

## *EXECUTIVE SUMMARY*

Water is a scarce resource in South Africa and future economic development may be increasingly restricted if water is allocated and used inefficiently. Water supply has traditionally been augmented in line with growing demand. However, in view of the increasing shortage of new supply options, water demand management and specifically the optimization of water distribution is coming to be of increasing importance. At present, national policy is moving towards water demand management. Thus there is a growing need to understand the economic features of water demand areas in South Africa.

In addressing the orderly management of water resources, the Water Research Commission (WRC) commissioned a research project in 1998 to determine the value of water in selected catchments of South Africa. The WRC put the research project out on tender.

In the invitation for tenders, the following catchments or sub-catchments were identified as possible case studies, namely:

- The Great Letaba River;
- The Berg River;
- The Great Fish Sundays River; and
- The Vaal River.

The tender to determine the value of water as an economic resource in the Vaal River catchment was awarded to Greengrowth Strategies cc.

In broad terms the objectives of this research initiative according to the tender document were stated as follows:

1. Determine the water balance and prevailing competition for water resources in the catchment.
2. Derive a demand schedule curve for water for important water use sectors.
3. Quantify the value of water resources at current levels of water use.
4. Compare the economic value with full economic costs (i.e. supply, opportunity and external costs, if applicable) as well as current water tariffs, and assess the incidence and nature of temporary or permanent transfers of water rights already occurring.

5. Explore a variety of scenarios and estimate the changes in the value and price of water resources through appropriate modelling, when negotiated and lawful transfers of rights to available water resources take place within or between existing uses.

In order to address these objectives, it was necessary that proper Natural Resource Accounts be drawn up for the Vaal River system, for the period 1980-1998. Natural Resource Accounts, which supplement a country's traditional national economic accounting system, are designed to assist in the analysis and design of sustainable development strategies through the optimization of natural resource utilization over the long term.

For development planning purposes, the geographic extent of the Vaal River system is normally defined from a water use point of view and this practice has been followed in this study. This differs from the practice in other areas where planning takes place strictly within the boundaries of catchments. An example of this is that the Tshwane Metropole was included in the study area, because most of the water it uses is transferred from the Vaal River system to it, although it actually is in the Crocodile catchment.

Due to the significant difference in the type of water use in the study area, the river was divided into two sections for purposes of this study, namely the "Upper Vaal" and the "Middle Vaal". The Upper Vaal user area as defined for this study closely corresponds to the Upper Vaal catchment, except for the inclusion of the Crocodile catchment. The Middle Vaal study area includes the whole Middle Vaal catchment as well as a portion of the Lower Vaal catchment. The water use of the Upper Vaal is mainly industrial and domestic whilst that of the Middle Vaal is mainly agricultural.

The supply of water was sub-divided into surface water and ground water. The main water use sectors are:

- Municipal use (subdivided into Household, Light Industry and Parks)
- Irrigation use
- Afforestation use
- Electricity use and
- Heavy Industry use.

For modelling purposes, a system dynamics model of the Vaal River system was developed. STELLA, a software package for developing system dynamics computer models, was used to model a variety of complex systems by attempting to understand the underlying relationships between the different parts of the system. For the purpose of this study, the total system has been consolidated into two "dummy dams" represented as the Upper and Middle Vaal systems. In practice these dummy dams represent the Vaal and Bloemhof dams respectively.

Important aspects pertaining to the historic water balance are:

- That the utilization level increased from 53.8 % in 1980 to 75.6 % in 1998 for the Upper Vaal River system even though it fluctuated over this period.
- For the Middle Vaal River system the water utilization level increased from 175.8 % in 1980 to 204.3 % in 1998. The increase is due to a usage increase without an equivalent increase in water supply. However, in practice, water releases from the Vaal Dam compensate for this deficit.
- The water utilization level within the total Vaal River system increased from 71.1 % in 1980 to 94.2 % in 1998.
- As far as the composition of water supply is concerned, transfers in exhibit an increase from 13 % in 1984 to 16 % in 1998. After 1998 which falls outside the time period analysed here, the percentage will increase considerably because of the introduction of the Lesotho Highlands Scheme.
- As far as the composition of water use in the Vaal River is concerned, irrigation is still the main user of water as its water utilization level stood at 35 % of total water use in 1998. In 1980 this utilization level stood at 37 % of total water use which implies a slight decrease over the period. The other important uses are light and heavy industries with 22 % in 1998 whereas in 1980 this figure was 20 %. Another notable trend is that water use for households has remained at 18 % of total use.

The economic value of water for the various users is calculated by estimating their demand schedules. The following procedures were used to derive demand schedules for the various use categories:

- For households a cross sectional analysis was done and the reaction of different users to different tariffs (tariff was used as a proxy for price) at the same point in time was investigated. A relationship was determined between consumption and tariff data for different municipalities. An advantage of this method is that many factors influencing water consumption can be simultaneously analysed through multi-regression analysis.
- In the case of irrigation use the so-called "budget approach" was used. It was decided to take the Vaalharts area as a sample for the total study area.
- For industrial use the budget approach was also applied to the various industries in South Africa. The information base for the calculation was an input-output table, which reflects the value of water per sector in relation to the sector's total production cost. In theory it could be stated that the water tariff could be increased up to the point where the industry does not make profits anymore. A problem associated with this approach is that the water tariff can be increased to absorb all the profits excluding a normal profit (normal profit already forms part of the total cost of the budget approach). In practice certain industries can easily relocate to other industrial locations in South Africa, where water tariffs are more

attractive. Therefore theory and practice are not compatible. For purposes of this study, it was assumed that industries will only be willing to pay more for water in the Vaal River system area if they derive a locational advantage from remaining there.

- As far as electricity use is concerned, a demand schedule was obtained by distinguishing between two cooling systems in power generation stations. In South Africa electricity is mainly generated by coal based power generation stations. Two alternative cooling systems are used in these power stations, namely wet and dry cooling systems. A wet cooling system uses much more water than a dry cooling system to generate the same amount of electricity. In a wet cooling system  $\pm 2.23$  l of water is used to generate 1 kWh of electricity compared with the 0.22 l of water per kWh of electricity in a dry cooled system. However, building a dry cooling system is much more costly than a wet one. The running costs of a dry cooling system are also slightly higher.

By applying the demand schedules above, the economic value of water for the total Vaal River system was calculated to be R13.3 billion for 1998. Of this total the contribution of the Upper Vaal is R11.6 billion (87 %) and that of the Middle Vaal R1.7 billion (13 %). It is important to note that this is a flow variable, i.e. it is a recurrent value.

Regarding the sectoral contribution to economic value, municipal use is by far the most prominent sector, contributing 81 % in 1998 in the Upper Vaal. In the Middle Vaal municipal use in terms of economic value is also dominant (93 %), although the most water used (physical units) is by irrigation.

Concerning the analysis of cost and revenues, it is important to note that over the last 10 years the Department of Water Affairs and Forestry (DWAF) has gradually phased in the policy that a specific catchment's revenue should pay for the delivery cost of the relevant water. One of the designated catchments in terms of this policy was the Vaal River and the policy resulted in revenue received from water tariffs being more than the delivery cost of the water including the cost of major water schemes. The total revenue for 1998 was calculated to be in the order of R1,682 billion, compared to a delivery cost of R1,547 billion. This implies an over recovery of R125 million.

The last objective of the study was to test the reliability of the model, by generating illustrative water management scenarios. Scenarios explored included different climatic conditions and various views on population growth, specifically taking into account the impact of AIDS. Although some of the assumptions are probably unrealistic, interesting conclusions could be derived from these scenarios.

An example of this is the impact of a dry weather cycle, the main effect of which will be that there will not be sufficient water for usage over the modelling period. In a real market situation the price of water will increase and selling of water will take place. The use sectors with low income yields will trade their water rights to other users with higher yields rather than proceed with their current activities. The following aspects of the dry cycle scenario are of importance:

- The price of water (proxied by tariff) will increase drastically by about 35 %.
- The average use of water has to drop by 14 % to conform with the supply conditions.
- The economic value of water will drop by approximately 12 %. This is mainly due to the fact that water shortages will be reflected mostly in the irrigation and household use sectors.
- Although less water will be sold, the revenue generated from the selling of bulk water will increase by 5,5 %. This can be attributed to the increase of 35 % in the water price.
- The consumption in terms of volumes for Industries and Electricity remains constant, although their percentage shares increase slightly.

In conclusion, it can be stated that the objectives set in the terms of reference have been met reasonably successfully, and a large amount of new information has been made available. In particular, a very significant contribution has been made to the development of Natural Resource Accounts in South Africa. However, it must be emphasized that the expectations with which the project team began the study met with some disappointment. In many cases, the first-choice data that the team had expected to be available was of such poor quality that alternative methods of addressing the objectives had to be found. The negative aspect of this is that it must be accepted that many databases in South Africa are currently in a state that does not support sophisticated economic analysis. More positively, this study has laid a foundation on which other studies of this nature can build, although it must be accepted that their results, like those of the present study, will be somewhat approximate in nature.

The model that has been constructed in this study must be viewed as a "living" one. Its usefulness lies much more in the future use that will be made of it than in the history of its development that has been reported in this present document. The first recommendation of this report is therefore that use of the model should be encouraged. Another recommendation of the project team is that water authorities in South Africa should take stock of the data that they may require in future to do their jobs, in particular in the light of changing water management requirements.

They need to ask whether the data they will need is being collected and maintained in an accessible format. If this is not the case, they need to take steps to remedy the situation.

