# The Pungwe River Basin

Pieter van der Zaag; 1 August 2000

## 1. Physical data

The Pungwe or Púngoè river is shared by Zimbabwe and Mozambique. The length of the river is nearly 400 km of which 340 km is in Mozambican territory. The Pungwe river drains an area of 31,000 km$^2$. Only 5% of the basin is situated in Zimbabwe. Since this part of the basin receives generous rainfall, it contributes considerably to the Pungwe discharge. (Figure 1)

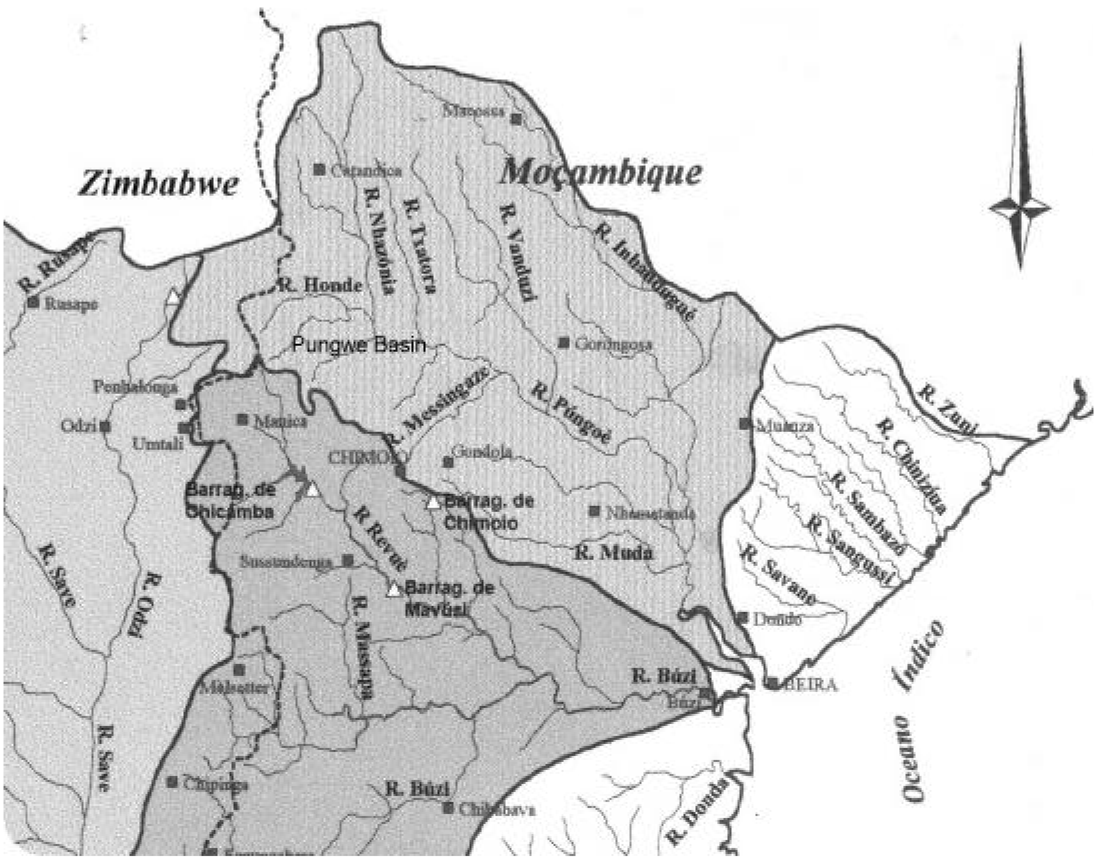


**Figure 1: The Pungwe basin with neighbouring basins (Revue, Buzi, Save etc)**

The Pungwe river rises from the foothills of Mount Inyangani in eastern Zimbabwe, flows into Honde Valley where it crosses into Mozambique. This part is considered the middle Pungwe, up to the point at Bué Maria where it reaches the plains, considered the lower part of the basin. Downstream of Bué Maria the river divides in several streams, of which the Dingue Dingue is the most important, because through it the main discharge in the dry period is transported. The streams join again near the bridge over the Pungwe river on the EN6, which is situated some 100 km from the estuary mouth, in the zone under tidal influence. At the estuary the Pungwe waters enter the Indian Ocean. This is some 20 kilometers north-west of the City of Beira.

**Table 1: Discharge of the Pungwe river at various gauging stations ($m^3/s$)**

| Site | Catchment area ($km^2$) | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pungwe Falls (F14) | 86 | 1.5 | 2.4 | 4.7 | 7.2 | 9.3 | 8.8 | 4.8 | 2.8 | 2.0 | 1.8 | 1.5 | 1.4 | 4 |
| Katiyo (E64) | 622 | | | | | | | | | | | | | 24 |
| Púngoè (E65) | 3,022 | | | | | | | | | | | | | 62 |
| Bué Maria (Db4910) | 15,046 | 21 | 32 | 119 | 200 | 270 | 238 | 118 | 67 | 47 | 37 | 28 | 23 | 100 |

(sources: Zanting et al., 1994; Nilsson & Shela, 1998; Liden, 2000; and unpublished data from DWD gauging station F14; and from DNA gauging station Db4910)

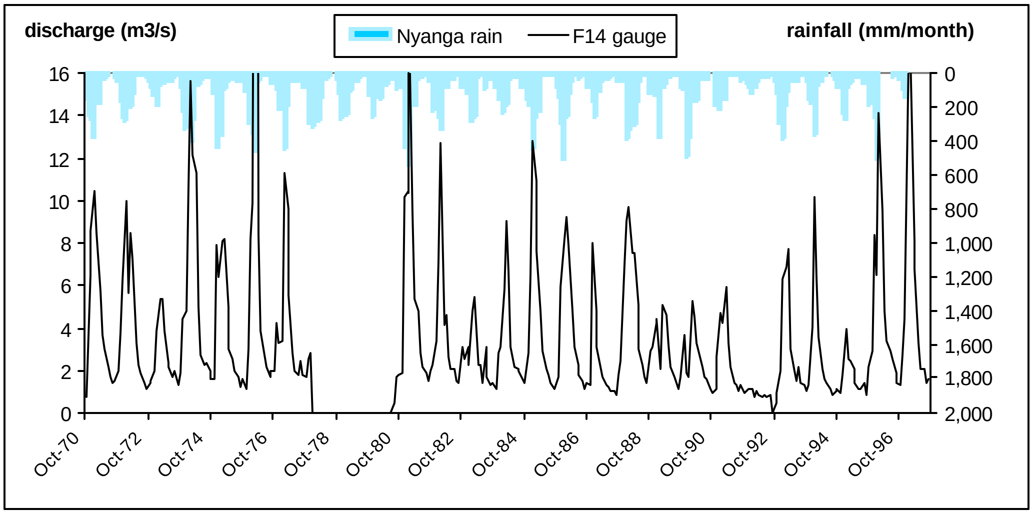


**Figure 2: Monthly discharge and rainfall data; 1970-1997 at Pungwe Falls in Nyanga, Zimbabwe**

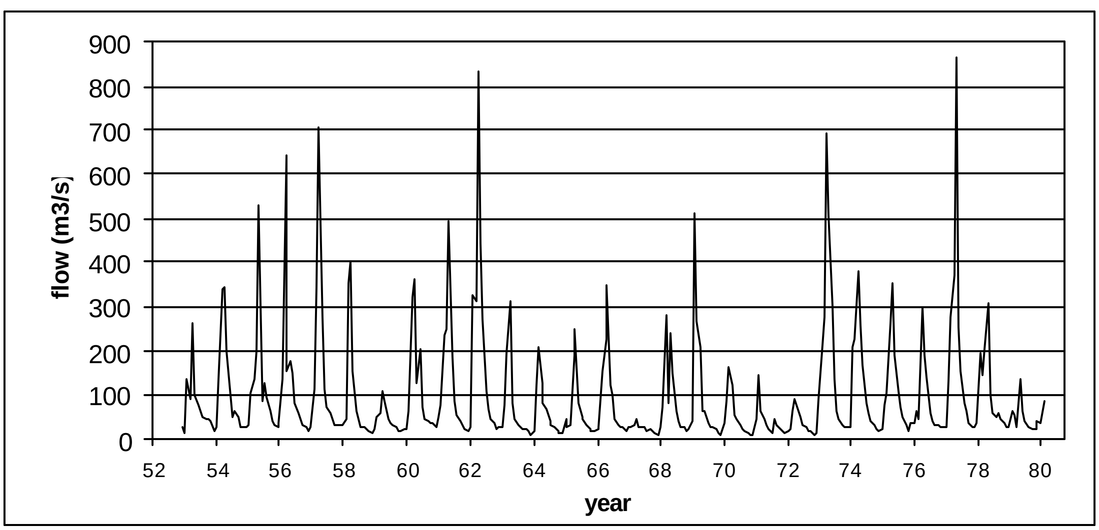


**Figure 3: Monthly discharge; 1953-1980 at Bue Maria, Mozambique**

The discharge at Bué Maria plays an important role in pushing back the salt sea water intruding through the estuary, which is crucial for the City of Beira's water supply intake. The 10% low flow (i.e. the flow with a chance of occurring of 0.10; with a return period of 10 years) at Bué Maria has been established at 8.8 $m^3/s$ (Zanting et al., 1994). A flow of 10 $m^3/s$ is considered the minimum flow to safeguard the intake of fresh water for Beira (Chamuço, 1997)

# 2. Uses of Pungwe waters

The uses of the Pungwe waters are summarised in Table 2. The table looks like a 'mirror', since in both Zimbabwe and Mozambique the Pungwe waters are used for similar types of needs.

**Table 2: Uses of Pungwe water**

| Zimbabwe | Sector | Mozambique |
|---|---|---|
| - rainfed<br>- irrigation | Agriculture – large scale | 'Farmeiros' are coming:<br>- rainfed<br>- irrigation |
| - rainfed<br>- irrigation, eg Mtarazi | Agriculture – small scale | - rainfed<br>- irrigation eg Gorongoza |
| - tea<br>- coffee<br>- exotic forests | Agriculture – plantations | - sugarcane<br>- citrus |
| Public water supply schemes, boreholes, etc. | Rural | Individual arrangements, such as wells; public schemes in a few growth points etc. |
| Mutare<br>- domestic<br>- commercial<br>- industrial (eg timber, paper) | Urban | Beira<br>- domestic<br>- commercial (eg harbour)<br>- industrial |
| Nyanga NP | Parks/tourism | Gorongoza NP |
| Certain fish and tree species | Ecology | Mangrove and prawns |
| Pungwe Sub-Catchment Council | Management Institution | ARA-Centro |

## 2.1 Zimbabwe

The part of the Pungwe river situated in Zimbabwe is relatively densely populated and substantially developed in terms of agriculture and tourism. It is likely that in future water consumption will increase further. Currently, the main water consumers in the upper part of the catchment are forest plantations of exotic trees which are known to affect negatively river discharge significantly; the City of Mutare; and tea and coffee estates near the border with Mozambique for irrigation. Other consumptive uses include smallholder irrigation and primary uses by communal farmers in the Honde Valley. It is likely that irrigation development in the area of both smallholder and estate will continue, and that water demand for irrigation will increase. The three principal non-consumptive uses in this part of the basin are: national park/environment; tourism; and fisheries.

The ecology of this part of the Pungwe basin is considered pristine. The Pungwe river hosts a variety of rare freshwater fish species such as the Mountain Catfish *(Amphilis uranoscopus)*, Barred Minnow *(Opsaridium zambezenze)*, African Mottled Eel *(Anguilla bengalensis labiatal)* and the Pungwe Chisel Mouth *(Varicorhinus pungweensis)*, among others. At the Pungwe Falls, the river supports spray dependent vegetation largely comprising Yellow Wood *(Podocarpus milanjianus)*, Cape Breech *(Rapanea melanophloeos)*, including creeping ferns such as *Pleopeltis excavata.* A new undescribed pendulous *Aloe* was discovered recently (Magara & Tapfuma, 2000)

**Table 3: Water uses of the Pungwe within Zimbabwe**

*Non-consumptive uses:*
National park (Nyanga)
Tourism (such as canoeing)
Fisheries (very limited

*Consumptive uses:*
Rural water supply for primary uses (including cattle, gardens etc.) (amount not known)
Water supply for the City of Mutare (0.7 $m^3$/s)
Wetland cultivation (amount not known)
Smallholder irrigation (amount not known)
Large-scale irrigation

- Katiyo Estate (government owned and managed by ARDA; water used not more than 1 $m^3$/s)
- Aberfoyle Estate (owned by Eastern Highlands Plantation, a private company; water used not more than 1 $m^3$/s)

Other large scale uses:

- Forestry plantations of exotic trees (mainly pine, but also eucalyptus and wattle)

**Mutare**

The City of Mutare has some 180,000 inhabitants, and requires some 0.6 $m^3$/s of water. The water supply system of Mutare consists of two storage dams in the Odzani catchment which is part of the Save basin (Lake Alexander and Smallbridge Dam, with a combined capacity of 21 $Mm^3$), a treatment works at Odzani not far from these dams, a 23 km pipeline to the city, and the usual distribution infrastructure within the city. In 1999 a third source of water was added to the system, which transfers water from the Pungwe river system directly to Odzani. The capacity of this additional supply is 0.7 $m^3$/s (or 22 $Mm^3$/year) (Figure 4).

Figures 5 and 6 shows the dramatic impact of the 1991/92 drought, when water stored in both dams dropped to an all time low of 375,000 $m^3$ in November 1992, an amount that would have been consumed within a week at pre-drought consumption levels! This forced water consumption in Mutare to be reduced dramatically; water abstraction during January-December 1992 averaged only 0.47 $Mm^3$/month; i.e. less than **one third** of the amount abstracted during 1990/91. From April 1992 to March 1993, gross per capita water consumption was only 3.0 $m^3$/month. This significant reduction can be explained by the massive campaigns, rationing, borehole drilling and tariff increases by the City of Mutare.

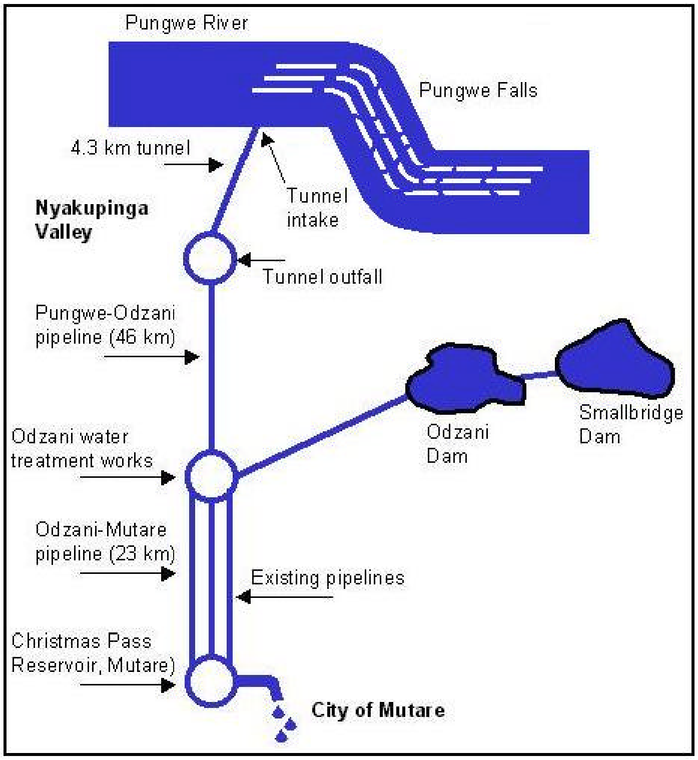


**Figure 4: The Pungwe-Odzani basin transfer scheme for Mutare**
(source: http://www.flowtite.com/literature/pungwe-mutare.htm)

It is worthwhile to observe that water abstraction during 1999 did not yet reach the levels of those during 1990/91. Monthly raw water abstraction during the period April 1999-March 2000 averaged 1.34 $Mm^3$/month.

*Hydrological impact*

The impact of diverting 0.7 $m^3/s$ out of the upper reaches of the Pungwe is significant in this part of the catchment, amounting to some 16% of the mean annual runoff at the diversion point. The impact during the low flow season is much larger (50% of mean runoff during September, the month of lowest flow). However, since at the border with Mozambique the discharge of the Pungwe is much larger due to the much larger catchment area (622 $km^2$ compared to 86 $km^2$), here the impact is considered to be relatively small (some 3% of the mean annual runoff; though higher during the low flow season).

This new source is considered sufficient to cater for Mutare's water needs up to the year 2015. However, some controversy exists on the risk of failure of the combined water sources of the city, i.e. lakes Alexander, Smallbridge and the Pungwe. The risk of failure of the Pungwe river supplying 0.7 $m^3/s$ may be higher than the generally accepted 4% (Figure 7). Note that the intake works are such that the agreement between Zimbabwe and Mozambique is honoured whereby Mutare may take out a maximum of 0.7 $m^3/s$ provided that always 0.5 $m^3/s$ is left in the river. Engineers have assured that the physical intake structure at the river intake as well as the regulation devices in the pipeline are such that it is impossible for Mutare to take out the first 0.5 $m^3/s$, as well as taking out more than 0.7 $m^3/s$ when river flow is above 1.2 $m^3/s$.

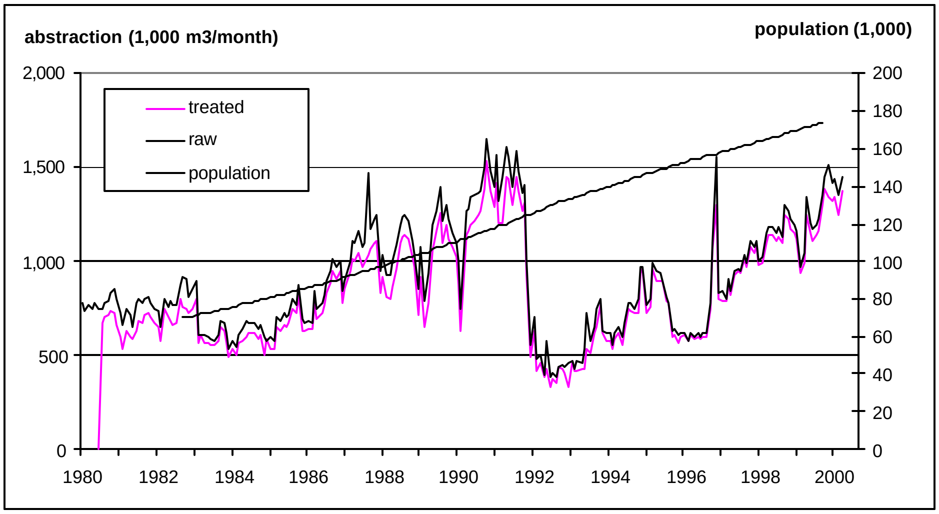


**Figure 5: Raw and treated water abstraction from Odzani Water Works for Mutare; and city population** (interpolated from 1982 and 1992 censi and 1995 survey)

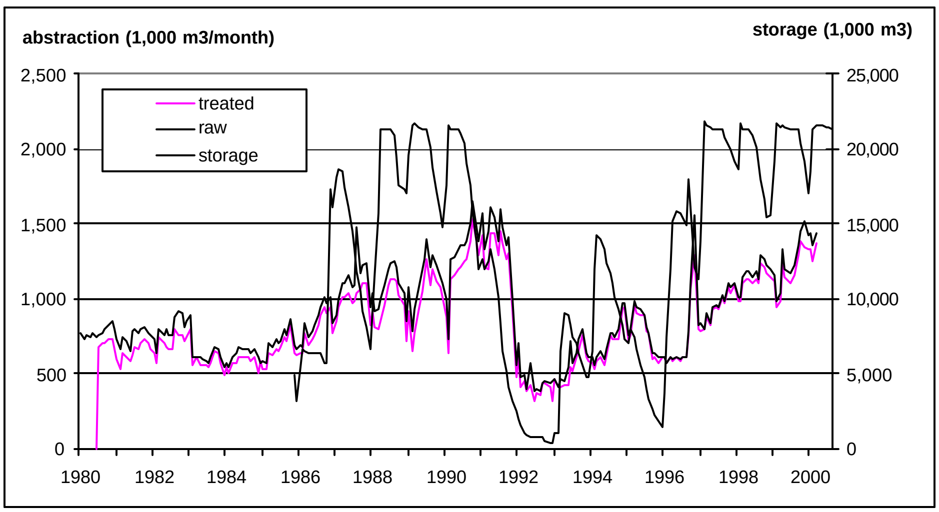


**Figure 6: Water stored in Smallbridge and Alexander dams, and raw and treated water abstraction from Odzani Water Works, Mutare; 1980-2000**

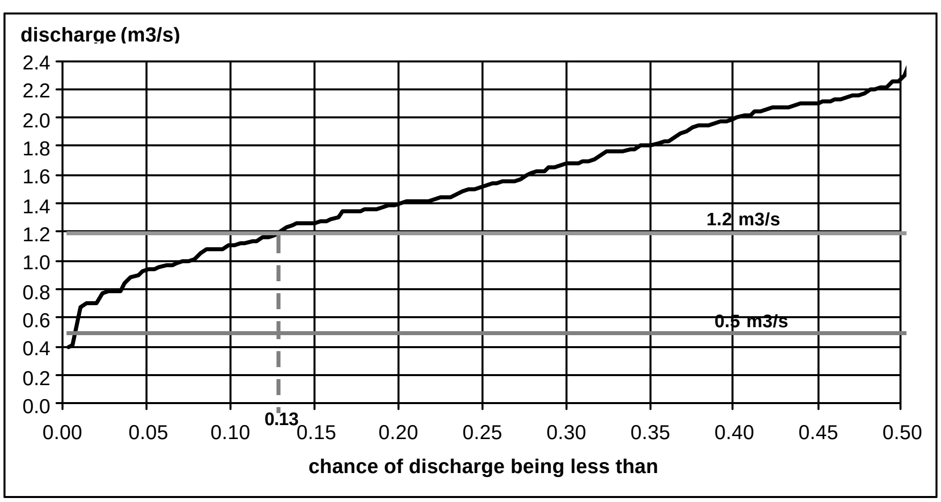


**Figure 7: Risk analysis of Pungwe river supplying 0.7 m$^3$/s to Mutare**
(based on monthly discharge data 1970-1997; gauging station F14; Nyanga)

As a result of the Pungwe project, Mutare steadily raised its water tariffs since 1996, which was one of the conditions of the donor (Figure 8).

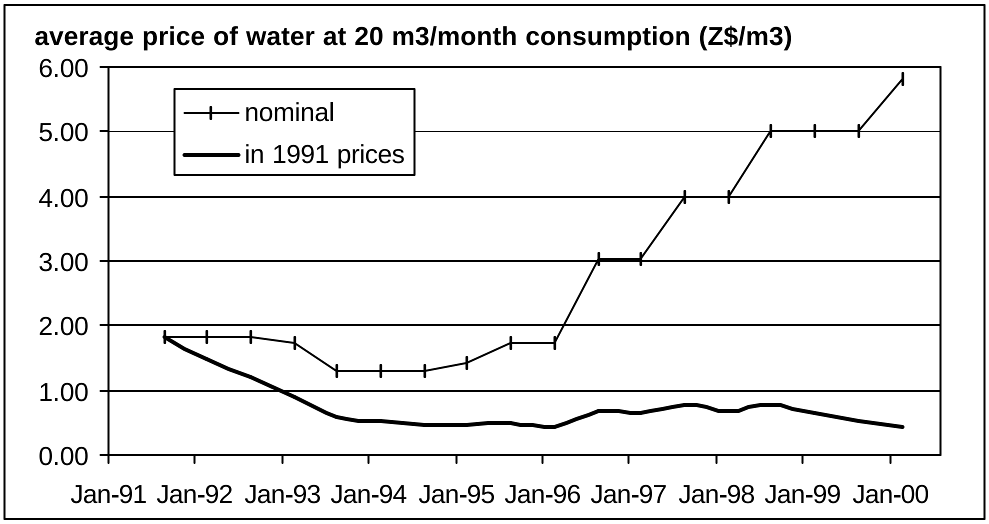


**Figure 8: Average water price (nominal and in constant 1991 prices) at 20 $m^3$/month consumption level; Mutare, 1991-2000**

*Economic dilemmas*

Prior to the implementation of the Pungwe pipeline, the Department of Water Development had developed the option of taking water from the recently built Osborne dam, drawn from a pickup point on the Odzi river and pumped through a 28 km pipeline to the City. DWD had already started constructing the headworks for the river intake. Meanwhile, the Mutare City, together with Swedish contractors, developed an alternative proposal for a tunnel into the Pungwe gorge, plus a permanent 80 km pipeline to the City.

At the time the two alternatives were appraised in early 1994, the Osborne/Odzi scheme would cost Z$ 197 million, of which Z$ 9 million had already been spent, leaving a balance of Z$ 188 million. Construction of the Pungwe scheme was estimated to cost Z$ 418 million (which increased to Z$ 620 million at the time the project went out to tender). However, the recurrent costs of the Osborne/Odzi scheme were high, due to the water having to be pumped, and the water requiring quite some treatment. The recurrent costs of the Pungwe option were low, since the water would reach the city by gravity and treatment costs would be minimal due to the high quality of the Pungwe water.

The two options thus presented a classic case of choosing between high initial capital costs and low running costs or low capital costs and high running costs. The appraisal therefore rested on assumptions about inflation and the choice of the discount rate for the calculation of net present values. With a relatively low discount rate the future (running) costs would be valued higher, favouring the Pungwe option. A higher discount rate would dwarf the present value of future costs, and would favour the Osborne option.

Since the City of Mutare would, for either project, receive a concessionary loan from Government, the City of Mutare used a discount rate of 12% per year, while at that time inflation was around 20% per year. This means that Mutare used in fact a *negative* discount rate, which would value future costs and benefits higher than present one's. Unsurprisingly, for Mutare the Pungwe option was therefore much more attractive.

However, what was good for Mutare, may not have been good for Zimbabwe as a whole, since it was unlikely that Government would be able to get loans for this project at such concessionary terms. Zimconsult (1996) maintains that at a more acceptable (=higher) discount rate, the Osborne/Odzi alternative would always have been preferable. A project of this magnitude, involving significant deployment of national resources, should not have been appraised just from the viewpoint of Mutare, but of the nation as a whole. To compound the problem, the Pungwe option would, and indeed did, raise more serious environmental and international water rights concerns with Mozambique, than the Osborne/Odzi scheme.

## 2.2 Mozambique

The middle Pungwe river basin on the Mozambican side of the border is less densely populated, as many areas were abandoned during the civil war and the level of development is much lower than in the other parts of the basin. Little information currently is available concerning demography, land use, environmental and infrastructural conditions. The Gorongosa national park is situated in this part of the basin. This used to be an important tourist attraction until it became the headquarters of Renamo during the late 1980s. Apparently the park has opened again, but the wildlife has reportedly been decimated in the park.

Further down the river, in the Pungwe's flood plains, there are two major water users: the City of Beira and the Mafambissa sugar plantation.

As of early 1998, only 15-20% of the population of Beira was served with treated water, mainly because the system was developed during the colonial period for certain parts of the city only, and that no proper maintenance was carried out since. The system suffers from very high leakages. It urgently needs to be rehabilitated and extended. There have been serious cholera epidemics in Beira, probably caused by the lack of coverage in combination with heavy flooding. There is no sewage treatment facility in Beira; sewage is let out through open channels directly to the sea. (Nilsson & Shela, 1998)

The Companhia de Aguas da Beira (Beira water supply company) abstracts about 0.3 $m^3$/s from the canal supplying water to the Mafambissa sugar plantation, fed from a pumping station on the Pungwe river. The pumps deliver 1 $m^3$/s total discharge, and 0.7 $m^3$/s is used on average for irrigating sugar cane over an area of some 3,000 ha. The intake is located within the 80 km long stretch of the river affected by saltwater intrusion during the dry season. Salt concentrations reach unacceptable levels several times during a normal low-flow season (Zanting et al., 1994; Nilsson & Shela, 1998). As stated earlier, the chance of the flow at Bue Maria being less than 10 $m^3$/s (considered the minimum flow to guarantee fresh water at Beira's intake) is larger than 10%.

Beira plans to establish an industrial free zone north of Beira, which would also use Pungwe for its water supply. The total use of water is expected to be 1.5 $m^3$/s and the intake will be 5 km upstream of the present intake in order to avert salt problems at higher intake levels. (Nilsson & Shela, 1998)

Excess water during the wet season is as much a problem as water scarcity during the dry season. Floods inundate extensive agricultural lands while damaging properties and settlements. The floods of February 1998 displaced many people and affected 45% of sugar cane production at Mafambissa estate. Floods and water scarcity are both the limiting factor for expanding irrigation for sugar cane and rice.

Out of 40 potential dam sites, the Bué Maria just west of the plains area is considered the best solution for solving the problems related to seasonal flow variations. The most important function of this dam would be to regulate the downstream flow in order to control salt intrusion during the dry season and floods during the wet season. The dam would also be used as a storage reservoir for irrigation, water supply and possibly hydropower. (Nilsson & Shela, 1998)

One environmental concern in the coastal area is the dependency of prawn cultivation on brackish water conditions; any drastic change of the Pungwe flow, including silt load, will have a detrimental impact on the habitat. (Nilsson & Shela, 1998)

**Table 4: Water uses of the Pungwe within Mozambique**

| |
|---|
| *Non-consumptive uses:* |
| National park (Gorongosa) |
| Salinity control at the intake for City of Beira water supply near the estuary (8-10 $m^3$/s required) |
| Fisheries |
| |
| *Consumptive uses:* |
| Rural water supply for primary uses (including cattle, gardens etc.) (amount not known) |
| Water supply for the City of Beira (410,000 inhabitants in 1992; of whom in 1998 only 15-20% were connected to the water supply system; currently using 0.3 $m^3$/s; to increase to 1.5 $m^3$/s) |
| Wetland cultivation (amount not known) |
| Smallholder irrigation (amount t not known) |
| Large-scale irrigation |
| • Mafambissa sugar estate with 2,620 ha (using 0.7 $m^3$/s; to increase to 5.5 $m^3$/s for 8,500 ha) |

# 3. Institutional set-up

The current institutional set-up is very new and not yet fully operational. Before the establishment of the Pungwe Sub-Catchment Council in Zimbabwe and ARA-Centro in Mozambique, one could hardly speak of any institutional arrangement which manage the Pungwe waters.

The Zimbabwean part of the Pungwe basin is officially managed by the Department of Water Development. In July 1999, the Pungwe Sub-Catchment Council was established, which forms part of the Save Catchment Council. Under the new Water Act and ZINWA Act, both of 1998, these Councils will regulate the uses of water in the basin. Representatives of different water user sectors are represented on the Pungwe Sub-Catchment Council. Currently, there are 7 Councillors, representing Communal, Commercial and Indigenous Commercial farmers, the Mutasa Rural District Council, traditional leadership, and the City of Mutare. The Pungwe Sub-Catchment Council is not yet fully operational.

On the Mozambican side, ARA-Centro, a regional body of the Water Affairs Department DNA, has the Pungwe basin under its responsibility. ARA-Centro was established in 1998, and is starting to become fully operational.

Both countries are members of SADC and signed in 1995 the Protocol on Shared Watercourse Systems in the SADC region. The recently successfully completed negotiations on the amendments to the Protocol have set the stage for the signing of the "Agreement on the Establishment and Procedures of a Joint Water Commission Concerning Water Resources of Common Interest". The Joint Water Commission Concerning Water Resources of Common Interest was recently established between Mozambique and Zimbabwe. The absence of the Commission made planning on joint management initiatives difficult. The Agreement on the Commission sets the framework for joint studies and development strategies of several shared rivers between Mozambique and Zimbabwe. The functions of the Commission are to analyse available shared water resources, advise on reasonable demands from common water resources, and exchange data and adopt criteria on the conservation, allocation and sustainable utilisation of common water resources. (Granit, 2000)

An agreement has been signed by both governments concerning the diversion of Pungwe waters for the City of Mutare.

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