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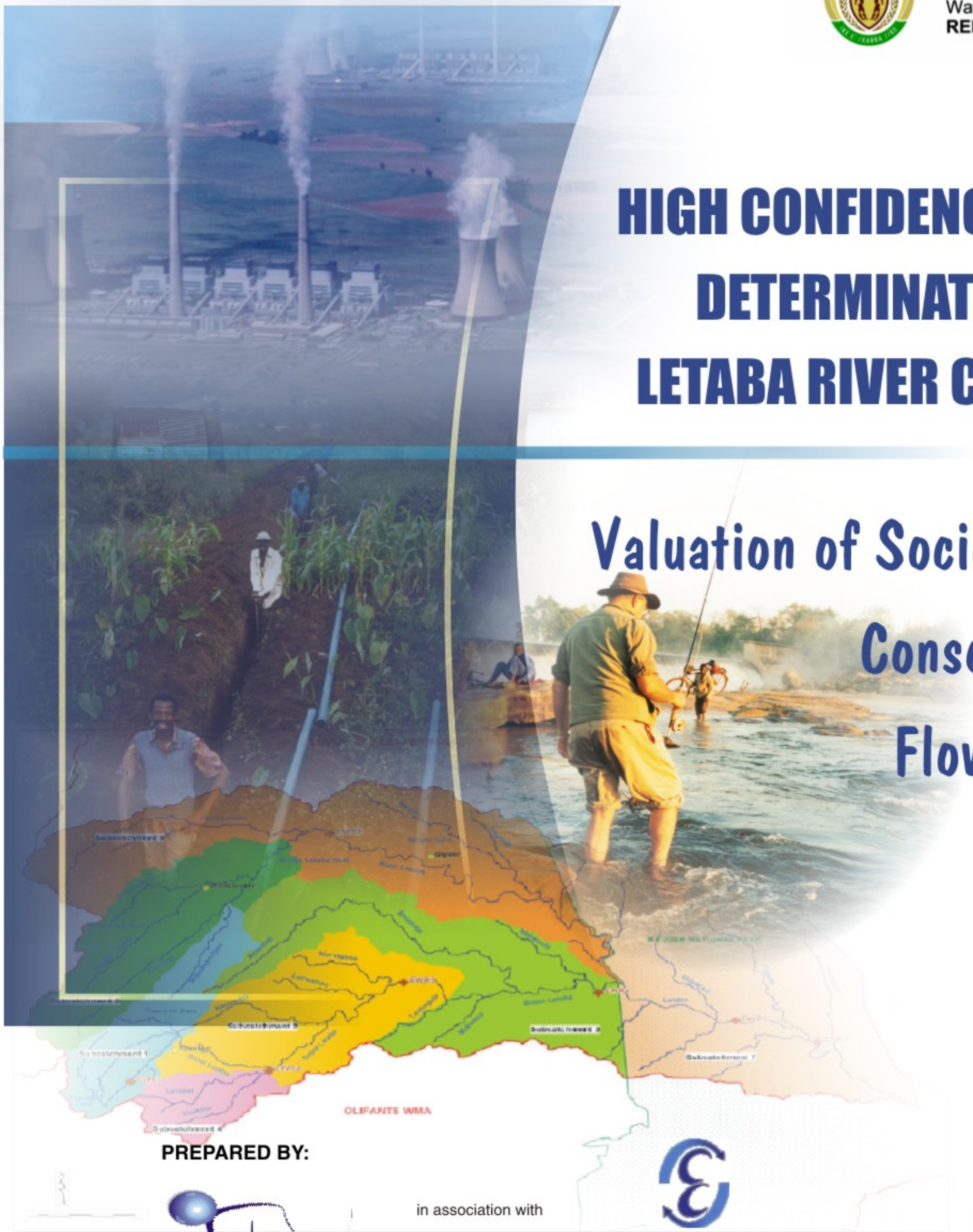

HIGH CONFIDENCE RESERVE DETERMINATION OF THE LETABA RIVER CATCHMENT

Valuation of Socio-economic Consequences of Flow Scenarios

FINAL

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Letaba Catchment Reserve Determination Socio-economics flow scenarios i

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DWAF Report No. RDM/B800/00/CON/COMP/0404

Main Report
Heath, R G
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Briefing Document
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EXECUTIVE SUMMARY

Introduction, Background and Objective

South Africa is a drought-prone, water poor country and water shortages will influence the economic development. As mentioned in the Water Research Commission scoping document, the value of water as an economic resource in the Great Letaba River Catchment is near completion and this document could serve as a background and source of information for this study. Attaching a value to water will assist water managers with water allocation planning among competing uses to ensure the social and economic welfare of the WMA is not seriously compromised while the ecology is protected for long term sustainability of the water resources.

This report describes the economic valuation of the ecological flow scenarios using the water impact model developed to determine the value of water in the Letaba River Catchment and the economic impact of different water allocation scenarios that could be adopted in this Catchment. This component of the study also provides for decision making in water allocation and reallocation of the competing water uses in the Letaba River catchment in order to ensure sustainable water resource management of the system.

Any water allocation reform and/or reallocation of water among the competing economic users will have international implications which have to be considered.

Valuation Concepts and Methods

Different valuation techniques were used for the market and non-market goods and services. For the out of stream uses

Furthermore the value of ecological goods and services were determined using different valuation techniques.

n order to conduct a valuation of the social and economic impact of the flow scenarios determined by ecological specialists on the water using sectors as identified in the preceding sections, a Water Impact Model modelling system was developed. The primary objective of the Water Impact Model is twofold. In the first instance, the model is structured in such a manner that it provides a detailed description of the current water usage situation in the catchment area i.e. the volumes of water used by various water users along the river banks, and the economic and socio-economic impacts resulting from this particular usage pattern. In the second instance, the model makes it possible to determine a new water usage situation where the amount of water used by each water user is altered from its current state. Once again, given the new water usage, it is possible to determine the economic and socio-economic impacts emanating from this change in water usage. The Water Impact Model determines the different impacts that the current and new situations will have on the economy. The next section focuses on the Current Situation component of the Water Impact Model and describes the intricacies of the modelling system related to this situation.

The criteria of the economic impacts of water re-allocations between users are measured in terms of the following macroeconomic variables:

- Impacts on profit (i.e. the impact on surpluses generated by each water user)
- Economic growth (i.e. the impact on Gross Domestic Product [GDP])
- Impact on capital formation
- Income distribution (i.e. the impact on low-income, poor households and the total income households)

After determining the magnitude of change for each water user individually, the model ranks water users in accordance with their contribution to these economic variables.

Findings of the study

Four scenarios were identified for the valuation of the impact of the ecological flows of each scenario of the water availability to the water using sector in the Letaba River catchment.

The findings indicated that the more water is left in the river the more severe the impact on the economic and social welfare of the Letaba River catchment. An optimised scenario was then developed that would achieve the ecological objectives of maintaining the present ecological state of the river while reducing the negative impact on the economic activity and the loss of employment. This was called scenario 7. The findings of the economic valuation indicate that the flow regime associated with scenario 7 provides the best balance between ecological sustainability and social and economic development. It therefore recommended that the flow regime of scenario 7 should be considered as the ecological Reserve of the Letaba River catchment.

From a water use efficiency perspective the water impact model was run with the conveyance and on-farm application and management practices improved. This resulted in the impact being further minimised. The impact was only 11% reduction in the area under irrigation that would be removed.

Conclusions and recommendations

As water scarcity increases, the need to manage water as a national asset for overall social benefit becomes imperative. This study was undertaken in order to determine to what extent the water supply can meet the water demand in this specific catchment, namely the Letaba River Catchment.

The results of the economic valuation of water using sectors in the Letaba River catchment illustrated that water provides important benefits to society as commodity benefits as well as from the value of the aquatic ecology through ecological goods and services that can be derived from the ecosystem. The findings of the economic valuation indicate that the flow regime associated with scenario 7 provides the best balance between ecological sustainability and social and economic development.

Although there are limitations in the valuation of the ecological goods and services because water is a classic non-marked resource, the valuation provides the implications of different flow scenarios on the social, economic and ecological welfare of the Letaba River catchment. It therefore recommended that the flow regime of scenario 7 should be considered as the ecological Reserve of the Letaba River catchment.

It is also recommended that consideration be made in improving the water use efficiency levels in all the water using sectors in the Letaba River catchment in order to reduce the negative socio-economic impact, implementation of the ecological Reserve will have on these sectors

ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
GDP	Gross Domestic Product
GGP	Gross Geographic Product
EC	Ecological Category
EWR	Ecological Water Requirements
PES	Present Ecological State
REC	Recommended Ecological Category
SAM	Social Accounting Matrix
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WRYM	Water Resource Yield Model
WTP	Willingness to pay (see Glossary of terms)

GLOSSARY OF TERMS

Consumer Surplus	The excess in monetary value an individual or sector would be willing to pay for a good over and above the total expenditures that would be made at a fixed price.
Contingent valuation	A method of non-market valuation which asks individuals their values (in money terms) for specified changes in quantities of qualities of goods and services
Economic benefit	A monetary measure of preference satisfaction or welfare improvement from some change in quantity or quality of a good or service. A person's welfare change is the maximum amount that person would be willing to pay to obtain that improvement
Intermediate goods	A product or service used to make other goods or services (as opposed to the final consumption goods, used directly by consumers). Also called producers' goods
Intrinsic value	Assigned to things, actions or outcomes for their own sake, independent of means of providing or attaining other items or situations of value for humans
Non-use value	This refers to the enjoyment people may experience by knowing that the resources exists even if they never expect to use the resource directly themselves.
Public goods	Goods and services enjoyed by any number of individuals without reducing the utility of the good or service by anyone else. These goods cannot be exchanged on the market
Total Economic Value	The sum of the use value and the now use value of goods and services
Value added	In any production unit, the difference between the value of output and the value of purchased inputs.
Willingness to pay (WTP)	A monetary measure of the value an individual would pay to have a specified change in the quantity or quality of a good or service

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1 INTRODUCTION

1.1 BACKGROUND

South Africa is a drought-prone, water poor country and water shortages will influence the economic development. As stated by Dinar, et al, because of the increasing scarcity of water for both its commodity and environmental benefits and the scarcity of resources required to develop water economic consideration is beginning to play and increasingly important role in public decisions on balancing protection for the resource to ensure sustainability and efficient use of the resource to achieve social and economic objectives.

As mentioned in the Water Research Commission scoping document, the value of water as an economic resource in the Great Letaba River Catchment is near completion and this document could serve as a background and source of information for this study. Furthermore, this document could be used in conjunction with other recent studies on the Letaba River.

Water is a non-market good, private in nature but with great public goodness associated with it. Attaching a value to water will assist water managers with tariff setting for redistribution of water resources, the determination of socially optimal water resources and the construction of policy interventions over time. To achieve this it is necessary to attach an economic value to a non-market good.

This report describes the economic valuation of the ecological flow scenarios using the water impact model developed to determine the value of water in the Letaba River Catchment and the economic impact of different water allocation scenarios that could be adopted in this Catchment. The results produced from the model will be divided between the once-off situation where water supply will be reduced when the policy is applied and on the other hand results provided in time span of five years where water supply will be reduced in the sectors affected by the policy where the chosen scenario will be used.

1.2 OBJECTIVE OF THE STUDY

1.2.1 Overall Objective

- This component of the comprehensive Reserve determination study of the Letaba River catchment was aimed at providing a review and analysis of the consequences of flow scenarios on the social, economic and ecological functioning of the catchment in monetary terms. This component of the study also provides for decision making in water allocation and reallocation of the competing water uses in the Letaba River catchment in order to ensure sustainable water resource management of the system.

Although there is an argument against valuation of the ecological goods and services because of its intrinsic value which cannot all be valued, the economic valuation of the competing water uses will assist with making informed decisions regarding trade-off required between socio-economic development and maintenance of environmental quality

It should be noted the Letaba River system is a tributary of the Olifants River which is an international shared watercourse with the Republic of Mozambique. Any water allocation reform and/or reallocation of water among the competing economic users will have international implications which have to be considered. However this has not be discussed as part of this component of the assignment.

1.2.2 Specific Objectives

The specific objectives of this report are to document the following aspects that were conducted for the Letaba River catchment based on a scenario based approach:

- Describe the methods used to undertake the evaluation of the different ecological goods and services as well as the methods of determining the value of out of stream water uses including the assumptions made and limitation to the valuation.
- Conduct an economic valuation of the competing water uses at a reconnaissance level of assessment for six scenarios namely (i) without ecological flows and (ii) with five different ecological flow regimes
- Provide a conclusion on the likely impact of implementing ecological Reserve and the mitigation measures to avoid significant impact on the social and economic welfare of the communities in the Letaba River catchment.

1.3 STRUCTURE OF THE REPORT

Chapter 1 of this report describes the background to the valuation of water resources in the competing uses in the Letaba River catchment. This chapter then provides the overall and specific objectives of the component of the comprehensive Reserve determination study.

The following **chapter 2** provides a description of the Letaba River catchment including identification and description of the current competing water using sectors. The ecological goods and services provided by the Letaba River system is also described in the chapter. These goods and services will change with any changes in the ecological flow regimes and therefore the benefit changes in the ecological services.

Chapter 3 describes the general approach and the specific methods used in the valuation of the water resources available to each of the above mentioned water using sectors. This chapter also discusses the conceptual framework of the Water Impact Model which was used to determine the macro-economic consequences of the ecological flow scenarios on the catchment. The limitation and assumptions made in the study are also described in this chapter in order to provide context to the results of the study.

Chapter 4 of the report then describes the ecological flow scenarios that were developed by the ecological specialists. The chapter then provides a rationale of the scenarios used in the economic valuation of the competing water uses. It should be noted that the flow regimes of each ecological category scenarios was treated as a water use in the economic valuation.

Chapter 5 then provides the results of the economic valuation for each sub-catchment for the both the out of stream water use as well as for the value of ecological goods and services identified in the sub-catchment. The implications of phased implementation of the flow scenarios are also presented. This was done to determine the implications of improving water use efficiency levels before implementation of the Reserve.

Chapter 6 then provides the conclusions and recommendations of the valuation of the consequences of the flow scenarios on the Letaba River catchment.

2 DESCRIPTION OF THE STUDY AREA

2.1 LETABA RIVER CATCHMENT

The Groot Letaba area is situated in the Lowveld area of the Limpopo Province and represents the economic heart of the provincial economy. The Klein and Middle Letaba can be classified as rural with a strong bias towards agriculture and retail. The Klein and Middle Letaba also have a significant agricultural potential in terms of the soil types and climate. This is confirmed by the fact that about 60-65 % of total domestic tomato production is produced in the Mooketsi Valley. The only variable limiting the full development of this potential is the acute shortage of water – as a result of the topography in this area, rainfall varies from as high as 1 400 mm per year to as little as 200 mm per year.

The Groot Letaba River is an international river with its headwaters in the high rainfall, Drakensberg Mountains, flowing through more arid areas and the Kruger National Park into Mozambique. At the border, it meets the Olifants River in a dramatic gorge, from where it flows into the Massingir Dam in Mozambique. The main tributary of the Groot Letaba River is the Klein Letaba flowing from the north with a confluence just upstream of the Kruger National Park. An important feature of the catchment area of the Groot Letaba River is that commercial forestry and irrigation agriculture occurs in the well-watered western zone.

The Letaba River Catchment extends over an extensive geographical area. In order to isolate the impacts of water reallocation on a more precise basis, the Letaba Catchment was subdivided into seven sub-systems as illustrated in **Figure 2.1** below. These sub-catchments are described as follows:

- Sub-system 1: Upper Groot Letaba
- Sub-system 2: Middle Groot Letaba
- Sub-system 3: Lower Groot Letaba
- Sub-system 4: Letsitele River
- Sub-system 5: Middle Letaba
- Sub-system 6: Klein Letaba
- Sub-system 7: Kruger National Park

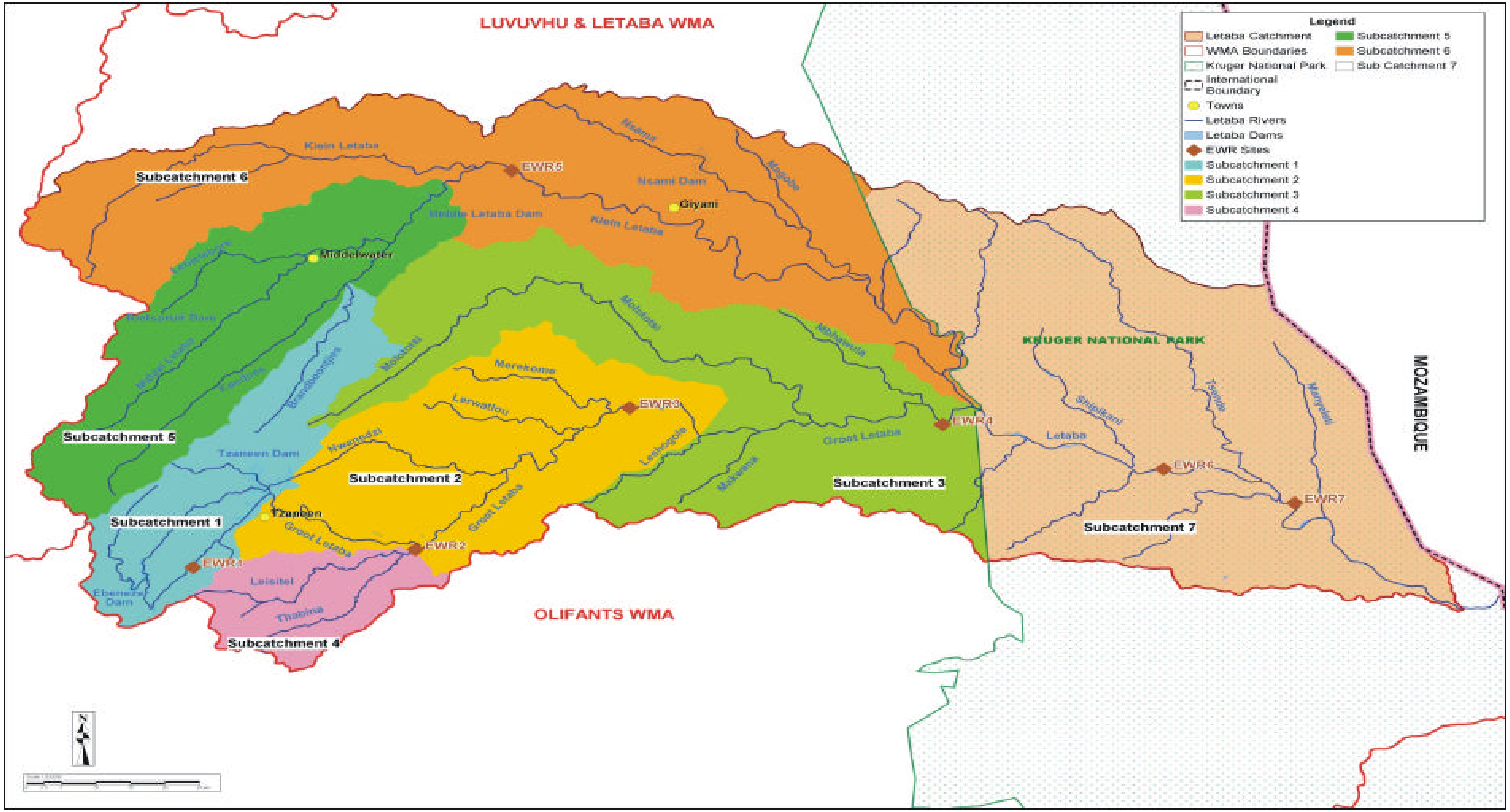

Figure 2.1: Economic sub-catchment of the Letaba River catchment

2.2 IDENTIFICATION OF WATER USING SECTORS

In order to undertake the economic valuation of flow scenarios, it was necessary to identify the water using sectors in the Letaba River catchment. These sectors were identified for each sub-catchment of the Letaba River Catchment. The following sectors are the most water using sectors in the catchment:

- Irrigated Agriculture
- Livestock Farming
- Game Farming
- Commercial Forestry
- Domestic Households
- Industry, and
- Ecology

The characteristics and the current water use (base year 2003) for each of the above water using sectors is discussed in detail in the following sections.

2.2.1 Irrigated Agriculture

Irrigation agriculture has long been established along the Letaba River catchment. This catchment is highly developed in an institutional sense, and in relation to the irrigation equipment technology and management expertise that exists in the Klein and Middle Letaba. The importance of irrigated agriculture in the Letaba River catchment cannot be under-estimated as it plays a significant role in the improvement of welfare many people, as it is a large employment creator in the Catchment. It is also an important contributor to the gross geographic product (GGP) of Limpopo Province.

Periods of water shortage for irrigation are of increasing frequency and severity and have placed this sector under severe stress. Growth of irrigation led to the need for water storage to stabilise water supplies. Most of the irrigation area benefits from a regulated source, with run-of-river abstractions being the main sources of water along the Nwanedzi and Letsitele Rivers and, to some extent, along the Thabina River. In spite of major investments in storage dams and other water supply infrastructure, severe shortages still occur. The availability of water from storage for irrigation, for current levels of development, drops as low as 50% of full quota in some seasons with an average of about 83%.

In this study, eight different crops that are irrigated in the Letaba River Catchment were identified and analysed as a proxy in order to calculate the economic value of agricultural production in this catchment area. Crops are divided into five tree crops and three annual vegetable crops:

- *Tree Crops*: Citrus, Mangoes, Macadamia Nuts, Bananas, Avocados,
- *Annual vegetables*: Tomatoes, Butternuts and Cabbages.

Table 2.1 reflects the number of hectares per crop within each sub-system as used in the study. As agriculture in this region is very dynamic a constant change in the production regime is taking place with areas constantly changing.

Table 2.1: Areas under different crop types per sub- catchment

	Citrus	Mangoes	Tomatoes	Macadamia Nuts	Bananas	Avocados	Butternuts	Cabbage
Sub-catchment 1	1 983	-	-	-	700	1 252	-	-
Sub- catchment 2	6 563	1 949	490	1 050	-	-	240	145
Sub- catchment 3	98		20	90	-	-	-	-
Sub- catchment 4	234	100	-	-	-	550	-	-
Sub- catchment 5	40	20	1 622	-	-	680	150	150
Sub- catchment 6	-	-	215	-	370	99	40	40
TOTAL	**8 918**	**2 069**	**2 347**	**1 140**	**1 070**	**2 581**	**430**	**335**

The Table shows that avocados and bananas are the dominant crops in the upper catchment of the Groot Letaba River catchment in sub-catchment 1 whilst other crops are produced in other sub-systems respectively. The Table above also shows that Sub-system 2 and Sub-system 5 produce six of the eight crops produced in the catchment. It is shown that citrus is the dominant crop in the Letaba River Catchment with the total of 8 918 ha cultivated followed by avocados with 2 581 ha and tomatoes with 2 347 ha. The least irrigated crops in the catchment are butternuts with 430 ha and cabbage with 335 ha respectively which represent annual crops.

Table 2.2 reflects the crop water use in each sub-catchment. Water usage has been calculated in cubic meter (m^3) per hectare and is based on information obtained from farmers in the area, the SAPWAT program and the publication: *Estimated Irrigation*

Requirements of Crops in South Africa - Part 2. The crop water usage reflected in this table is the average for each crop.

Table 2.2: Crop water use per sub-catchment

	Citrus	Mangoes	Tomatoes	Macadamia Nuts	Bananas	Avocados	Butternuts	Cabbage
Sub-catchment 1	7 400	7 400	5 300	7 400	9 200	5 500	5 300	5 300
Sub- catchment 2	9 200	9 200	5 300	8 160	9 600	5 500	5 300	5 300
Sub- catchment 3	10 600	10 600	5 300	10 600	10 600	5 500	5 300	5 300
Sub- catchment 4	9 600	9 600	5 300	9 600	9 600	5 500	5 300	5 300
Sub- catchment 5	9 600	9 600	5 300	9 600	10 600	5 500	5 300	5 300
Sub- catchment 6	9 600	9 600	5 300	9 600	10 600	5 500	5 300	5 300

The tree crops, except avocados, reflect the highest water usage of all the crops where in the sub-catchment 3 the most water is used, 10 600m^3. The high crop water use is due to the climatic conditions which are dry compared to the upper catchment. All the annual crops represents a water usage of 5 300 m^3 in all the sub-catchment.

2.2.2 Commercial Forestry

Commercial forestry plantation has been classified as a streamflow reduction activity (SFRA). It is therefore a highly regulated activity and before any new, or in some cases even replanting is allowed, the landowner or producer must apply to the Department of Water Affairs and Forestry (DWAF) for a license. This is normally only allocated after a proper impact assessment has been conducted, taking into consideration the environmental impacts, current and future water demands in the Catchment, as well as impacts on local communities. It is therefore clear that it is not only market and climatic conditions that dictates afforestation, but also environmental and human needs.

The Letaba River Catchment, and, specifically, the Magoebaskloof area in the Groot Letaba, is ideally suited for afforestation. The rainfall in the upper reaches of the Groot Letaba varies between an average of 832 mm to 1 200mm per annum. The area is frost-free, and the soils are relatively deep. The afforested areas are ± 35 000ha in the Groot Letaba Catchment and

± 7 500ha in the Klein and Middle Letaba Catchment. Roughly 60% is planted to Gum and 40% to Pine.

DWAF regulates the afforested area, and no new permits will be issued, as this area is the main source of water for the Ebenezer and Tzaneen dams, which are the lifeblood of agriculture in the area. The total water provision situation in the catchment has been the subject of a number of studies. The present empirical models used by DWAF to predict flow reductions were tested and refined on the Westphalia estate near Tzaneen.

Using these empirical models (the Scott/Smith models) the total reduction in the Groot Letaba causes a reduction of 9.21% or 35.1 x 106 m^3 close to the 35 Mm^3 quoted in the National Water Resource Strategy. For the Klein- and Middle Letaba sub-catchments the reduction comes to 0.8% or 1.2 x 106 m^3, which is close to 1Mm^3 reflected in the National Water Resource Strategy.

2.2.3 Water use in the Domestic sector

Municipal water use consists of domestic households and industrial use. Consumptive use of water for municipal purposes in the Letaba Study Area is less than 0.7% percent of total municipal water consumption in South Africa.

Municipal water use in the Letaba Catchment area is given in **Table 2.3.** It will be seen that industrial water use is 4% of the total municipal use, whereas domestic households use 96% of municipal water. The water use by the municipality is mainly in the town of Tzaneen which is situated in sub-catchment 2.

Table 2.3: Municipal water use in the Letaba Catchment (million m^3 per annum)

	Mm^3	%
Domestic Households	25.32	96%
Commercial	0.95	4%
Total	26.57	100%

Source: DWAF, National Water Resource Strategy (2003)

2.2.4 Industry water use

The following industrial water users have been identified in the Groot Letaba Catchment:

- Manufacturing

- Mining
- Electricity (i.e. Eskom)
- Transport, Construction, Finance and Services industries
- Commercial tourism (excluding eco-tourism)

To determine the effect of the flow scenarios may have on the industry, the information gathered from Contingent Valuation surveys that represent users' willingness-to-pay for water, was used to synthesise water demand schedules from which the economic value of water can be derived.

2.3 THE ECOLOGY

2.3.1 Ecological systems and the services they provide

Ecological systems provide a wide variety of services that not only enhance the human welfare but also ensure sustainability in water resource management. Because of a growing concern worldwide about the destruction and degradation of the ecological system services, Chapter 3 of the National Water Act (Act 36 of 1998) has provided the need for ensuring that water is left in the hydrologic system in order to protect the resources. This amount of water left in the system is known as the ecological Reserve.

The purpose in valuing ecological goods and services is to illicit measures of human preference for or against environmental change. The objective of sustainable development and management of water resources in the Letaba Catchment almost certainly cannot be interpreted without some idea of the value of ecological services and assets provided by the Letaba River.

It is important to note that human activities are not separate to the ecology of rivers. Human use of goods and services creates impacts that influence ecological functions, structure of habitats, or larger scale sub-system processes. The implication is that, while the river has a biophysical potential to supply goods and services, the river depends on how much it is allowed to function naturally. For example, upstream water abstraction and effluent discharges will impact on the quality of the water – all of which limit ecological functionality, thereby limiting the range and quality of services supplied to users, and obviously limiting the benefits which people can gain.

2.3.2 Typology of ecosystem services

Table 2.4 presents the ecological goods and services provided by the Letaba River Catchment.

In the out-of-stream economic scenarios, water is physically removed from the river and used. However, in the case of the ecology, the economic value (benefit) of the water is evaluated whilst the water is still in the river.

The table also provides the value type that was considered and the method used in the valuation. It should be noted that the total economic value (TEV) of the goods and services were not considered because of time and budget constraints.

Table 2.4: Typology of ecological services and valuation methods

Aquatic ecological goods and service	Value type	Method used	Constraints & limitations
Services			
Recreational activities: swimming, boating	Indirect use value	Replacement costs	It is assumed that the cost of replacement match the original benefit. Method may lead to under or over-estimates
Biodiversity maintenance	Non use value	Contingent valuation	There are various sources of possible bias in the interview techniques. There is also controversy over whether people would actually pay the amounts stated in the interviews.
Water regulation: Waste assimilation/dilution	Indirect use value	Substitute cost	The approach provides costs rather than the value of the service. This provides a rough estimate of value.
Raw material: Thatch grass, reeds, wood gathering and sand mining.	Indirect use value	Substitute cost	The approach provides costs rather than the value of the service. This provides a rough estimate of value.
Goods			
Food production: fishing	Direct use	Market price	Most of the goods are public

Aquatic ecological goods and service	Value type	Method used	Constraints & limitations
by the community, fish farming, cultivated floodplains, medicinal plants, hunting smaller animals		method	goods and therefore result in market imperfections.
Tourism	Indirect use	Benefit transfer method	This was done because it is too expensive to conduct a new full valuation for the specific site

3 ECONOMIC VALUATION METHODS

3.1 CONCEPTUAL FRAMEWORK OF THE WATER IMPACT MODEL

In order to conduct a valuation of the social and economic impact of the flow scenarios determined by ecological specialists on the water using sectors as identified in the preceding sections, a Water Impact Model modelling system was developed. The underlying principal of this model is the fact that water is a scarce resource. As such, the allocation of water between competing users (i.e. agriculture, domestic households, industry, and the ecology) needs to be structured in such a way that positive socio-economic impacts are maximized.

The primary objective of the Water Impact Model is twofold. In the first instance, the model is structured in such a manner that it provides a detailed description of the current water usage situation in the catchment area i.e. the volumes of water used by various water users along the river banks, and the economic and socio-economic impacts resulting from this particular usage pattern. In the second instance, the model makes it possible to determine a new water usage situation where the amount of water used by each water user is altered from its current state. Once again, given the new water usage, it is possible to determine the economic and socio-economic impacts emanating from this change in water usage. Thus, the model can produce two different, parallel water use situations i.e. the Current Situation and the New Situation.

The Water Impact Model determines the different impacts that the current and new situations will have on the economy. By subtracting the impact of these situations from each other, the marginal differences in economic and socio-economic impacts can be calculated. This makes it possible to ascertain the nature and magnitude of the impact that changes in water use patterns will have on the community around the catchments, as well as the broader economy.

The next section focuses on the Current Situation component of the Water Impact Model and describes the intricacies of the modelling system related to this situation. General references will be made to the so-called New Situation; however, the primary focus will be on establishing the current situation, since the same theories and methodologies apply to both situations. After the groundwork has been established for the current situation, the fine-tuning of the New Situation is discussed in detail.

3.2 ECONOMIC VALUATION AT SUB- CATCHMENT LEVEL

The Water Impact Model makes provision for the evaluating the economic consequences not only for the entire system but at sub-catchment level, depending on climatic, geographical, socio-economic and other considerations. In the case of the Letaba River catchment, the catchment as discussed in chapter 1 was sub-divided into seven (7) sub-catchments based on the above criteria.

A separate dynamic Water Impact Model has been developed for each of the sub-systems listed above. These separate models only feature the water users that are relevant for each sub-system, i.e. in Sub-system 1, only avocados, bananas and citrus are included in the Agricultural Water Impact Model since these are the only crops that are found in this particular area.

In addition, the sub-system models are structured in such a way that each user is dealt with individually so that the economic and socio-economic impacts emanating from re-allocations of water between users can be calculated separately. In doing so, the impact of changes in water use patterns can be uniquely measured for each water user, and comparative analyses between various users can be performed in terms of the economic impacts emanating from each water re-allocation change.

3.3 ECONOMIC VARIABLES USED

The criteria of the economic impacts of water re-allocations between users are measured in terms of the following macroeconomic variables:

- Impacts on profit (i.e. the impact on surpluses generated by each water user)
- Economic growth (i.e. the impact on Gross Domestic Product [GDP])
- Job creation (i.e. the impact on labour requirements)
- Impact on capital formation
- Income distribution (i.e. the impact on low-income, poor households and the total income households)

After determining the magnitude of change for each water user individually, the model ranks water users in accordance with their contribution to these economic variables. In doing so, the allocation of water rights in this catchment can be re-visited, and adjustments can be made according to the magnitude of each entity’s contributes towards the economy.

3.4 STRUCTURE OF THE WATER IMPACT MODEL

The water impact model comprises of various sub-models which are used in determining the values of the above economic variables. These are described in detail below.

3.4.1 Primary Impetus Model Drivers

The primary impetus drivers of the Water Impact Models are:

- The volume of water allocated to the various water users in each sub-system, and
- The level of water assurance given to each water user in each sub-system.

- Water Assurance is the guarantee given by the Water Management Area (WMA) to individual water users in respect of the amount of time that water will be available to them, expressed as a percentage – this figure is always less than 100%. The Water Impact Model accommodates varying levels of assurance for each water user in each sub-system

Each water user within each sub-system has an existing water allocation at a specified level of assurance of supply. This has been described as the “without ecological flow” which is the baseline for the analysis. For each ecological flow scenario described to achieve an ecological category for example such as category C, the available water to each sector was determined using the Water Resources Yield Model (WRYM). The model measures the impact of these new water allocation/assurance scenarios in terms of the economic criteria described in the previous section. As each water users’ usage patterns change, the economic impacts emanating from each user are altered. Thus, the Water Impact Models make it possible to develop various “change-in-water-allocation” scenarios to determine the impact this will have on the various water users, as well as on the broader economy.

It is important to note that the “without ecological flow” scenario incorporates “normal changes” in future water usage patterns, i.e. normal economic and demographic growth, normal price changes, etc. As such, the current situation is a reflection of future water usage with its associated economic impacts, excluding changes resulting from water re-allocation decisions (i.e. the “without intervention” scenario). The so-called “with ecological flow” reflects changes in water allocations, and the economic impacts that will result from these changes (i.e. the “with intervention” scenario).

As stated previously, the Water Impact Model is structured so that various water allocation scenarios can be tested in order to measure each scenario’s economic viability and effectiveness.

3.4.2 Secondary Inputs Model

In addition to the Primary Impetus model drivers, a next level of Secondary Inputs has been identified. **Table 3.1** reflects these secondary inputs for each category of water user. Secondary Inputs are derived from the “Current Situation” and do not change with each “New Situation” water allocation/assurance scenario. As such, once they have been entered into the model, no additional adjustments need to be made to determine the economic and socio-economic impacts resulting from a re-allocation of water.

Table 3.1: Variables of the secondary inputs

Water using sector	Secondary Input
Agriculture	Number of hectares

Water using sector	Secondary Input
	Water usage per hectare [m^3] Tons per hectare Annual production (Gross income) [Rands] Labour requirements per hectare [Numbers] Annual capital requirements per hectare [Rands] Water Production Elasticity [%]
Commercial Forestry	Number of hectares Water usage per hectare[m^3] Tons per hectare Annual production (Gross income) [Rands] Labour requirements per hectare [Numbers] Annual capital requirements per hectare [Rands]
Domestic Household	Total population [Numbers] Water use per person per annum [m3] Current economic value of water
	Current cost of supply of water [R/kl] Direct labour requirements [Numbers] Direct capital requirements [R million]
Industry	Current water usage [Mm3] Current GDP [R million] Number of tourists Water per tourist
	Spending per tourist [Rand per tourist per day] Direct labour [Numbers]

Water using sector	Secondary Input
	Direct capital requirements [R million]
Ecology	Current water usage [Million cubic metres] Current production value [R million] Current cost of water Direct labour requirements [Numbers] Direct capital requirements [R millions]

3.4.3 Immersed Model Inputs

In addition to the Primary and Secondary Input Requirements, a further level of Immersed Inputs has been embedded in the modelling system. These inputs can be altered by trained econometricians only, and consist of an array of multipliers that are crucial in calculating the macroeconomic and socio-economic impacts emanating from water re-allocations across individual water users in the different sub-systems.

3.4.4 Economic Multipliers

All economic models incorporate a number of "multipliers" that form the nucleus of the modelling system. The nature and extent of the impact of a change in a specific economic quantity (e.g. exports), on another economic quantity or quantities (e.g. production output or employment), is determined by a "multiplier".

Miernyk (1967) indicates that R.F. Kahn used the multiplier concept for the first time in economic theory in 1931 in his article "The relations of Home Investment to Unemployment", as published in the Economic Journal of June 1931. Keynes (1936) refined the concept and incorporated it as an integral part of his theory on income and employment. Both Keynes and Kahn dealt mainly with global multipliers in order to measure the changes in the total income of the national economy, caused by autonomous changes in investment.

The multiplier is indeed a concept that is much beloved by economists and has been much discussed since the thirties. It is a concept that is often misunderstood even by experts according to Van den Bogaerde (Pretoria, 1972); consequently we should approach it with considerable caution. The following example is provided for demonstrative purposes as adapted from the Eighth Addition of ECONOMICS by Paul A. Samuelson (1955):

"Let us consider investment, savings and national income. Savings as well as investment determine the level of national income. Analyses have shown that an increase in investment will increase the level of income and employment. Thus, an investment boom may bring a nation out of a deep or mild depression.

An increase in private investment will cause income to expand; a decrease in investment will cause it to contract. This is not a surprising result. After all, we have learned that investment is one part of net national product: when one of the parts increases in value, we should naturally expect the whole to increase in value. This is only part of the story - the theory of income determination provides a much more striking result.

Income analysis shows that an increase in net investment will increase national income by a multiplied amount – by an amount greater than itself. Investment spending – like any independent shifts in governmental, foreign or household spending – is high-powered, double-duty spending so to speak.

This amplified effect of investment on income is referred to as the "multiplier" doctrine; the word multiplier itself is used for the numerical coefficient showing how much of the above unity is the increase in income resulting from each increase in investment. Therefore, a multiplier is a number by which the change in investment must be multiplied in order to present us with the resulting change in income."

For example, a R5 billion change in investment spending may give rise to a R15 billion change in the output-income level of a country. This is typically called the "multiplier effect" or, more simply, the multiplier. Although this multiplier effect is usually associated with investment spending for the simple reason that investment is the most volatile component of the macroeconomic aggregates. However, it must be emphasised that changes in other aggregates are also subject to the multiplier effect.

On account of their global nature, the economic application of the above-mentioned multipliers is somewhat restricted, both for policy and analysis purposes. However, Input-Output analysis provides a method by which global multipliers can be broken down to a more detailed level, and, therefore, causal factors can be better identified. The most important causal factors that determine multipliers are, firstly, the industry structures (technical coefficients) and, secondly, the final demand structure.

3.4.5 The Social Accounting Matrix

In layman's terms, a Social Accounting Matrix (SAM) is a matrix that depicts the linkages that exist between all of the different role players in the economy i.e. business sectors, households and government. A SAM is very similar to the traditional Input-Output Table in the sense that it reflects all of the inter-sectoral linkages that are present in an economy. However, in addition to these inter-sectoral linkages, a SAM also reflects the activities of households, which are the basic unit where significant decisions regarding important economic variables such as expenditure and saving are taken. By combining households into meaningful groups, the SAM makes it possible to clearly distinguish between these household groups, and to study the economic welfare of each household group separately.

The SAM serves a dual purpose in the national accounts of a country. Firstly, it is a reflection of the magnitude and linkages that exist between the various stakeholders in the economy. Secondly, once a SAM has been developed, it becomes a powerful tool that can be used to conduct various macroeconomic analyses such as calculating sectoral multipliers.

In undertaking this study, Conningarth Economists has constructed a specific SAM for the Limpopo Province, using input from the official 2000 SAM for South Africa, which is based on the official 2000 Population Census published by Statistics South Africa. Conningarth Economists has calculated sectoral multipliers for a number of economic variables in the Limpopo SAM.

By applying the Limpopo SAM used in this study, the direct, indirect and induced multipliers for each economic sector have been calculated. The so-called “direct multiplier” measures the effect occurring in a specific sector, whilst the “indirect multiplier” measures those effects occurring in the different economic sectors that link backwards to this sector due to the supply of intermediate inputs. The “induced effect” on the other hand, refers to the chain reaction triggered by the salaries and profits (less retained earnings) that are ploughed back into the economy in the form of private consumer spending. These linkages are represented schematically in **Figure 3.1**.

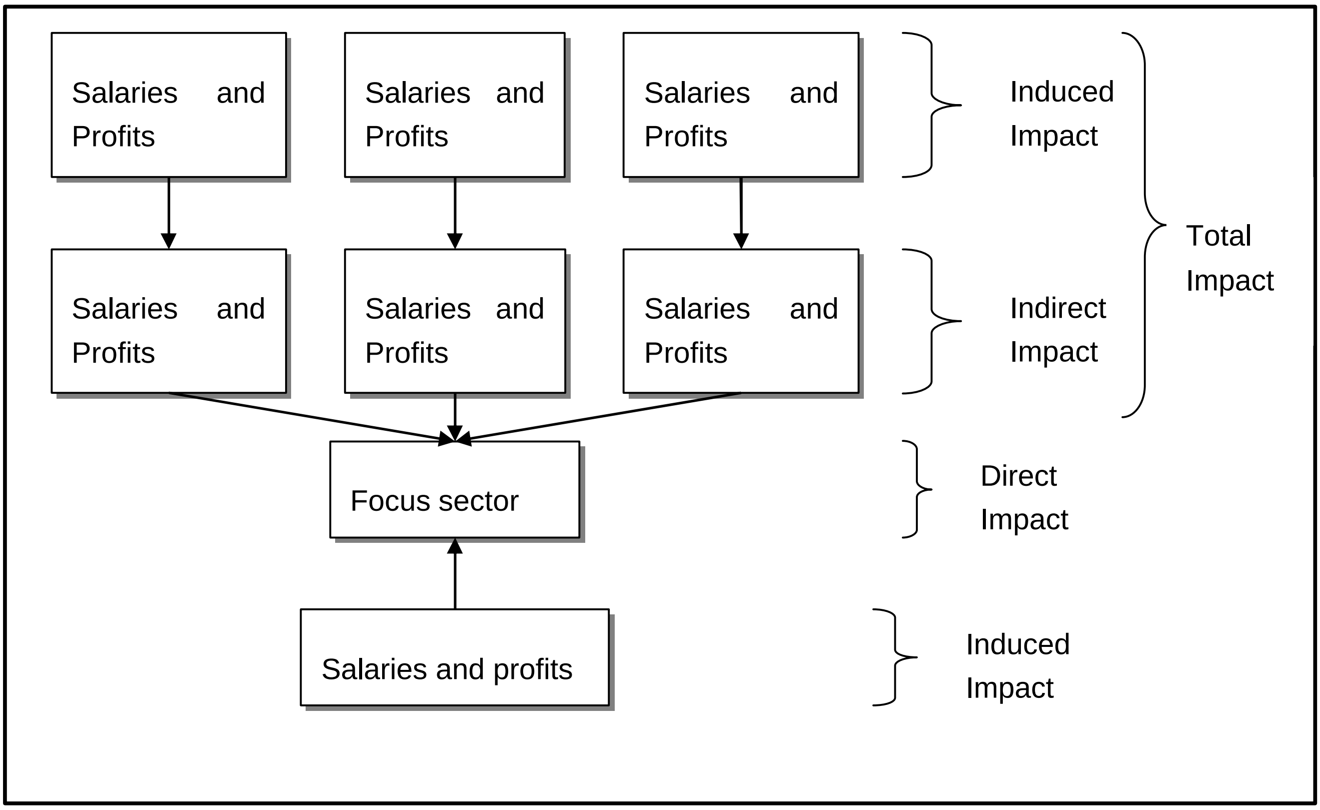

Figure 3.1: Schematic Representation of Direct, Indirect and Induced Impacts

An example of the agriculture sector multipliers used in this study is as follows:

- Direct effect: refers to effects occurring directly in the agriculture sector.
- Indirect effects: refer to those effects occurring in the different economic sectors that link backward to agriculture due to the supply of intermediate inputs, i.e. fertilisers, seeds, etc.
- Induced effects: refers to the chain reaction triggered by the salaries and profits (less retained earnings) that are ploughed back into the economy in the form of private consumption expenditure.

3.4.6 Economic Variables Included in the Limpopo SAM

The following economic variables have been included in the Limpopo SAM that was developed for the catchments analysed in this study.

- Contribution to GDP

The impact on GDP reflects the magnitude of the annual value added to the South African economy. Value added consists of three aspects, namely:

- Remuneration of employees

- Gross operating surplus
- Net indirect taxes
- Employment creation

Labour, together with capital and entrepreneurship form the primary production factors required for economic production. In South Africa there is vast unemployment and poverty, and the creation of employment is therefore of paramount importance.

- Capital utilisation

For an economy to operate at a certain level, an amount of investment is needed to support such a level of activity. Capital, together with labour and entrepreneurship form the basic production factors needed for production in the economy. The effectiveness and efficiency with which these factors are combined will determine the overall level of productivity of the production process. The latter in turn will depend on a whole array of factors, of which the appropriate technology and skills content of the labour force are two important elements

- Household income

Reduction of poverty and inequality has been a central concern of South Africa's government since 1994. Low household income has been specifically used in this study to indicate the impact that a sector has on the reduction of poverty.

3.4.7 Methodology for calculating sectoral multipliers

Sectoral multipliers are calculated using information contained in the Limpopo SAM and data obtained from the Reserve Bank of South Africa and Statistics South Africa. These inverse matrices capture all of the direct and indirect relationships among the inputs and outputs of the various entities included in the Limpopo SAM.

Direct GDP, labour and capital multipliers for each sector are calculated using the following formula:

$$\text{GDP multiplier} = \frac{\text{Value Added}}{\text{Production}}$$

$$\text{Labour multiplier} = \frac{\text{Employment}}{\text{Production}}$$

$$\text{Capital multiplier} = \frac{\text{Capital stock}}{\text{Production}}$$

3.4.8 Multipliers Incorporated into the Water Impact Model

By using a SAM applicable for the studied area, multipliers calculated. The multipliers that were used in this study to determine the economic impacts for the Water Impact Model are as follows:

- Economic growth (i.e. the impact on GDP)
- Job creation (i.e. the impact on labour requirements)
- Impact on capital formation
- Income distribution (i.e. the impact on low-income, poor households and the total income households)

3.5 ASSUMPTIONS AND LIMITATIONS

There were limitations to the valuation. Because the analysis was done at a reconnaissance level, proxy values from other studies were transferred to the Letaba River catchment where these were not available.

It is important to note that because actual values could be determined, the values determined are potential values of use of the ecological goods and services. In particular it is important to determine whether the value is marginal, average or total and whether it is an upper-bound or lower-bound estimate.

A complicating factor presently, is that water users have very little information regarding the value and benefits of the services provided by aquatic ecosystems. Relatively few users are able to indicate the value of their use of water, and have very little knowledge of the cost of this use to other users. Consequently, there is a clear need to develop a framework to quantify and value water services, and to identify the full range of beneficiaries.

4 SCENARIOS CONSIDERED IN THE ECONOMIC VALUATION

Table 4.1 presents all the scenarios that were generated by the Ecological specialist to achieve certain ecological category objectives. Because economic valuation to changes in flows is not sensitive to small changes, the flow scenarios chosen for the valuation where those that would reflect changes in the economic activity as well changes in the levels of employment.

The baseline used in the economic valuation was the present water allocations to the water using sectors without the proposed flow scenarios. It should be noted that the baseline included however the current allocation of 15 million m^3 per annum to the Kruger National Park from Tzaneen dam. It was determined that this allocation was not being met under current operating rules.

The flow scenarios chosen and the rationale for choosing them in valuation of economic consequences are provided as follows:

- *Scenario 1:* This was to achieve the current present ecological state (PES) of each resource unit in the Letaba River system. Additional water to the current flow regime for the ecological requirement was required because it was stated by the specialists that the current functioning of the ecosystem was in a negative trajectory of change. The flow regime for this scenario includes both flows for maintenance as well as floods required for specific purposes. As a result this had a significant impact on the yield of the catchment particularly where these floods would be through managed releases from the existing dams.

- *Scenario 2:* This scenario aimed to lower the category of each resource unit by one category where the EC was high than category D. The flow requirements in this scenario were significantly lower but still included the floods. This still had significant impact on available water for offstream use.

- *Scenario 4:* It was noted that in practice and given the limitations in the outlet structures, the floods cannot be managed through releases from existing regulations. Therefore the floods which could not be managed from releases were taken out (see **Table 4.1**)

- *Scenario 6:* This scenario was included in the valuation because it provided on some of the EWR sites lower categories and therefore lower flow regimes than for scenario 4.

- *Scenario 7:* The operating rules were optimised for this scenario. The releases that could practically be managed from the dams in the Letaba River catchment were designed into the system while some curtailment were developed for the users abstracting water from the system (see scenario 7 in Table 4.1).

Table 4.1: Description of scenarios developed by ecological specialists

Scenario Number	Description
1	EWR for PES.
2	EWR for the alternative categories below the PES were modelled
3	EWR for the alternative categories above the PES were modelled
4	**Main river downstream of Tzaneen Dam:** The model provides the REC flow requirements to EWRs 6 and 7 with the following modifications: • High flows are moved to more appropriate months EWR 1**: The model provides the REC flow requirements but with floods > 8 m^3/s removed.** EWR 2**: (Letsitele) All high flows are removed. Low flows decreased to be equal to the present flows in the dry season. Wet season flows are provided for the REC.** **EWR 5** (Klein Letaba): The model provides for the REC flow requirements but with high flows removed to appropriate months. Low flows decreased to be equal to present day in June and July.
5	**Same as Scenario 4 with the following changes**: **EWR 3:** If EWR 3 is not met with Scenario 4, supply EWR 3 at PES category. **EWR 4**: Decrease August, September and October low flows to present. Move the Nov. floods to Dec. or any other high flow month so that there is no conflict.
6	**Same as Scenario 4,** but where relevant, the alternative category below the PES are supplied rather than the PES or REC.

Scenario Number	Description
7	**Same as for Scenario 6 with the following changes:** • Delete all floods at EWR 4, 6 and 7 • Delete all floods at EWR 5 >than 5 m^3/s • Delete all floods at EWR 3 > than 18 m^3/s • Supply demand at EWR 3 and 4, according to the changes in requirements set up by the fish specialist, from Tzaneen Dam. • Supply the deficit at EWR 6 and 7 from Middle Letaba Dam (not from Tzaneen Dam)

5 RESULTS OF THE ECONOMIC VALUATIONS

5.1 RESULTS OF IMMEDIATE IMPLEMENTATION OPTION

The following tables present the results of the evaluation of the scenarios described in chapter 4. It should be noted that the figures present the immediate consequences on changing the available water to each sector and to each sub-catchment if the ecological flow scenario is implemented. If time is allowed for other water using sectors to improve their water use efficiency levels the impact would be different but at a cost of implementing water use efficiency practices. This is presented latter in this section of the report.

All the additional results for the immediate implementation option, is in Annexure Tables 1-7.

The results are firstly presented on a sub-catchment basis and then also compared to their influence on the total catchment.

5.2 SOCIO ECONOMIC IMPACTS ON SUB-CATCHMENT 1: UPPER GROOT LETABA

5.2.1 Economic impact on out of stream water use

Table 5.1, presents the impact of the flow scenarios on the water using sectors in sub-catchment 1 of the Letaba River Catchment. As can be seen from the table, the impact is severe for the flow scenarios 1, 2 and 4. This is due to the fact that these scenarios require more water than is available due to the fact that floods are being managed through releases from dams although the existing outlet infrastructure cannot manage such releases.

As a result there is significant reduction in water availability for the irrigation sector in particular. For scenario 4 however some of the floods required were removed and the impact became less severe. This is shown by the number of hectares which need to be withdrawn compared to scenario 1 where all floods are managed from dam releases.

The impact is least severe for scenario 6 and 7, an optimisation of the current operating rules by removing all flood flows that cannot be managed through dam releases. In this case the irrigation sector will lose approximately 1 220 hectares in the upper Groot Letaba sub-catchment which represents 31% of current irrigation area. It should however be noted that this is based on current water use practices by the irrigation sector and maintaining the same level of reliability of supply as they experience now.

Table 5.1: Results of the value of incremental benefits for each flow scenario in the Upper Groot Letaba sub-catchment

Scenario	**Total Surplus** **Rand million**	**GDP** **Rand million**	**Capital Formation** **Rand million**	**Low income households** **Rand million**	**All households** **Rand million**	**Employment** **Numbers**	**No. of ha withdrawn** **hectares**
Without ecological flows	1 119	2 931	14 136	1 049	4 134	38 040	3 935
Scenario 1	-42	-258	-766	-76	-299	-18 638	-3 935
Scenario 2	-10	-113	-256	-30	-119	-10 696	-2 335
Scenario 4	-35	-167	-550	-51	-201	-10 110	-2 086
Scenario 6	-31	-118	-436	-38	-150	-5 548	-1 102
Scenario 7	-5	-61	-128	-16	-64	-5 744	-1 220

By taking all the impacts into consideration, Scenario 7 has the least unfavourable effect on the social (i.e. impact on employment and the low income households). The total surplus, GDP, capital requirements, low income households and all households have a substantially less negative incremental change than the other proposed scenarios. Although Scenario 6 has less number of employment opportunities taken away, as well as the number of hectares withdrawn compared to the other scenarios, Scenario 7 remains the best option.

5.2.2 Valuation of ecological goods and services in the upper Groot Letaba sub-catchment

Table 5.2 presents the results of the valuation of the ecological flows in the upper Groot Letaba sub-catchment. The main ecological goods and services identified in the upper sub-catchment include the following:

- *Intermediate goods and services:* waste assimilation and dilution, cultivated floodplain fish farming,
- *Final goods and services:* fishing by local communities, recreational swimming, gathering of wood and reeds,
- *Disbenefits:* bilharzia, malaria

Table 5.2 illustrates that although the economic surplus from water left in the river is small comparatively to economic surplus from out of stream water use the incremental change from the baseline is significant (i.e. 86%). This contributes to the long term sustainability of the water resources for out of stream uses such as irrigation agriculture and industrial production. As the flow regime decreases to meet the ecological objectives, so does the incremental benefit reduce as indicated by flow scenario 7 which has the least incremental benefit. However it is noted that scenario 7 still represents a positive incremental benefit to the aquatic ecology.

Table 5.2: Valuation of incremental benefit of ecological flows for sub-catchment 1

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	2 590	2 240	1 450	1 260	890	470
GDP	3 080	2 660	1 720	1 500	1 050	550
Low income households	170	140	90	80	60	30
Employment generated	487	390	252	219	154	81
Percentage change from baseline of the surplus value		86%	56%	49%	34%	18%

5.3 SOCIO ECONOMIC IMPACTS ON SUB-CATCHMENT 2: MIDDLE GROOT LETABA

5.3.1 Economic impact on out of stream water use

Table 5.3, illustrates the same trend as for the upper Groot Letaba sub-catchment. There is a significant reduction in the economic surplus of this sub-catchment for flow scenarios 1, 2 and 4. The numbers of jobs that will be lost are also significant for these flow scenarios. This is due to the fact that these scenarios require more water than is available due to the fact that floods are being managed through releases from dams although the existing outlet infrastructure cannot manage such releases.

The impact on the economic surplus and the employment is less severe for flow scenarios 6 and 7. Therefore from a market valuation perspective, scenarios 6 or 7 have the least impact on the macro-economy of the sub-catchment 2. Considering the fact that this sub-catchment is dominated by irrigation agriculture as far as employment is concerned, the number of hectares that will be withdrawn is the least for scenario 7. Irrigation agriculture will shrink by approximately 8% compared to 94% is ecological water requirements of scenario 1 were to be implemented.

As is the case with sub-catchment 1, it should however be noted that the valuation has been based on current water use practices by the irrigation sector and maintaining the same level of reliability of supply as they experience now. The impact will be less severe if there is potential for implementing water conservation and water demand management (WC/WDM) in the irrigation and domestic sectors.

The Directorate: Water Use Efficiency identified that there is potential for implementing WC/WDM measures in the two sectors because the conveyance infrastructure efficiency levels are low in the case of irrigation and the per capita consumption in Tzaneen and the township of Nkowankowa is very high.

5.3.2 Valuation of ecological goods and services in the middle Groot Letaba sub-catchment

Table 5.4 presents the results of the valuation of the ecological flows in the middle Groot Letaba sub-catchment. The main ecological goods and services identified in the upper sub-catchment include the following:

- *Intermediate goods and services:* waste assimilation and dilution, fish farming, medicinal plants

Table 5.3: Results of the value of incremental benefits for each flow scenario in the Middle Groot Letaba sub-catchment

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers	No. of ha withdrawn hectares
Without ecological flows	1 011	2 805	12 149	932	3 674	66 830	10 437
Scenario 1	-108	-603	-1 191	-136	-535	-48 362	-9 811
Scenario 2	-72	-402	-782	-91	-357	-32 427	-6 575
Scenario 4	-35	-213	-392	-48	-190	-17 530	-3 549
Scenario 6	-14	-87	-138	-20	-78	-7 304	-1 461
Scenario 7	-6	-47	-53	-11	-42	-4 260	-835

Table 5.4: Valuation of incremental benefit of ecological flows for sub-catchment 2

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	2 820	1 160	1 130	1 020	730	480
GDP	3 350	1 370	1 340	1 210	870	570
Low income households	180	70	70	70	50	30
Employment generated	503	206	201	181	131	86
Percentage change from baseline of the surplus value		41%	40%	36%	26%	17%

- *Final goods and services:* fishing by local communities, recreational swimming, recreational boating, gathering of wood and reeds,
- *Disbenefits:* bilharzia, malaria

Table 5.4 illustrates that although the economic surplus from water left in the river is small comparatively to economic surplus from out of stream water use the incremental benefits of ecological flows from the baseline of scenario 1 is significant (i.e. 41%).

Although the value of the ecological flows for scenario 7 have the least positive impact on the contribution of the water left to achieve aquatic ecosystem functioning, it still represents a positive impact.

As discussed for the macroeconomic impact on out of stream water use, scenario 7 also represents the least negative impact on GDP contribution as well as reduction in employment. The ecological water requirements for scenario 7 represent the best balance between protection of the resource and the maintenance of socio-economic development.

5.4 SOCIO ECONOMIC IMPACTS ON SUB-CATCHMENT 3: LOWER GROOT LETABA

5.4.1 Economic impact on out of stream water use

Table 5.5 presents the analysis of the different impacts of the flow scenarios on the seven socio-economic variables in the lower Groot Letaba sub-catchment. It is important to note that there are very small differences in the value of the incremental reduction in benefits between each flow scenario. The reason for this is because the ecological flows of EWR sites 6 and 7 which are situated in the Kruger National Park are driving the requirements past the lower Groot Letaba sub-catchment.

To meet the ecological flow requirements, water is being drawn from the storages in the upper catchments. The ecological flow regimes past EWR sites 3 and 4 situated in this sub-catchment are much higher than the requirements for each flow scenario. As a result there is surplus water available that can be withdrawn out of the system for socio-economic activities. This accounts for the positive impact in incremental benefits in all the flow scenarios with the most positive impact being scenario 1.

In the Lower Groot Letaba Sub-system, no irrigated hectares will be taken away in the agriculture sector, in any of the scenarios presented. Furthermore, no jobs will be lost and the low income households will not be impacted by any of the flow scenarios.

5.4.2 Valuation of ecological goods and services in the lower Groot Letaba sub-catchment

Table 5.6 presents the results of the valuation of the ecological flows in the lower Groot Letaba sub-catchment. The main ecological goods and services identified in this sub-catchment include the following:

- *Intermediate goods and services:* waste assimilation and dilution, flood plain agriculture, fish farming, medicinal plants
- *Final goods and services:* fishing by local communities, recreational swimming, recreational boating, gathering of wood and reeds,
- *Disbenefits:* bilharzia, malaria

Table 5.5: Results of the value of incremental benefits for each flow scenario in the Lower Groot Letaba sub-catchment

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers	No. of ha withdrawn hectares
Without ecological flows	307	771	3 896	274	1 083	12 756	208
Scenario 1	3	3	1	0.2	0.73	539	0
Scenario 2	1	2	1	0	0.5	246	0
Scenario 4	1	3	1	0	0.5	224	0
Scenario 6	1	1	0.5	0	0	166	0
Scenario 7	1	1	0.5	0	0	126	0

Table 5.6: Valuation of incremental benefit of ecological flows for sub-catchment 3

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	3 050	2 870	1 310	1 190	880	670
GDP	3 620	3 400	1 560	1 410	1 050	800
Low income households	200	180	80	80	60	40
Employment generated	573	539	246	224	166	126
Percentage change from baseline of the surplus value		94%	43%	39%	29%	22%

Table 5.6 illustrates that the instream water use for aquatic ecosystem functioning will result in a significant contribution to the GDP for scenario 1. The GDP will be doubled from the current baseline of R3,6 million per annum to R7 million per annum. This is attributed mainly to the floodplain agriculture in this sub-catchment. The incremental benefit as represented by the economic surplus from water left in the river is significant for scenario 1 compared to the upper sub-catchments.

Although the value of the ecological flows for scenario 7 have the least positive impact on the contribution of the water left to achieve aquatic ecosystem functioning, it still represents a positive impact from the current situation where pattern of ecological flow requirements to achieve the aquatic ecosystem functioning objectives are not being met.

As discussed for the macroeconomic impact on out of stream water use, the entire scenarios investigated will not impact on the macro-economy of the sub-catchment. It should be noted that in this case, *scenario 1* represents the best balance between protection of the resource and the maintenance of socio-economic development.

5.5 SOCIO ECONOMIC IMPACTS ON SUB-CATCHMENT 4: LETSITELE RIVER SUB-CATCHMENT

5.5.1 Macro-economic impact on out of stream water use in sub-catchment 4

Table 5.7 presents the findings of the value of changes in flow scenarios for an unregulated Letsitele River catchment. As can be seen because no flow scenario will change the ecological category, the present economic value of the water using sectors in Letsitele river sub-catchment will not change with any of the flow scenarios.

Based on the economic analysis, the available water to the sectors will not change from the current situation as the level of resource protection will be the same as is currently the case. No jobs will be lost nor will the contribution of the catchment to the Gross Domestic Product.

5.5.2 Valuation of ecological goods and services in sub-catchment 4

The following main ecological goods and service were identified through a specialist workshop:

- *Intermediate goods and services:* waste assimilation and dilution, flood plain agriculture, medicinal plants

Table 5.7: Results of the value of incremental benefits for each flow scenario in the Letsitele River sub-catchment

Scenario	**Total Surplus** **Rand million**	**GDP** **Rand million**	**Capital Formation** **Rand million**	**Low income households** **Rand million**	**All households** **Rand million**	**Employment** **Numbers**	**No. of ha withdrawn** **hectares**
Without ecological flows	256	658	3 182	236	928	8 626	884
Scenario 1	0	0	0	0	0	0	0
Scenario 2	0	0	0	0	0	0	0
Scenario 4	0	0	0	0	0	0	0
Scenario 6	0	0	0	0	0	0	0
Scenario 7	0	0	0	0	0	0	0

Table 5.8: Valuation of incremental benefits ecological flows in Letsitele River sub-catchment 4

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	820	620	620	620	620	620
GDP	970	740	740	740	740	740
Low income households	50	40	40	40	40	40
Employment generated	252	191	191	191	191	191
Percentage change from baseline of the surplus value		76%	76%	76%	76%	76%

- *Final goods and services:* fishing by local communities, recreational swimming, recreational boating, gathering of wood and reeds,
- *Disbenefits:* bilharzia, malaria

Table 5.8 has demonstrated that the incremental benefits of all flow scenarios investigated will be the same. The reason for this is that, Letsitele river sub-catchment is unregulated and the flows required in each scenario are the same.

Therefore any of the flow scenarios will achieve the objectives to ensure long term health of the sub-catchment if not additional water is abstracted out of the sub-catchment and not major storage infrastructures are developed.

Addressing the water needs of aquatic ecosystems in the Letsitele river sub-catchment will not mean reducing the water use of one or more sectors (see **Table 5.7**). There are therefore no tough choices to be made to ensure the long-term health of the sub-catchment and the activities it encompasses This is different for the sub-catchments 1, 2 and 3 where trade-off will have to be made to ensure a sustainable river health system.

5.6 SOCIO ECONOMIC IMPACTS ON SUB-CATCHMENT 5: MIDDLE LETABA RIVER SUB-CATCHMENT

5.6.1 Valuation of the macro-economic consequences of flow scenarios on out of stream water uses

Table 5.9 below shows the effects of the different scenarios in sub-system 5, i.e. the Middle Letaba. If scenarios 1 to 6 are compared, the impacts of Scenario 4 and 6 are less severe than scenarios 1 and 2. It is only the total surplus (profit) that is less unfavourable than the other impacts. Despite this situation, the best option in the Middle Letaba sub-catchment is still Scenario 7 as it was analysed in the sub-systems above. No hectares are projected to be withdrawn in agriculture sector and only 5 job opportunities will be lost compared to the possible 6 104 to 18 841 job opportunities in the other scenarios discussed.

Table 5.9: Results of the value of incremental benefits for each flow scenario in the Middle Letaba River sub-catchment

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers	No. of ha withdrawn hectares
Without ecological flows	875	2 231	10 553	787	3 098	31 760	2 662
Scenario 1	-8	-241	-505	-62	-246	-18 841	-2 662
Scenario 2	-8	-241	-505	-62	-246	-18 841	-2 662
Scenario 4	-16	-96	-212	-25	-95	-6 116	-852
Scenario 6	-12	-91	-195	23	-90	-6 104	-852
Scenario 7	-1	2	-6	-1	-2	-5	0

Table 5.10: Valuation of incremental benefits ecological flows in Middle Letaba River sub-catchment 5

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	210	80	80	20	20	0
GDP	250	90	90	30	30	0
Low income households	10	10	10	0	0	0
Employment generated	262	97	97	26	26	0
Percentage change from baseline of the surplus value		37%	37%	10%	10%	0%

5.6.2 Valuation of the incremental benefits of the flow scenarios in the Middle Letaba sub-catchment

The following main ecological goods and service were identified through a specialist workshop:

- *Intermediate goods and services:* waste assimilation and dilution, flood plain agriculture, medicinal plants
- *Final goods and services:* fishing by local communities, recreational swimming, recreational boating, gathering of wood and reeds,
- *Disbenefits:* bilharzia, malaria

As presented in **Table 5.10** above, the incremental benefits of the ecological flows do not change significantly from one scenario to the other. However the most positive benefit is by the flows to achieve scenario 1 and scenario 2. These two represent a percentage from the current baseline situation of 37% compared to the other three scenarios.

5.7 VALUATION OF IMPACTS OF ECOLOGICAL FLOWS ON SUB-CATCHMENT 6: KLEIN LETABA SUB-CATCHMENT

5.7.1 Valuation of the macro-economic impact on out of stream water use

Table 5.11 illustrates the consequences of the flow scenarios on the economic sectors using water in the Klein Letaba river sub-catchment. By taking an overall view of all the impacts used, scenarios 1 and 2 are the worst-case scenarios. The less negative scenarios in the Klein Letaba sub-catchment are 4 and 6 while scenario 7 is the best scenario projected.

The economic growth (GDP) will decrease by R3 million for scenario 7 compared to a decrease of between R34 million and R50 million in the other scenarios. All the other impacts similarly support the scenario 7 situation that is the least detrimental to sub-catchment 6.

5.7.2 Valuation of the incremental benefits of the ecological goods and services in the Klein Letaba sub-catchment

The following main ecological goods and service were identified through a specialist workshop:

Table 5.11: Results of the value of incremental benefits for each flow scenario in the Klein Letaba sub-catchment 6

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers	No. of ha irrigated /withdrawn hectares
Without ecological flows	607	1 434	7 087	515	2 033	12 990	764
Scenario 1	-4	-50	-101	-12	-49	-3 067	-764
Scenario 2	-4	-50	-101	-12	-49	-3 067	-764
Scenario 4	-9	-34	-76	-8	-32	-1 567	-382
Scenario 6	-7	-36	-78	-9	-34	-1 838	-451
Scenario 7	-1	-3	-5	-1	-3	-171	-38

Table 5.12: Valuation of incremental benefits ecological flows in Klein Letaba River sub-catchment 6

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	530	20	20	0	0	0
GDP	630	30	30	0	0	0
Low income households	30	0	0	0	0	0
Employment generated	343	14	14	0	0	0
Percentage change from baseline of the surplus value		4%	4%	0%	0%	0%

- *Intermediate goods and services:* waste assimilation and dilution, flood plain agriculture, medicinal plants

- *Final goods and services:* fishing by local communities, recreational swimming, recreational boating, gathering of wood and reeds,

- *Disbenefits:* bilharzia, malaria

As presented in **Table 5.12** above, the incremental benefits of the ecological flows do not change significantly from one scenario to the other. However the most positive benefit is by the flows to achieve scenario 1 and scenario 2. These two represent a percentage increase from the current baseline situation of 4% compared to the other three scenarios where the incremental benefit of flows is zero.

5.8 VALUATION OF THE IMPACTS ON SUB-CATCHMENT 7: KRUGER NATIONAL PARK SUB-CATCHMENT

Sub-catchment 7 is the portion of the Kruger National Park of which the Letaba River system traverses. All water uses in the Kruger National Park contribute to the tourism sector. The valuation has therefore focused on the contribution of this sector on the macro-economic variables such as GDP, economic surplus, employment and imapc on low income households.

Table 5.14, indicates that the contribution of the Kruger National Park portion of the Letaba system to the macro-economy is positive in all respect from the current situation. This is because all scenarios will leave more water than is currently the situation.

If all the impacts are considered, scenario 1 will be the best option despite the capital requirements impact which is higher in scenario 2 than in scenario 1. Due to the fact that there are no agriculture activities in the KNP, no column in respect of the number of hectares is shown.

Table 5.13: Results of the value of incremental benefits for each flow scenario in the sub-catchment comprising Kruger National Park

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers
Without ecological flows	95	200	1 178	73	287	1 441
Scenario 1	24	50	294	18	72	360
Scenario 2	10	22	507	8	31	155
Scenario 4	8	17	480	6	24	122
Scenario 6	6	13	77	5	19	94
Scenario 7	4	9	53	3	13	64

5.9 OVERALL IMPACT OF FLOW SCENARIOS ON THE LETABA CATCHMENT

5.9.1 Overall economic valuation of changes in flows on market (rival) goods and services

In **Table 5.15** the total impact of a specific scenario is compared to the other scenarios in the Letaba Catchment.

From **Table 5.15** it is clear that scenario 1 will have the most severe influence on the economy in the Letaba River catchment if implemented and specifically on irrigated agriculture where a possible 95% of present cultivated lands will have to be curtailed. scenario 7 is as far as economic impacts are concerned the least severe and if decided upon, only 11% of the irrigation lands will have to be withdrawn. This does not take into account the potential for improving the current efficiency levels through improving the conveyance infrastructure for the irrigation system and reducing water losses in the domestic sector.

5.9.2 Overall economic valuation of changes in flow scenarios on ecological goods and services

The value of ecological goods and services were determined for the whole of the Letaba River catchment for each flow scenario. The results are presented in **Table 5.15**. The outcomes of each scenario mirror the positive impact that each flow scenario has in each sub-catchment.

The overall incremental benefits are significant for scenario 1 but they tail of towards scenario 7. This indicates that any further optimisation will not realise significant benefits in the ecological flows which is the water regime provided within a river zone to maintain ecosystems and provide goods and services where there are competing water uses.

Scenario 7 therefore provides the optimised scenario for ecological goods and services in the Letaba River catchment. This is also the scenario with the least impact on the socio-economic growth of the catchment.

Table 5.14: Results of the value of macro-economic impacts for each flow scenario for the Letaba River catchment

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers	No of ha withdrawn ha	% irrigation withdrawn
Scenario 1	-137	-1 140	-2 363	-280	-1 103	-92 024	-18 056	95%
Scenario 2	-83	-824	1 612	-200	-787	-68 644	-13 220	70%
Scenario 4	-86	-533	-1 226	-138	-540	-38 992	-7 752	41%
Scenario 6	-58	-359	-866	-97	-380	-24 548	-4 750	25%
Scenario 7	-7	-101	135	-25	-97	-9 794	-2 093	11%

Table 5.15: Valuation of incremental benefits ecological flows in the whole of Letaba River catchment

Socio-economic variable	Baseline (Current situation) R*1000	Scenario 1	Scenario 2	Scenario 4	Scenario 6	Scenario 7
		Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000	Incremental benefit R *1000
Surplus value	10 020	6 990	4 610	4 110	3 140	2 240
GDP	11 750	8 230	5 480	4 890	3 740	2 660
Low income households	940	1 180	290	270	210	140
Employment generated	2 420	1 437	1 192	841	668	510
Percentage change from baseline of the surplus value		70%	46%	41%	31%	22%

5.10 INCREMENTAL AND PHASED IMPLEMENTATION OF ECOLOGICAL FLOWS: FINDINGS AND RESULTS

As explained in conceptual framework of the water impact model, the model makes provision to measure the impacts if certain changes in management and technology are introduced in the irrigation-farming sector. It was therefore decided to apply some of these improvements to the farming sector over a 5-year period and to calculate whether the improvements are meaningful if compared to the results of the immediate introduction of water cutbacks.

In Table 5.16 the possible benefits of the phased option to the region is compared to the immediate applied option.

Table 5.16: Benefits derived from phased implementation of the flow scenarios

Ecological flow scenario	**Benefits from the Phasing Options**			
	Employment Opportunities	*Percentage Improvement*	*Irrigation Hectares*	*Percentage Improvement*
Scenario 1	6013	6.5%	1222	6.8%
Scenario 2	7534	10.5%	1550	11.2%
Scenario 4	6866	17.6%	1346	17.4%
Scenario 6	4278	17.4%	814	17.1%
Scenario 14	2194	22.3%	455	21.7%

From **Table 5.16** it is clear that phasing will have definite benefits to the farming community. In the case of scenario 7 the hectares to be withdrawn, decrease from 2 093 to 1 638, while the possible job losses decrease from 9 859 to 7 664.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSION

South Africa is a drought-prone, water poor country and water shortages will influence economic development. As water scarcity increases, the need to manage water as a national asset for overall social benefit becomes imperative. This study was undertaken in order to determine to what extent the water supply can meet the water demand in this specific catchment, namely the Letaba River Catchment. A Water Impact Model was developed to determine what the impacts would be if water will be affected in the various sectors in the economy. The total surplus, economic growth, employment opportunities, capital formation, income of households, and number of hectares withdrawn from agriculture were the impacts that were submitted by the model.

Various assumptions were made and methods applied to determine the end results, namely, the economic impacts in the Water Impact Model for the Letaba Catchment. These impacts were calculated for each of the seven sub-systems in the Catchment and five scenarios for each sub-system. The scenarios were a method that was used to determine the impact of different flow regimes for maintaining ecosystems for the competing out of stream use namely (i) irrigation agriculture, (ii) domestic and commercial supply, and (iii) industrial and mining sector. The calculations were done for immediate introduction of water cutbacks and a five year phasing period where the farmers could prepare them to adjust their farming methods and improve their irrigation efficiencies when the reduction of water is implemented.

After all the sub-catchments, as well as the different scenarios and the water reduction options were considered, it was found that scenario 7 represents the best trade-off between the need for protecting the aquatic ecology while impacting the situation together with the proposed phasing period strategy.

6.2 RECOMMENDATIONS

The results of the economic valuation of water using sectors in the Letaba River catchment presented in **Chapter 5** have illustrated that water provides important benefits to society as commodity benefits as well as from the value of the aquatic ecology through ecological goods and services that can be derived from the ecosystem.

Although there are limitations in the valuation of the ecological goods and services because water is a classic non-marked resource, the valuation provides the implications of different flow scenarios on the social, economic and ecological welfare of the Letaba River catchment. This provides both stakeholders and decision makers with information to make informed decisions on the level of preference for protecting the resource while balancing with the need for social and economic development to achieve government objectives of poverty eradication in a sustainable manner.

The findings of the economic valuation indicate that the flow regime associated with scenario 7 provides the best balance between ecological sustainability and social and economic development. It therefore recommended that the flow regime of scenario 7 should be considered as the ecological Reserve of the Letaba River catchment.

It is also recommended that consideration be made in improving the water use efficiency levels in all the water using sectors in the Letaba River catchment in order to reduce the negative socio-economic impact, implementation of the ecological Reserve will have on these sectors.

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