Chapter 1 - Introduction

1.1 Setting and motivation

Water is scarce and precipitation is extremely variable in South Africa. South Africa is also a country with great welfare needs where challenging economic development targets need to be achieved within the constraints of limited and unreliable water supply. These development targets are underpinned by the growth in economic activities such as agriculture, mining, energy production and many small, medium and micro enterprises, which constitute some of the largest water using sectors in the economy (Crafford et al. 2001). Within these industries, increased competition place pressure on water users to keep supplying their markets with competitively priced goods, while rising costs of new water supplies puts pressure on water users to achieve higher efficiency in water use. These market forces, and the relative scarcity of water as a critical production factor, impact on financial viability and imply that the economic efficiency of water use becomes increasingly important.

In response to this situation, a new National Water Act (NWA) has been instituted in SA in 1998, which signified a radical departure from previous water use policies in the country (NWA, 1998). The NWA accordingly has important implications for future management, allocation and use of water resources in SA. The NWA revolves around the principles of equity, social justice, economic efficiency and environmental sustainability. Major features of the Act include among others:

- Abolishment of private rights to water,
- Application of economic efficiency principles to allocation of water for productive economic uses,
- Priority to correction of inequalities of the past in terms of access to water and water services for poverty reduction, and
- Protection of the people and the environment against the hazards of production and consumption activities that deplete stocks and degrade the quality of water and watershed services.

Pursuance of the above principles in the implementation of the NWA impacts on the design of different policy instruments and strategies for the management and use of water. For instance, the *equity and poverty reduction* goals will lead to increased demand for water for domestic purposes as millions of people are catered for who were previously excluded from this service. The stated *efficiency principle* requires removal of subsidies, which could in the short term negatively influence returns on capital invested during periods of high water subsidies. Efficiency also requires the implementation of water demand management strategies, a major component of which is related to water allocation based on economic efficiency principles, and would therefore have to be carefully designed to ensure that sustainability and equity principles are achieved. *Environmental sustainability* requires water to be managed with a long-term view of sustaining the natural system, while maintaining an adequate supply of good quality water.

Water users who require water as an input to economic activities are consequently seriously revising their water use patterns in response to one of the major implications of the NWA and its related principal strategy, namely: **water demand management**. The water demand management strategies which are implemented through the Act ultimately work towards ensuring equity in satisfying household water demand, the full recovery of financial costs, and promote efficient use of water through increased charges and tariffs, especially in sectors where users have traditionally been subsidised. It is also true that economic activities impact on the natural environment and consequently water demand management decisions must observe possible negative impacts on the natural environment.

This study made an attempt to compare the social, economic and environmental costs and benefits of water use by production sectors in SA, with particular emphasis on the comparative effects of water demand management. The rural area of the Crocodile River Catchment was used as a case study, being a typical example of an area where competition for water will increase in SA. Although the study will not attempt to determine the value of or a price for water, this research will use proxy measures of the economic and environmental costs and benefits of water use in the compared activities. Direct as well as indirect (backward and forward linked) costs and benefits associated with the studied activities will be assessed using the social accounting matrix (SAM) framework to trace multiplier effects throughout the rural economy of the Crocodile River Catchment.

Total economic benefits were used in this study to represent the sum of direct and indirect benefits in the sectors under study. Direct benefits refer to benefits generated directly by an economic activity and do not capture the total benefits from that activity. As its output is further processed by other economic activities (which add further value), the value addition chain of the sectors linked forward with the activity is considered part of its total indirect economic benefits. Indirect benefits are also generated in sectors that supply inputs to the activity in question. Indirect benefits therefore originate from forward and backward linkages in production. Accounting for indirect economic benefits is particularly important and of large orders of magnitude for primary production activities such as agriculture, mining and energy production. This is because these industries are merely a source of the raw material, which supports extensive further processing for higher values in secondary and tertiary production. The indirect benefits discussed above represent spin-off effects of production multipliers only. That means additional outputs need to be generated by sectors supplying the required extra intermediate inputs or processing the extra output. Demand-side multiplier effects caused by spin-offs resulting from spending of the additional value (income) generated throughout the forward and backward chains on more goods and services for final consumption is referred to in the literature as the "income leakage" (Pyatt and Round, 1985). While calculation of production and demand multipliers is very demanding in terms of data requirements, this study intends to account for a feedback effect from consumption or final demand to close the loop of income leakage from the system.

Water demand management decisions also impact on the environment, both directly and indirectly. The direct impacts are attributed to abstraction of water from the natural environment and an adverse effect on water quality of the production activity. The indirect impacts are attributed to the water abstraction and adverse quality impact of the indirect economic activities (of backward and forward linkages).

1.2 Objectives of the study

The main goal of this research is to develop and apply an analytical framework to assess the relative importance of alternative water use options for production in terms of the efficiency and sustainability principles specified by the NWA. The specific objectives are therefore:

- To develop and use a framework that allows for the assessment of direct as well as indirect (economy-wide) benefits and costs of key water use sectors;
- To apply the developed framework to conduct a comparative analysis of the economic and environmental net benefits of alternative major water use options in the rural areas of the Crocodile River Catchment of SA;
- Analyse the implications for management and allocation of water resources of potential eminent changes in the policy environment introduced by the NWA.

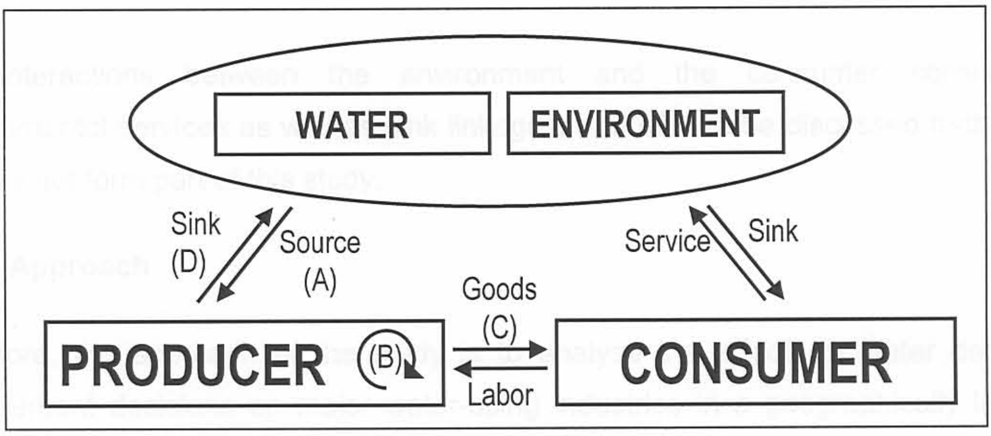
It has to be emphasized that this is not a water valuation study. The total economic benefits approach is not a measure of the marginal value of water. Measures of the marginal contribution of water to total benefits are more appropriate for water pricing purposes.

1.3 Approach and methodology

1.3.1 Background

In the previous sections, three concepts that are key to the analysis of the total economic benefits of water use were discussed: water allocation, economic (backward and forward) linkages and environmental impacts. These concepts can be viewed as interactions between the natural environment, and the production and consumption spheres of the economic system. Figure 1 provides a conceptual framework integrating such linkages between the environmental and economic systems.

Figure 1.1: A simplified framework for modeling the economic and environmental linkages under study.



The Source link (A) relates to water allocation and use by production sectors where the environment supplies water. These linkages are limited by the physical nature of water (its ability to flow and evaporate), the limited geographical distribution of water, and the fixed nature of water distribution systems. Where water markets are functioning in South Africa they are therefore governed by institutional water allocation decisions. Linkage B defines the economic transactions taking place in the backward and forward linkages of production activities and gives rise to intermediate demand for goods and services. Linkage C defines the interaction between final consumption and production activities and is responsible for the final demand for goods and services. The application of the total economic benefit methodology relies on data sourced from transactions A, B and C. Obtaining these data is complicated by the following factors:

- There are practical difficulties in the measurement of water supply and water use, which forces a reliance on hydrological and process estimations for generating data on linkage A.
- The network of all sectors' transactions and value addition chains throughout the entire economy; constitutes a complex system of multiplier effects.

Another dimension of the water allocation and use debate is the significant role water use plays in the life cycle of final consumption of goods and services. This is because the environmental impacts of the backward and forward linkages of activities form an additional consideration in water allocation decisions. The arrow D in Figure

1 designates these transactions as sink linkages for which data are also difficult to obtain.

The interactions between the environment and the consumer consist of environmental services as well as sink linkages, and will not be discussed further as they will not form part of this study.

1.3.2 Approach

Therefore, the approach of the study is to analyse the effects of water demand management decisions on major water-using industries in a geographically limited catchment area. This will be achieved when best available water beneficiation data (a combination of A&B data in Figure 1), detailed value chains (B data in Figure 1), an economy-wide model (B&C data in Figure 1), and environmental impacts (D data in Figure 1) are combined.

The choice of this integrated framework of multi-sector economic model and environmental impact modules was guided by the combination of the results of five relevant studies:

- A study by Hassan (1998) employing a social accounting matrix (SAM) to analyse economy-wide impacts of the new NWA of South Africa.
- A WRC funded study (Crafford et al. 2002 and Hassan, 2002), measuring the social, economic, and environmental direct and indirect costs and benefits of water use in the irrigated agriculture and forestry sectors in the Crocodile River catchment.
- A CSIR study (Crafford et al. 2001) on water resource accounts for South Africa: 1991-1998.
- A Conningarth Consultants (2000) study which developed a SAM (social accounting matrix) for the Komati River Basin.
- Eiolca, a web-based life cycle analysis tool hosted by the Carnegie Mellon Green Design Initiative (www.eiolca.net).

Availability of data from the above studies enabled the analysis of the costs and benefits of water use in the rural areas of the Crocodile River catchment in the Inkomati Water Management Area in South Africa, which was used as the study area.

1.3.3 Methodology

The following methodology was followed:

- The major water users in the Crocodile River catchment were selected for study purposes.
- Primary data, sourced through the CSIR Crocodile River Study (Crafford et al. 2002), was used to calculate multiplier values for the economic transactions taking place in the selected economic sectors. These multipliers were used to construct a partial Input-Output matrix.
- Secondary data were sourced from the Conningarth study (2000) to convert the partial Input-Output matrix to a social accounting matrix (SAM) for the study area.
- Water use data were sourced from the CSIR water accounts study (Crafford et al. 2001) and incorporated into the SAM.
- Eiolca environmental impact coefficients were converted through a random-effects benefits transfer study and built into the Input-Output matrix to construct an environmental impacts Input-Output matrix for the Crocodile River catchment.
- The economic framework with an integrated environmental model was then used to analyse the developed implications of potential water demand management interventions.

1.4 Organisation of the study

This study consists of six chapters. Chapter 1 introduces the research project, and describes the setting, motivation and objectives to the study. It also outlines the approach and methodology followed. Chapter 2 provides an overview of the economic water use in South Africa as well as an overview of the water policy context, and the case study area. The literature on water demand management and water valuation as well as on applications of economy-wide models to water policy analysis and water resources management is surveyed in Chapter 3. Chapter 4 provides a detailed description of the approach followed and methods employed by the study. Chapter 5 presents and discusses the results obtained. The study closes with Chapter 6, which provides conclusions, discusses limitations and suggests future research.