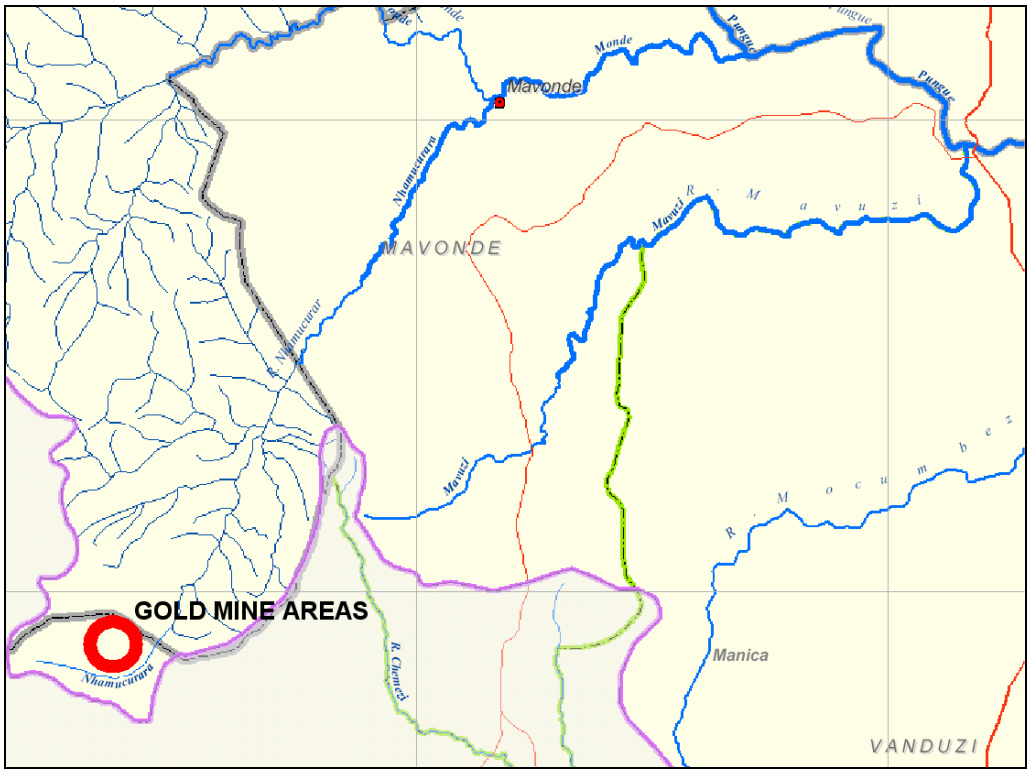
Thus, the following potential source of pollution in the basin have been identified:

1. Large-scale commercial agriculture through both point and diffuse pollution;
2. Subsistence agriculture, predominantly through diffuse pollution;
3. Urban settlements;
4. Rural settlements due to inadequate sanitation resulting in diffuse pollution;
5. Saline water intrusion in the Pungwe Estuary area;
6. Afforestation;
7. Gold panning in the Nyamakwarara River and its environs.

The most evident source of pollution identified is associated with alluvial gold mining practised in the mountainous areas in the upper part of the basin. The mining for gold takes place in the Nyamakwarara River and its immediate environs. The river originates in Mozambique, passing through Zimbabwe to enter the Honde River in Mozambique.

Currently, small-scale operators using rudimentary gold panning technology carry out most of the gold mining. In addition, an Australian-Malaysian mining company has established a production unit with dams and equipment for the gravitational extraction of gold. The crushed ore is fed into sieves where gold particles are separated by gravity.

The informal gold mining activities in Mozambique upstream the border with Zimbabwe have been confirmed by visits. Oral information gained at the mining area has indicated that these activities also expand into Zimbabwean territory. However, this has not been confirmed by the visits to Zimbabwe, in which no direct mining activities were observed.



Location of confirmed gold mining areas in the Upper Pungwe Basin

Mining activities entail the clearance of vegetation to facilitate excavation, while recovering firewood for other uses. This exposes the soil to erosion by wind and rain, leading to the loss of fertile topsoil. The disturbed topsoil and sediments from excavations are washed into the stream during rains causing siltation of the aquatic system. Therefore, the gold mining activities in the Nyamakwarara River area are causing a significant increase in sediment load downstream of the mining areas. Because of the fine texture of the eroded soil the effects of sediment transport can be seen by eyesight during the low flow season as far down as the Bué Maria site in the Pungwe River some 200-300 km downstream the mining areas.

Eroded mountainside due to excavation for gold-rich deposits.

The extraction of gold is carried out by amalgamation with mercury. In this approach, gold concentrate is passed over a mercury-coated plate. The amalgamated mercury mixture is then separated from the excess liquid mercury by squeezing it through a leather cloth or similar contraption. The mercury is evaporated from the amalgam to separate the gold by heating in a suitable container.

Mercury is a heavy silver-white liquid at room temperature, with a melting point of –38.89 °C at ambient temperatures. Purified mercury in air vaporises at an hourly rate of 0.007 mg/cm^2. The World Health Organisation recommends average levels of 0.05 mg/m^3 and 0.015 mg/m^3 respectively for occupational exposure on human beings, and for continuous environmental exposure. In the liquid state, the heavy metal easily vaporises due to its tendency to break up into tiny droplets. Consequently, its use for gold recovery creates a health hazard for the miner, and has the potential to compromise the aquatic food chain.

There is unfortunately no data to clarify the extent of mercury that stems from the gold mining areas. A few recent samples have confirmed the existence of mercury in the water and riverbed sediments downstream the mining areas. Measurements show high levels of mercury in one sample taken suggesting that that the environmental effects of gold mining operations might be serious or at least constitute a potential threat to human health and the integrity of the aquatic ecology. However, further sampling is needed to monitor the situation.

Although sediment loads from gold mining operations in the Nyamakwarara River area are high in relation to the small local catchment, they probably do not significantly affect the long-term average sediment load transport in the system. The natural erosion and sediment transport in the upper areas of the river basin is large (615 tonnes per km^2 and year) because of the steep slopes and high rainfall intensities.

The informal miners use panning and mercury to extract the gold

Also for other constituents than mercury, existing water quality data in the basin is very sparse, with most stations consisting of short series of measurements. It is therefore not possible at this stage to fully characterise current water quality in the basin with reasonable confidence. Available historical data have been analysed, together with data from recent water quality measurements to obtain an initial appreciation of the status of water quality in the basin.

The data indicate that water quality in the upper catchment in Zimbabwe generally complies with South African Water Quality Guidelines (which is adopted in Mozambique) for most constituents for domestic, ecological and irrigation uses as well as for the Zimbabwe standards. There is a sharp deterioration in water quality of the Pungwe River after the confluence with the Honde River resulting from gold mining operations in the Nyamakwarara River. There is, however, a marked improvement in turbidity in the Pungwe River after the confluence with the Nhazonia-Vunduzi system, although the concentration of the constituent still significantly exceeds guidelines for domestic use.

3.6 Future problems to address

Despite that the present water demand is low and that most of the tributaries of the Pungwe basin have more or less perennial flows there are some problems to address. The potential for irrigation is very large and the demand cannot be fully met by the Pungwe River system. However, the more immediate challenges for water management in the Pungwe River basin are how to handle the spatial and temporal variation of surface flow.

The water resources assessment has shown that a large part of the runoff is generated in the small upper mountainous part of the basin. This is especially pronounced during the dry season when almost half of the water is generated in the upper Zimbabwean subbasins.

The temporal variation is also large. Low flows much less than the normal may occur, which was shown during the dry years 1991-92 when the October flow at the intake of Beira Water Supply was only some 9 million m^3/month. On the other hand the 2000 and 2001 high flows during January and February caused severe flooding in the lower Pungwe River basin.

Another issue of concern is the water quality. The gold mining activities in the upper river basin may be a serious threat to the use of water for both domestic use and irrigation. Recent information has also indicated that the gold panning activities are staring to occur in other parts of the Pungwe River basin.

Although a natural pollution, the salt-water intrusion in connection with low flows cause problems for the Mafambisse and Beira water intakes.

The aquatic life of the Pungwe River and estuary is well adapted to extreme environmental variations caused by seasonal floods and droughts. Future change in the timing of seasonal floods, the content of silt and sediment in the water, the concentrations of fertilizers and organic matter, due to manmade activities, may however influence the aquatic life. This may harm the environment which in turn may give socio-economics consequences, for instance if the fish fauna and the productivity of the fishery would decrease.

The wildlife of the Gorongosa National Park to a large extent relies on a very tight equilibrium of the Urema Lake, which annually floods part of the park. Indication of agricultural development in the catchments of the tributaries rising in the Gorongosa Mountains feeding the Urema Lake is worrying. The future development of tourism related to activities in the Gorongosa National Park depends on secures inflow of water to the Urema Lake.

3.7 Development options

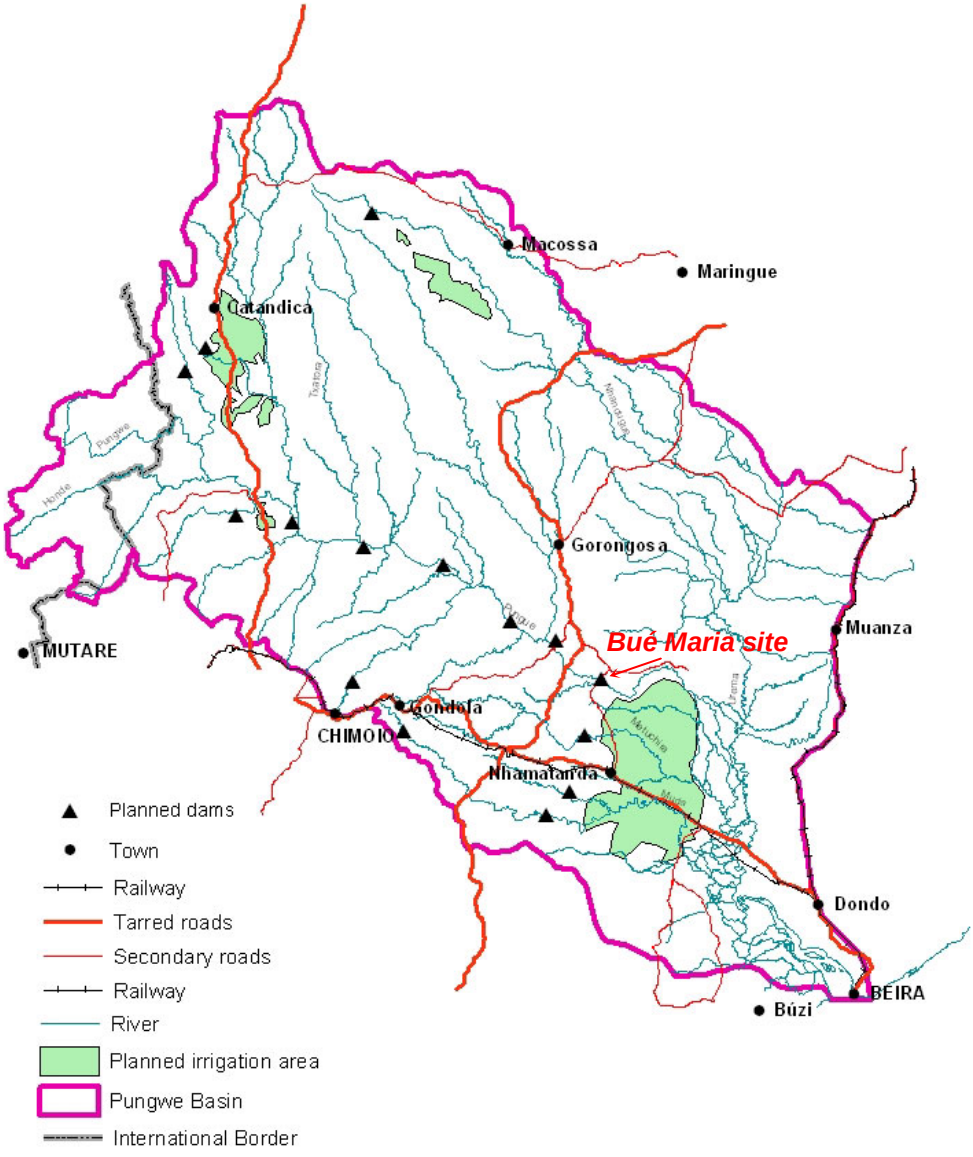
To enhance future economical development and reduce poverty in the Pungwe River basin, various options of how to utilise the surface- and groundwater are probably needed. The major purposes would be to secure water supply and irrigation during dry periods, to control floods and salt water intrusion or to mitigate pollution, e.g. from the gold mining activities. It is, however, essential that all development options are made taking the environmental and socio-economic consideration into account.

There is great potential for the construction of large and small dams in the Pungwe basin as well as other hydraulic infrastructures. There are good dam sites and a significant potential runoff. However, the present water demand is very low and the perennial nature of most of the tributaries of the Pungwe basin permits the satisfaction of all the needs only with abstractions directly off-river.

The previously identified major water resources development project in the region is the construction of Bué Maria dam. This large dam, with 70 m height and a storage capacity of about 987 Mm^3, can represent a potential solution for some of the major problems in the Lower Pungwe River, namely those related with floods, low flows and water salinity intrusion. This dam could have an important contribution to the socio-economic development of the region, with the increment of agriculture production with irrigation, flood control and power production. However, there are concerns about possible negative environmental impacts of such a dam.

Also other large dam sites have been identified. In 1973, the COBA Consultant Company developed a comprehensive study, presented in 23 volumes, proposing an integrated water development plan to the Pungwe Basin River. This study proposed the construction of forty large dams, of which two dams for agriculture, 31 mainly for hydropower production and 7 for multiple uses. This study evaluated an area of 827 000 ha of good arable areas and more 938 000 ha of arable or limited arable lands. The study proposed an irrigation area of 245 000 ha. From the General Scheme, COBA proposed to give priority to 13 large dams and four distinct irrigation areas.

Furthermore, as result of the last drought situation in Pungwe basin, DNA elaborated an emergency action plan for the construction of small dams in the Manica and Sofala Provinces. In a preliminary evaluation, a list of 28 small dams was selected for future studies. The priority was given to develop the detailed design for three small dams, Gorongosa dam, Metuchira Dam and Chitunga Dam. The design of these three dams has been completed and the construction will begin in a short time. DNA will fund the construction of the dams. The operation and maintenance of the dams will become the responsibility of the Ministry of Agriculture and Rural Development.



Proposed priority dam sites in the Pungwe River basin by previous studies

4 The Way Forward

The Pungwe Project is scheduled to be finalised in February 2006.

Based on the findings in the monograph phase, which are summarised in this report, different development scenarios will be identified and evaluated in terms of economical feasibility and environmental and socio-economic impacts. Three main development scenarios will be presented to stakeholders and water management institutions in both Mozambique and Zimbabwe. Based on the chosen development option a joint integrated water management strategy for the implementation will be developed.

Institutional capacity building is a major part of the project to prepare the implementing agencies in both Mozambique and Zimbabwe for carrying out the strategy. Likewise the mobilisation of stakeholders and an increased communication between the two countries are essential ambitions within the project.

The Pungwe River basin has great natural potential that provides the basis for social and economic development. The only way is forward.