DEPARTMENT: WATER AFFAIRS AND FORESTRY
DIRECTORATE: RESOURCE DIRECTED MEASURES

OLIFANTS/DORING CATCHMENT ECOLOGICAL WATER REQUIREMENTS STUDY

SOCIO-ECONOMICS STUDY (REPORT VO2)

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EXECUTIVE SUMMARY

Introduction

This report forms part of a Comprehensive Assessment of the Ecological Water Requirements of the Olifants/Doring River Catchment for the Department of Water Affairs and Forestry: Directorate Resource Directed Measures. It is the eight in a series of nine project reports.

The aim of this socio-economics report is to describe the social and economic implications of a range of scenarios of progressively increased water allocations to offstream users, in order to facilitate the decision process required for classification. The specific aims of the study were to:

1. summarise the socio-economic characteristics of the catchment;
2. describe the social and economic value of the aquatic ecosystem goods and services that are influenced by changes in water quantity, distribution and quality;
3. describe the social and economic value of water that is currently extracted from the system, based on existing information resulting from various previous basin and water resource feasibility studies;
4. describe the potential water quality impacts of increasing agricultural irrigation as far as possible based on available data; and
5. estimate the change in these values under different scenarios of water allocation.

The study was largely a desktop study and relied on existing information as well as expert input. Direct and indirect use values of the affected aquatic ecosystems and the value of water use in irrigation were described and quantified as far as possible. Values were expressed in terms of contribution to national income (GDP). The impacts of change in water quality on agricultural production and other values could not be assessed.

The study excludes the non-use values of the affected ecosystems, such as option and existence value, and is hence a partial valuation of the environment. Both changes in aquatic ecosystem values and the value of water use required several relatively simple assumptions regarding the way in which economic activities would be affected.

Description of the study area

The study area is the Olifants/Doring Catchment, which forms the bulk of the Olifants/Doorn Water Management Area (WMA) and covers about 49 000 km^2. The catchment straddles the Western and Northern Cape Provinces. It is physiographically complex with extensive mountainous areas, and has a steep rainfall gradient from being very wet in the south (1500mm) to arid regions in the north (<300mm). The vegetation is dominated by the Nama Karoo biome, and to a slightly lesser extent, the Fynbos biome, and the northernmost part falls within the Succulent Karoo biome.

The Olifants River is the main river, but its catchment is only 6% of the total area, with the rest linked to its main tributary, the Doring River. The Doring River joins the Olifants in its lower reaches. The rivers vary in condition from good condition for the tributaries to poor condition in the vicinity of the major dams. The catchment contains several important endemic freshwater species. The permanently-open Olifants River estuary extends 36km from the mouth up to the causeway at Lutzville. It is about 700 ha in extent, is mostly undeveloped, and is of high biodiversity importance from a national perspective.

The population of the catchment is about 83 200 people, with most people concentrated in the south western part and the rest of the catchment being sparsely populated. More than half of the population is urban, based mainly in Vredendal and Calvinia, as well as Citrusdal, Clanwilliam, Vanrhynsdorp, Nieuwoudtville, Loeriesfontein, Ebenhaesar, Wuppertal and other small settlements. The population is predominantly coloured (77%) and Afrikaans speaking (>90%).

The catchment is largely untransformed (>90% of the WMA) with natural vegetation being used for conservation, tourism and low intensity livestock grazing. Up to 4% of the WMA is used for dryland farming, mainly for wheat and rooibos tea within the Olifants/Doring Catchment. A further 46 700 ha of the WMA is under irrigation agriculture, of which most (45 300 ha) falls within the Olifants/Doring Catchment. Most irrigation occurs along the Olifants River and in the Koue Bokkeveld. Potential for further irrigation in the WMA has been identified as 134 500 ha, of which 42 300 ha is in the Doring River catchment. There are also 997 ha of tree plantations in the mountainous areas. There is limited mining of gypsum, salt, sand and diamonds, mostly at the coast. Urban areas are small.

There are two major impoundments in the catchment (the Clanwilliam Dam and the Bulshoek Barrage) which together give rise to a network of canals for irrigation, urban water supply and mining. Water is also supplied from a large private dam and a large number of smaller farm dams, as well as from direct abstraction from rivers. Groundwater also provides a significant component of urban and rural water requirements. Several options have been considered for further dam development in the catchment, of which raising the Clanwilliam Dam is considered the most viable in terms of minimising environmental impacts.

The Olifants/Doring Catchment has an allocable yield of 307 Mm^3 (based on 98% assurance of supply). Water is naturally fairly saline, especially in the Doring River. Water quality is impacted by agricultural activities, especially in the middle and lower reaches of the Olifants River and during the summer months.

Total water requirements of the WMA exceed available water by 34 Mm^3, with a deficit of 29 Mm^3 in the Lower Olifants ISP sub-area. The National Water Act requires that the reserve be taken into account prior to any licensing of future water use.

Irrigation accounts for about 96% of water demand, with grapes and deciduous fruits being the most important crops. Crops with a lower assurance of supply such as vegetables and lucerne are also grown. The upper Olifants River valley is characterised by citrus and deciduous fruit orchards, irrigated from farm dams or directly from the river. In the Koue Bokkeveld irrigation crops are mainly deciduous fruit and some vegetables, irrigated from farm dams. The Tankwa and Upper Doring areas contain small areas of irrigated lucerne and pasture, irrigated from the Inverdoorn Canal from the Breede River Basin, as well as from private and farm dams. Lucerne and pasture and some vegetables are grown in the Oorlogskloof and lower Doring areas. Below the confluence, the lower Olifants River valley is characterised by grapes, deciduous fruits and vegetables, irrigated by canals, and lucerne, irrigated by diverted floodwaters ("saaidam" irrigation).

Other water users include domestic users, plantation forestry, livestock, alien vegetation, hydropower (though not operational at present), mining and industry.

The WMA makes the smallest contribution to the economy of any of the WMAs, contributing less than 0.5% to GDP. The agriculture sector contributed some 36% of the output of the Olifants/Doring Catchment in 2001, compared with the national contribution of 3.4% from this sector. Thus agriculture is highly significant in the study area. Trade, which includes tourism, is the second-most important sector, contributing 15%.

Based on considerations of land tenure, land use, water use and ecosystem use, the catchment was divided into relatively homogenous socio-economic zones to be used in this study, as follows.

1. Koue Bokkeveld:
   High altitude irrigation farming area, characterised by relatively high winter rainfall and use of numerous farm-dams for irrigation.
2. Doring rangelands:
   Relatively mountainous area characterised by conservation and livestock farming and low population density.
3. Knersvlakte:
   This is an arid area characterised by very low population density and extensive rangelands as the main land use.
4. Upper Olifants:
   Irrigation farming area along the Olifants river valley, with major urban areas.
5. Olifants/Doring dryland farming:
   This area is characterised by a relatively higher proportion of land under dryland farming, but with livestock still an important activity.
6. Lower Olifants:
   Irrigation farming area along the lower Olifants river valley and floodplain down to the estuary, with several small urban areas.
7. Estuary
   Communal land area comprising the poor fisher-farming community of Ebenhaesar. This is identified as an important target area in terms of resource-poor irrigation farmers. This area falls within the previous area and is associated with the Olifants estuary.

Description of the affected communities

More than half of the population is concentrated in the lower and upper Olifants River zones (about 29 000 and 19 000 people, respectively). The dryland farming zone, Doring Rangelands and Koue Bokkeveld zones each have about 9000 – 11 000 inhabitants, the Knersvlakte is very sparsely populated (<5000) and about 3500 people live in the vicinity of the estuary. The characteristics of these populations were described on the basis of Census 2001 data, for which Sub-place level data were adjusted on the basis of percentage area falling within each zone. Estimates of the rural and urban proportions thus differ slightly from the quarternary-based estimates.

Communities are predominantly rural in all the zones apart from the Lower Olifants zone, where most people are in towns (Table I). The estuary zone only considers the largely rural population of the Ebenhaesar community. The rural population is decreasing beuse of lack of economic stimulants, migration and HIV/AIDS.

Table I. Summary of population characteristics for each zone. All are % households except education, which is % individuals.

	Koue Bokkeveld	Doring Range-lands	Knersvlakte	Upper Olifants	Dryland farming	Lower Olifants	Estuary
% rural	94	57	57	53	61	33	100
% poor	85	82	84	77	84	73	71
% with Matric education	9	13	13	17	15	18	23
% without flush toilets	15	32	55	28	23	16	17
% in rent-free housing	84	40	33	38	41	33	0

Poverty levels are extremely high throughout the catchment, with more than 70% of households earning less than R38 500 per year in all areas. The eastern parts of the catchment, which are more sparsely populated, are characterised by high levels of poverty (over 80%). About 10% of the labour force are unemployed, which is lower than the national average, and about 2% of the employed are seasonal labourers. There is also a strong immigration of seasonal workers during the harvest and planting seasons.

Education levels are low throughout, being higher in the Lower and Upper Olifants zones and highest in Ebenhaesar. Very few (about 4%) are educated beyond matric, and those are mainly white. Educated young people tend to leave the area.

The majority of households have flush toilets, but significant proportions of households still rely on chemical or pit latrines or have no sanitation. Sanitation conditions are worst in the Knersvlakte area, but are relatively good in the main irrigation zones (Koue Bokkeveld, Lower Olifants) and around the estuary.

Security of tenure is fairly low generally, with more than a third of households occupying rent-free dwellings (e.g. labourer cottages) in most zones, and as many as 84% in the Koue Bokkeveld. There is no rent-free occupation in the estuary (Ebenhaesar) zone, which is a communal land area.

Community cohesion and organisational skills reflect the “social capital” within communities, and are indicated to some extent by the extent to which communities have developed forums, committees and associations such as Water User Associations (WUAs). Communities in most of the zones are relatively well organised in respect of water, with several WUAs, irrigation boards and committees, apart from the arid Knersvlakte zone.

The communities of the different zones have different relationships with water and aquatic resources. The Koue Bokkeveld, Upper and Lower Olifants zones are important irrigation areas where economic activity and income is highly dependent on water supply. Other zones rely extensively on groundwater. The Lower Olifants zone is also interesting in that there is some saaidam agriculture. Tourism-related activities occur in all the zones which depend to a certain extent on aquatic systems (e.g. hiking, scenic, fishing, rafting, birdwatching). Direct dependence on aquatic ecosystem resources is negligible, except in the case of the estuary, where up to 200 households in the Ebenhaesar community are involved in a gill net fishery.

Description of scenarios

As part of the Olifants/Doring Catchment Ecological Water Requirements (EWR) Study, a number of scenarios were developed in order to evaluate the ecological implications for each resource unit. The scenarios were based on a combination of water resource development options and targets for meeting the recommended ecological category at different points in the river system. Thus each scenario has different implications for (a) the water yield of the system and (b) the health of the aquatic ecosystems. The scenarios used in this study are described in Table II. Scenarios 2 and 7 emphasise meeting aquatic ecosystem needs, while the remainder emphasise the increase in yield to water users.

Table II. Summary of scenarios used in this study, giving the % MAR and yield to schemes for each (Mm^3/a).

Scenario	Description	MAR	Yield to schemes
1	Present day conditions, i.e. with no Reserve releases	715.0	148
2	Present Day level of development and meeting the Reserves for the REC (recommended ecological category) at each of eight EWR sites along the river	800.3	84.6
7	Raising Clanwilliam wall (15 m) and meeting the Reserves for the REC (recommended ecological category) at each of eight EWR sites along the river	741.5	135
5	Raising Clanwilliam Dam by 15 m and meeting the Reserves for the REC at 5 of the 8 EWR sites along the river, excluding sites 2, 7 and 8	605.7	258
17	Raising Clanwilliam Dam by 15 m, plus an abstraction weir at Melkbosrug (Brandewyn option) in the Doring catchment and meeting the flow requirements of the Reserve at 4 of the 8 EWR sites, excluding sites 2, 5, 7 and 8.	529.3	317
10	Raising Clanwilliam Dam by 15 m, plus an abstraction weir at Melkbosrug (Brandewyn option) in the Doring catchment, but with no River EWR releases. This development would maximise the yield from the Olifants / Doring River system.	423.5	408

The valuation framework and methods

Ecosystem goods, services and attributes can be thought of as follows:

1. goods are the tangible products provided by ecosystems, such as timber;
2. services encompass benefits such as those associated with ecosystem functioning, for example, water purification; and
3. attributes, such as biological diversity and scenic beauty, which contribute to their potential, such as ecotourism value, or sense of place, adding to overall quality of life.

These generate economic value which can be divided into direct consumptive use value (such as small-scale fisheries) associated with goods, direct non-consumptive use value (such as tourism) associated with attributes, indirect use value (such as nursery value) associated with services, and non use values, which comprise option value (the potential future use value) and existence value (the value of knowing something exists, without necessarily being a user). Only use values were considered in this study.

Aquatic ecosystem values are measured using a number of methods that are applicable to different types of value or circumstances, and depending on availability of information and budget. Direct use values (of goods and attributes) are ascertained by estimating total usage and the market value of that use, or by estimating consumer surplus where there is market failure (prices do not reflect true Willingness to Pay), using methods such as the Travel Cost Method. Indirect values (of services) are typically measured using replacement cost estimates, such as the engineering costs required to replace an environmental function, or change in productivity estimates, in cases where an ecosystem output (e.g. water or fish) forms an input into a production process elsewhere. Option value cannot be measured, but proxies can be used, such as income generated by bio-prospecting. Existence values are measured using stated preference techniques such as the Contingent Valuation Method which elicits the public willingness to pay for environmental amenities. Option and existence values were not considered in this study. In this study measures of ecosystem values were estimated in terms of gross income or sectoral turnover and the economic impacts of this turnover was estimated in a macroeconomic model.

Macroeconomic impacts of changes in ecosystem and irrigation farming values were analysed using a Water Impact Model. These impacts are expressed in terms of surpluses generated, contribution to Gross Domestic Product (annual value added to the South African economy), job creation, capital formation (the amount of investment needed) and income distribution (how much of household income generated goes to poor households).

The changes in turnover of water users are estimated on the basis of the volume of water allocated to the various water users, and their level of assurance of supply. For most users, a specific change in the volume of water available for productive usage or the level of water provision assurance does not have a directly proportional affect on the volume of output produced. For instance, a 5% increase in water availability may only have a 3.5% increase in the output of citrus fruit per hectare over the long term. For this reason, two demand schedules (so-called elasticity curves) have to be used for each individual water user, one that accommodates changes in the volume of water available, and another that accommodates changes in water provision assurances, i.e. the volume of water elasticity that reflects the productivity of water usage; and water provision assurance elasticity that reflects the effective utilisation of water. These are used in conjunction with various inputs on the costs and production in each activity in order to determine changes in turnover.

Macroeconomic impacts are then estimated using economic multipliers obtained from a regional Social Accounting Matrix (in this case for the Western Province).

Value of aquatic ecosystems and implications of flow scenarios

A range of ecosystem goods and services provided by aquatic ecosystems were considered. Their importance in the Olifants Doring was assessed (Table III) and those for which there was both significant value and this value was likely to be affected by the scenarios were considered in more detail.

Freshwater recreational fisheries are likely to be impacted under some of the scenarios, but this impact was considered to be negligible.

Table III Summary of aquatic ecosystem values.

	Ecosystem Goods, Services & Attributes	Description	Value
Goods	**Water**	Negligible use for basic human needs	Not valued
	Food, medicines and grazing	Subsistence estuarine fishery at Ebenhaesar	R0.5 – 0.6 million / annum
	Raw materials	Sand mining near Klawer	R35 000 / annum
Services	**Gas regulation**	Carbon sequestration assumed to be negligible	Unlikely to affected by scenarios, not valued
	Disturbance regulation	Flood attenuation possibly important but unknown	Unlikely to affected by scenarios, not valued
	Water regulation	Timing of flows probably regulated by upper catchment aquatic systems, but not been studied,	Unlikely to affected by scenarios, not valued
	Erosion control and sediment retention	Downstream erosion likely if Doring system dammed, effect unquantified	Not valued, losses could be >R100 000 per ha
	Waste treatment	Several sources of pollution benefit from the carrying capacity of the system; load capacity and actual loads unknown	Not valued, estimation of impacts under different scenarios would require further study
	Nursery areas	Olifants estuary provides important nursery area for West Coast fisheries	Value R3.45 million in contribution to commercial and recreational fisheries
\Attributes	**Genetic resources**	There are some unique biological materials and products that may have future potential value	Unlikely to affected by scenarios, cannot be valued
	Structure and composition of biological communities	There is extensive recreational and tourism use of the Catchment, with several activities being water based, though generally on a fairly small scale	Estuary fisheries R0.6 – 1.3 million per annum, and likely to be impacted by scenarios. Freshwater fishery values unknown but probably significant. Effect of scenarios very slight. Other recreational activities unlikely to be affected by scenarios.

The estuarine gill-net fishery at Ebenhaesar is likely to be impacted to some extent, with losses of up to 20% in the most developed scenario (Table IV).

Table IV. Estimated value of the estuarine gill net fishery under the different scenarios (R millions per annum).

Fishery		Scenario					
		Present	**2**	7	5	17	10
Olifants gill-net	Lower	0.491	0.436	0.436	0.478	0.403	0.417
	Upper	0.630	0.559	0.559	0.612	0.517	0.534

The recreational estuarine fishery is similarly impacted, but the changes in fish abundance area unlikely to have a measurable impact on utility and hence recreational expenditure.

The nursery value of the estuary is most important from an economic perspective, contributing some R3.45 m to the value of West Coast fisheries. Losses of up to R0.76 m per year are incurred in the most developed scenario (Table V)

Table V. Estimated change in value of the West Coast recreational and commercial fisheries under different flow scenarios (R millions).

	Scenario					
	Present	**2**	**7**	**5**	**17**	**10**
Recreational fisheries*	341.7	341.5	341.5	341.7	341.2	341.5
Commercial fisheries	305.0	304.9	304.9	305.0	304.7	304.9
Total fisheries value (lower bound)	646.7	646.6	646.6	646.7	646.4	646.6
Total fisheries value (upper bound) **	646.7	646.4	646.4	646.6	645.9	646.4
Change from present (lower bound)		- 0.07	- 0.08	- 0.01	- 0.28	- 0.07
Change from present (upper bound)		- 0.25	- 0.26	- 0.05	- 0.76	- 0.25
Nursery value (lower bound)	3.45	3.38	3.37	3.44	3.17	3.38
Nursery value (upper bound) **	3.45	3.20	3.19	3.40	2.69	3.20

*estimated maximum change assuming anglers respond to changes in catch rates
** upper bound estimates assume no change in recreational value

The overall economic impact of the changes in ecosystem quality (in terms of GGP) are estimated to range from R40 000 under scenario 5 to R270 000 under scenario 17. These are effectively negligible losses (Table VI).

Table VI Baseline values and values of fisheries under different scenarios (R millions).

	Baseline	Sc 2	Sc7	Sc5	Sc17	Sc10
Impact on Surplus Value	2.90	-0.13	-0.06	-0.03	-0.20	-0.13
Impact on GDP	3.97	-0.17	-0.07	-0.04	-0.27	-0.17
Low Income HH	0.41	-0.019	-0.008	-0.005	-0.031	-0.019
All Income HH	0.70	-0.031	-0.013	-0.007	-0.048	-0.0301
Impact on Labour Numbers	124	-7	-4	-2	-12	-7

Value generated by water use and implications of scenarios

Changes in water yield were estimated entirely in terms of changes in irrigation farming outputs in the lower Olifants area. This was done using estimates of the area under irrigation and the volume of water used per ha for each of the crops grown in the area. It was assumed that there have been no major changes in cropping pattern in the last few years.

The economic losses and gains under the different scenarios due to changes in water use are orders of magnitude higher than those due to changes in ecosystem quality. Scenarios 2 and 7 result in losses of GDP from agriculture in the order of R14 to R300 million, whereas scenarios 5, 17 and 10 result in gains of R1 – 2.5 billion (Table VII). There are also considerable social benefits in the form of increases in employment.

Table VII Baseline values and values of irrigation under different scenarios (R millions).

	Baseline	Sc 2	Sc7	Sc5	Sc17	Sc10
Impact on Surplus Value	R364.84	R-66.02	R-10.66	R+359.80	R+437.17	+R647.55
Impact on GDP	R1299.38	R-270.74	R-36.42	R+1231.78	R+1538.73	R+2265.91
Impact on Capital	R2796 .31	R-584.35	R-71.58	R+2637.56	R+3314.84	R+4870.75
Low Income HH	R199.60	R-36.84	R-5.01	R+192.73	R+237.77	R+350.04
All Income HH	R452.49	R-87.22	R-11.22	R+435.28	R+538.23	R+790.61
Impact on Labour Numbers	13 253	-4788	-756	+ 9976	+14 078	+20 274
Hectares	11 640	6 122	11 240	20 554	25 960	33 212

Social impacts

Changes in the estuary fish stocks will have an impact on the wellbeing of fishing households in the Ebenhaesar community. Some 40% of fishing households obtain more than 75% of their income from fishing, and these households would be particularly affected. All scenarios are predicted to have a negative impact on the fishery, but this impact is negligible in the case of Scenario 5. In addition, changes in fish stocks are likely to have an impact on the nutritional security in Ebenhaesar. About 64% of households eat fish at most meals, and changes in catch will thus affect protein intake and nutrition in the community.

Agriculture was seen as the main alternative to fishing in the Ebenhaesar community, which means that improved access to water for irrigation will make a difference to livelihood strategies of the poor households in this community. The degree of change will depend very much on social cohesion in the community and on the level of support that goes with improved water supply. These benefits are also true of the poor households in other affected zones, particularly the Lower Olifants zone which would be the most likely to benefit from the development scenarios. Scenarios 5, 7, 17 and 10 are likely to lead to positive impacts on employment and income to poor households, with benefits being correlated with the level of development.

Conclusion

The value of developing water resources generally appears to far outweigh the environmental costs, with overall changes in value being increasing positive for scenarios 2, 7, 5, 17 and 10 (in that order). Environmental costs are dominated by estuary fishery values and are lowest for Scenario 5, followed by Scenario 2 and Scenario 7. The range of error in estimation of environmental costs is also likely to be relatively greater than that for agricultural output.

It is important to note that while the environmental costs are low in economic terms they may be considerable in terms of some people's livelihoods. None of the scenarios meets the Pareto criterion that a development should not make anyone worse off, but Scenario 5 is closest to this in that it has the smallest impact on the value of ecosystem goods and services. Under scenario 5, the impacts on estuarine fisheries and nursery value are lowest, and thus so are the impacts on the livelihoods of small-scale fishers of Ebenhaeser, many of whom do not benefit from agriculture. This is a critical issue, since these households are very poor and thus extremely vulnerable. However, it is also very important to remember that MCM is planning to eventually phase out the Ebenhaesar fishing licences, using an alternative livelihoods approach. In this respect, the provision of irrigation water to this community would provide a development opportunity.

It should also be noted that the environmental costs and benefits of the different scenarios were only partially estimated, in that they not include non-use values such as option and existence value. For example, if the area around the Olifants estuary becomes developed, the quality of the estuary could have a very measurable impact on tourism expenditure and real estate value. Option and existence value of genetic diversity and rare species such as the endemic fish species found in the catchment was not included in the study. The estimates also do not include external costs such as impacts of reduced water quality that could have a significant impact on agricultural output. The choice of scenario should thus be driven by consideration of biodiversity impacts as well as the measurable economics impacts.

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ACRONYMS AND ABBREVIATIONS

CSIR	Council for Scientific and Industrial Research
CCAW	Coordinating Committees for Agricultural Water
CNC	Cape Nature Conservation (now Cape Nature)
COMBUD	Department of Agriculture Commodity Budgets
DANIDA	Danish International Development Agency
DEAT	Department of Environmental Affairs and Tourism
DM	District Municipality
DWAF	Department of Water Affairs and Forestry
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
GGP	Gross Geographical Product
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resource Management
LM	Local Municipality
MCM	Marine and Coastal Management
Mm^3	Million cubic metres
NWRS	National Water Resources Strategy
PES	Present Ecological Status
RADC	Regional Agricultural Development Centre
RDM	Reserve Determination Method
SAM	Social Accounting Matrix
WMA	Water Management Area
WODRIS	Western Cape Olifants Doring Irrigation Study
WUA	Water User Association

INTRODUCTION

1.1 BACKGROUND

This report forms part of a Comprehensive Assessment of the Ecological Water Requirements of the Olifants/Doring River Catchment, initiated and funded by the Department of Water Affairs and Forestry: Directorate Resource Directed Measures (RDM). Ninham Shand Consulting Services managed the project on behalf of the Client. The lead technical consultant for the project was Southern Waters Ecological Research and Consulting cc, with the following main sub-consultants:

- CSIR;
- DH Environmental Services;
- E.S.J. Dollar Consulting cc;
- Freshwater Consulting Group;
- GEOSS;
- Ninham Shand Consulting Services;
- Streamflow Solutions;
- Stellenbosch University;
- University of Cape Town;
- University of Port Elizabeth;
- A. Bok and Associates;
- Anchor Environmental Consultants;
- Tlou and Mallory Consulting Engineers.

Project duration was from July 2003 to June 2006[1].

1.2 OBJECTIVES OF THE SOCIO-ECONOMICS STUDY

This report is the Socio-economics Study Report and is the eighth in a series of nine project reports. The aim of the socio-economic component is to describe the social and economic implications of a range of scenarios of progressively increased water allocations to off stream users, in order to facilitate the decision process required for classification. The specific aims of the study were to:

6. summarise the socio-economic characteristics of the catchment;
7. describe the social and economic value of the aquatic ecosystem goods and services (riverine and estuarine) that are influenced by changes in water quantity, distribution and quality;
8. describe the social and economic value of water that is currently extracted from the system, based on existing information resulting from various previous basin and water resource feasibility studies;
9. describe the potential water quality impacts of increasing agricultural irrigation as far as possible based on available data; and
10. estimate the change in these values under different scenarios of water allocation.

For the RDM study, a number of scenarios are being considered which involve various degrees of water supply infrastructure development and provision for the environment. The development measures include the raising of the Clanwilliam Dam, as well as the

[1] Extended from the original contract.

development of new water supply infrastructure. While numerous scenarios were considered for the river RDM study, only five of these were taken forward for the estuary RDM study, and for consideration in this study (see Scenario Report).

Note:	The raising of Clanwilliam Dam will result in inundation of land, which will affect the Clanwilliam Dam Holiday resort (on DWAF land, managed by Cedarberg Municipality); the Aquatic Club; nine private chalets, RAMSKOP Nature Reserve (a tourism asset), the newly developed Crystal Waters residential area; Caleta Cove luxury holiday residences, art sites, some orchards, vineyards, structures, the national road and other roads. These impacts are described in the detailed Environmental Impact Assessment study being conducted for the Raising of Clanwilliam Dam (forthcoming), and are not dealt with in this study.

1.3 APPROACH

This study considers both conventional measures of economic impact associated with changes in available water yield under the different scenarios, such as changes in output from irrigated agriculture, and the less commonly-measured values of goods and services derived from aquatic ecosystems, which are linked to environmental water requirements. The study concentrates on the most significant values that are potentially affected by alternative flow scenarios. It is expected that these aspects will be traded off against one another in the different scenarios. Ecosystem goods and services are assigned a monetary value to attempt to provide a platform for evaluating the trade-offs between alternative scenarios, using a common currency. Valuation methods are described in Sections 4 and 5.

Economic values generated by out-of-stream uses and environmental flow are estimated using conventional and resource economics measures and evaluated in terms of their contribution to national income (GDP Value Added), and their contribution to local livelihoods and poverty reduction. This is explained more fully in Section 4. Social considerations in evaluating the scenarios included their contribution to human well-being, health implications, contribution to basic human needs and the impact on social systems and fabric.

The study was carried out as a desktop study, and thus relied to a large extent on existing information and rapid assessment using expert input on the implications of different flow scenarios for specific components. The five operational scenarios provided for the estuarine flow assessment were evaluated in this study, and compared with the present-day situation.

1.4 ASSUMPTIONS AND LIMITATIONS

This study was carried out at a desk-top level, which means that certain types of value could not be investigated. Thus the valuation of ecosystem goods and services, in particular, must be seen as a partial valuation. In particular, the non-use values of the system, such as option and existence value (explained in Section 5) could not be valued, since this requires extensive questionnaire surveys within and beyond the study area.

With regard to the valuation of out-of-stream water use, it was necessary to make simple assumptions regarding the use of water under different scenarios. These are described in more detail in Section 7.

Another limitation of the study was that the change in distribution of water under the different scenarios was unknown, especially in regard to use by resource-poor farmers. It was assumed that resource-poor farmers would be prioritised in water allocation.

A major constraint of this study was the inability to quantify the external costs to agricultural production associated with changes in water quality. The valuation of water use under the different scenarios does not account for any losses due to reduction in quality of water for downstream users.

Several of the scenarios include the development of water resource infrastructure, including major water resource infrastructure in the Doring River (Scenarios 17 and 10). Neither the engineering nor the environmental costs of the structures themselves have been considered in this report as these would be the subject of separate detailed assessments should these developments be considered.

1.5 LAYOUT OF THE REPORT

Section 1: Describes the background to the valuation of water resources in the competing uses in the Olifants/Doring Catchment. It also provides the aim of the socio-economic component of the Comprehensive Reserve determination study.

Section 2: Provides a brief description of the Olifants/Doring Catchment including its biophysical and socio-economic characteristics. Based on the patterns described, the catchment is then divided into socio-economic zones that form the basis for the descriptions of communities.

Section 3: Provides a description of the communities of the Olifants/Doring Catchment, drawing on Census data as well as from existing unpublished reports. Socio-economic profiles are provided of the communities within each zone. These describe variables that indicate the wellbeing of the communities, and describe their use and dependence on run-of-river water and aquatic ecosystems for subsistence, commercial or recreational use.

Section 4: Summarises the ecological flow scenarios that were developed by the ecological and hydrological specialists, and is drawn mainly from existing reports from the Olifants/Doring Catchment EWR study as well as additional specialist input.

Section 5: Describes the valuation framework and models used in the study. It explains the goods and services and types of value generated from aquatic ecosystems. It then describes the general approach and the specific methods used in the valuation of the water resources available to water user sectors. This section also describes the Water Impact Model, which was used to determine the macro-economic consequences of the ecological flow scenarios on the catchment.

Section 6: Provides a brief qualitative description of aquatic ecosystem goods and services as they pertain to the Olifants/Doring Catchment, and provides the rationale for the choice of those values that were quantified in this study. The valuation methods are described and estimates of the value of the Olifants estuary fisheries and the nursery value of the estuary are made. The changes in these values under different scenarios are described.

Section 7: Describes the use of water in the catchment. Assumptions made in evaluating the different scenarios are described. Results of the economic valuation for the out of stream water use are then described, as well as the expected changes in value under the different flow scenarios.

Section 8: Summarises and compares the values of water and ecosystem use under the different scenarios.

2 DESCRIPTION OF THE STUDY AREA

2.1 LOCATION

The study area is the Olifants/Doring Catchment, which forms the bulk of the Olifants/Doorn Water Management Area (WMA). The Olifants/Doorn WMA 17 is located on the West Coast of South Africa and is the second-largest WMA in the country. The southwestern half of the catchment falls within the Western Cape, and the remainder in the Northern Cape Province (Figure 2.1). The Olifants/Doring Catchment has a total area of 49 066 km^2.

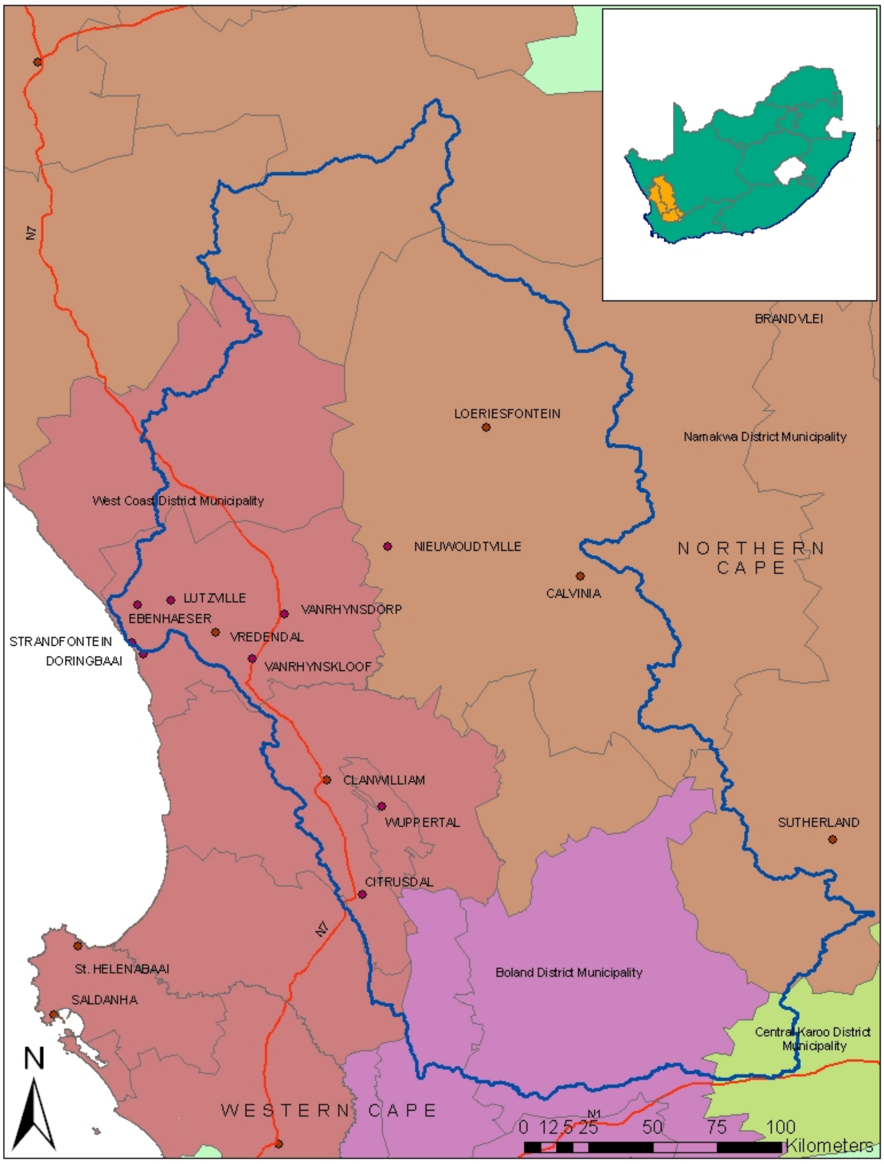

Figure 2.1 Location of the Olifants/Doring Catchment and its main towns and administrative composition, and other towns mentioned in the text. The Namakwa District Municipality lies in the Northern Cape, the others are in the Western Cape.

2.2 TOPOGRAPHY AND CLIMATE

The WMA is physiographically complex, with several high mountain ranges running in a north-south direction and smaller ranges and valleys running in a north-easterly direction (Figure 2.2).

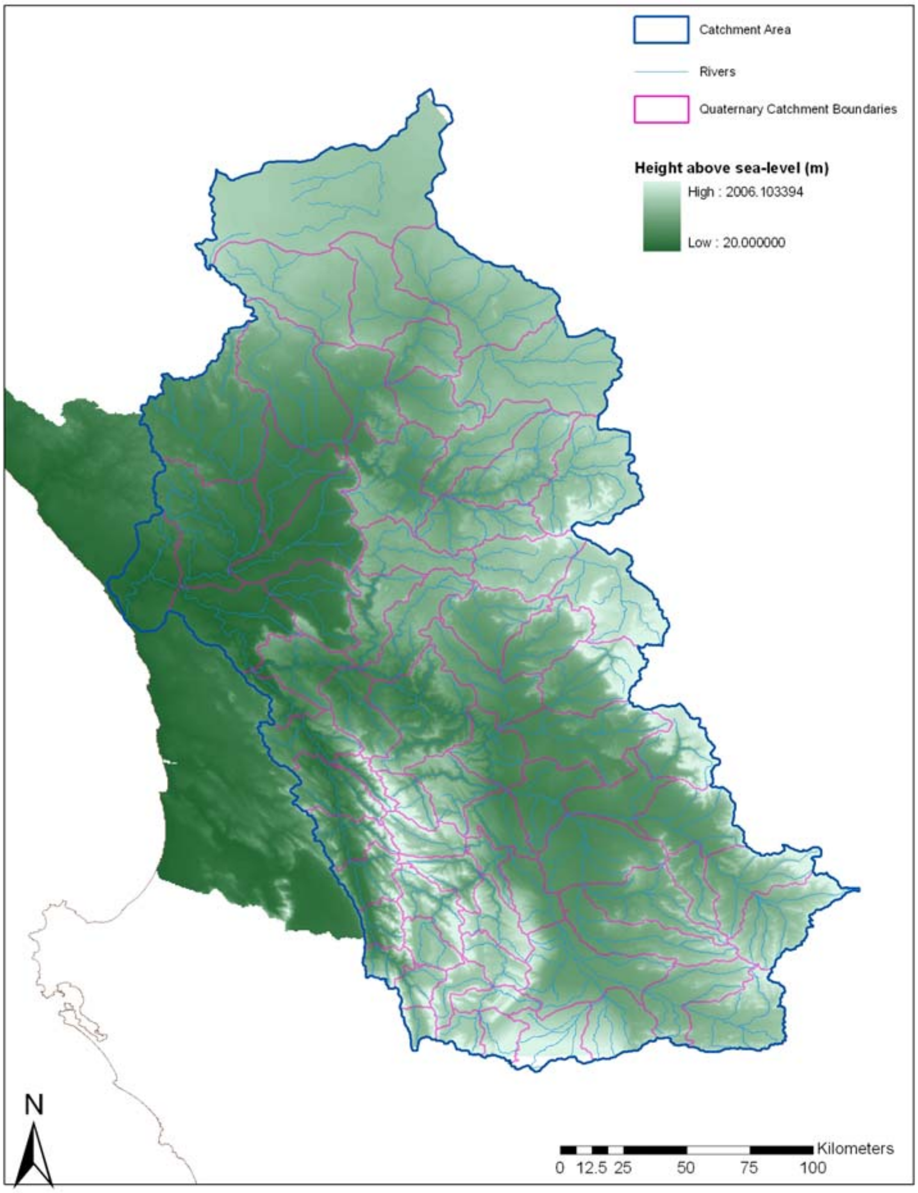

Figure 2.2 Relief, quarternary catchments and rivers of the Olifants/Doring catchments.

The WMA is generally arid, with an average annual rainfall of less than 300mm, but there is much variation across the catchment. The catchment lies partly in the summer rainfall area, but the highest rainfall occurs in the winter rainfall area, which dominates its hydrology. The average rainfall is up to 1500mm in the mountainous regions in the south. The northern part of the basin is extremely arid, with an average rainfall of less than 100mm.

2.3 VEGETATION

The vegetation of the basin is dominated by the Nama Karoo biome, and to a slightly lesser extent, the Fynbos biome in the west. The northern-most part of the catchment falls within the Succulent Karoo biome.

2.4 RIVERS AND ESTUARY

The Olifants River is the main river, with the Doring River its principle tributary. However, the catchment of the Olifants River is only about 6% of the total Olifants/Doring catchment. The Doring River and the Olifants estuary are among the few rivers and estuaries in South Africa that have been relatively unaffected by human development.

2.3.1 The Olifants River

The Olifants River rises on the Witzenberg plateau at about 800m altitude, as a network of small mountains streams and wetland areas. It then flows northwards for about 12km before entering a narrow gorge for 30km. It emerges into a wide valley at Keerom, then flows northward for 100km between the Olifantsrivierberge, Swartberg and Cederberg mountain ranges. The river is perennial and has a total length of 280km.

The Olifants River mainly drains sandstones and quartzites of the Table Mountain Group in its upper reaches, and Bokkeveld Group shales in its middle reaches and Tertiary to Quaternary sands, together with some Nama Group outcrops in its middle and lower reaches (Inception Report - DWAF 2003a).

Two major tributaries, the Doring and Hol Rivers, join the river near Klawer and Vredendal, respectively.

EWR Sites on the Olifants River were rated, in terms of their present ecological status, as a D above the Clanwilliam Dam, E immediately below the Bulshoek Dam, and B on the Rondegat River, one of the tributaries (Riverine RDM Report – DWAF 2005).

2.3.2 The Doring River

The Doring River rises on the northern slopes of the Hex River Mountains and flows north east into the dry region to the east of the Cedarberg Mountains. It is joined by several small tributaries in its upper reaches. Along the first 150 km the river is naturally seasonal, but now flows for much of the year as a result an interbasin transfer from Lakenvlei Dam near Ceres (Delineation Report - DWAF 2004a). 150km from its source, the Doring River is joined by the perennial Groot River, and becomes a large, often-braided river which flows strongly in winter and maintains some flow for most of the year. 50km downstream, it is joined by the Tankwa, a seasonal river that drains a vast area of the Karoo, and 5km thereafter, by the Tra-tra, a seasonal river that drains the Cedarberg. The Doring then enters a deep gorge for about 60km, and where it emerges is joined from the west by the Biedou. The Brandewyn and Koebee Rivers join the Doring about 250 and 280km from its source, and at 310km, the Doring enters the Olifants River, just upstream of Klawer. The lower sections of the Doring stop flowing for periods of up to several weeks during summer.

In the western and extreme southern portion of its catchment area the river drains sandstones and quartzites of the Table Mountain Group, Bokkeveld Group shales and Witteberg Group quartzites and shales. These three units are components of the Cape

Supergroup. The eastern parts of the catchment consist of Karoo Supergroup rocks: the easily-eroded Dwyka Formation tillites and the Ecca Group shales and sandstones (DWAF 2004a). The Doring contributes a very large proportion of the silt carried down to the Olifants River (Morant 1984).

Two sites on the Doring and one on the Groot River were rated as B/C, B and B/C, respectively, in terms of their present ecological status (Riverine RDM Report – DWAF 2005).

2.3.3 The Olifants estuary

The Olifants River flows into the Atlantic Ocean approximately 250km north of Cape Town. The estuary, defined by the extent of tidal influence, extends about 36km from the mouth, to the causeway at Lutzville. The Lutzville causeway inhibits tidal intrusion, and the estuary would probably have originally extended another 5 – 10 km upstream. Covering a total of 702 ha, or about double that if paleo-saltmarsh is included, the Olifants estuary is one of only four permanently-open estuaries on the West Coast. The mouth is permanently open, with a rocky bluff on the northern side. The lower estuary contains extensive saltmarshes and channel areas whose configuration changes after floods. There is a strong tidal influence, with the tidal prism extending up to 15 km upstream. Saline water penetrates further upstream (sometimes to Lutzville) than under natural conditions due to reduction in freshwater inflow (Estuary RDM Report - DWAF 2005a).

2.5 POPULATION

The Olifants/Doorn WMA is the least populous WMA in the country, with about 0.25% of the national population. About two thirds of the population is concentrated in the south-western part, in the Koue Bokkeveld, the Olifants River Valley and the Sandveld (outside of the Olifants/Doring catchment), corresponding with the areas of most economic activity. Only 30% of the population live in the arid areas of the Doring River Catchment, the catchments of the northern tributaries of the Olifants River, and the Namaqualand coastal catchments (though these areas account for 80% of the WMA) (DWAF 2002). Thus the majority of the area is very sparsely populated (Figure 2.3), with the result that more than half of the population of the WMA is classified as urban, despite the strongly agricultural base of the economy. Note that DWAF (2002) defined functional urban areas (although populations in many of these had been defined as rural in the census). Due to HIV/AIDS and urbanisation trends, a general decline is expected in the population of the area, particularly in the rural population (DWAF 2003b).

Various estimates have been made of the 1995 population of the WMA, and these range from 104 000 people (DWAF 2001, 2002; based on estimated population per quarternary catchment), to 113 000 people (DWAF 2003b; based on estimated population per quarternary catchment), to 267 000 (DWAF 2004b; based on the population of all the municipalities in the WMA). The population of the Olifants/Doring catchment, based on quarternary catchment estimates, is approximately 83 200 people.

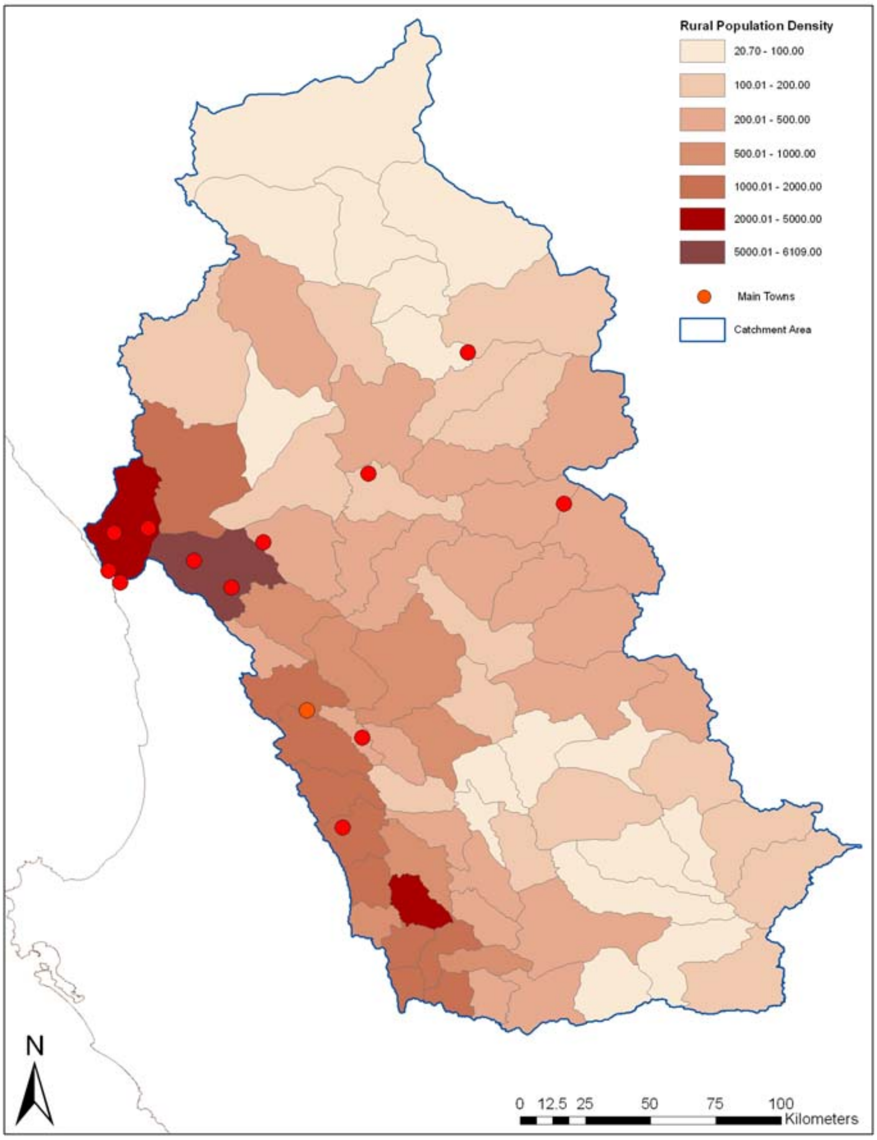

Figure 2.3 Rural population densities in the quarternaries for Olifants/Doring catchment, based on the 1996 census.

The urban population is based mainly in Vredendal (Matzikama Local Municipality) and Calvinia (Hantam LM), as well as Citrusdal, Clanwiliam, Vanrhynsdorp, Nieuwoudtville, Loeriesfontein, Ebenhaesar, Wuppertal and other small settlements. Based on analysis of the municipal populations (DWAF 2004b), the population is predominantly coloured (77%), with 20% white and 3% African (Table 2.1). More than 90% of the population are Afrikaans speaking, and relatively few (3.9%) have tertiary education. Only 9% of the population are without sanitation.

Within the Northern Cape, the sparsely populated areas of the catchment are relatively poor. Rich commercial activities are concentrated in those portions of the catchment within the Western Cape. Unemployment is a problem throughout the catchment (DWAF 2004b).

Table 2.1 Population of the Olifants/Doorn WMA (DM = district municipality, LM = local municipality).

	West Coast DM			Boland DM	Namakwa DM			Central Karoo DM
	Matzikama LM	**Cederberg LM**	**Bergrivier LM**	**Witzenberg LM**	**Hantam LM**	**Karoo-Hoogland LM**	**Kamiesberg LM**	**Laingsburg LM**
Total Population	**50208**	**39326**	**46325**	**83567**	**19814**	**10512**	**10754**	**6681**
Male	25045	19607	23125	41522	9535	5066	5454	3227
Female	25162	19719	23198	42046	10278	5507	5299	3453
African	2800	3139	2335	16606	250	285	178	150
Coloured	38212	30764	35009	59189	16470	8348	9345	5539
Indian	66	26	64	118	19	13	12	8
White	9124	5405	8917	7654	3075	1866	1219	984
Education: >Grade 12	1925	1664	1940	3213	730	533	257	244
Total Households	13264	9915	11391	17569	5257	2860	2748	1901
Water in Household	9092	7167	8570	12347	2229	1412	549	1152
Water in yard	3069	2437	2002	3614	2604	1137	1252	618
Communal tap	1442	598	889	2149	475	342	641	112
Non retic: Borehole, spring, dam,river	221	142	178	92	56	25	61	40
Toilet flush	10245	8500	10272	16422	3419	1433	1158	1446
Toilet: latrine	850	600	833	1215	1315	1061	1288	327
Toilet: none	612	1265	612	1776	669	449	303	149
Refuse municipal service	8577	5415	7405	12215	3547	1723	2053	1218
Refuse communal/own dump	5370	4872	4259	6616	1851	1200	745	693
Refuse disposal: none	147	79	43	581	46	19	37	12

2.6 LANDUSE

Due to the low rainfall over much of the area, the catchment is not suitable for dryland farming on a large scale. Thus more than 90% of the land is untransformed, with these lands being utilised for **conservation, tourism** and low intensity **grazing for livestock** (DWAF 2002), retaining its indigenous vegetation cover (Figure 2.4). There are about 11 780 large stock (mainly cattle), 336 000 small stock (sheep and goats) and 10 930 pigs in the Olifants/Doring catchment (DWAF 2002, based on 1994 livestock census).

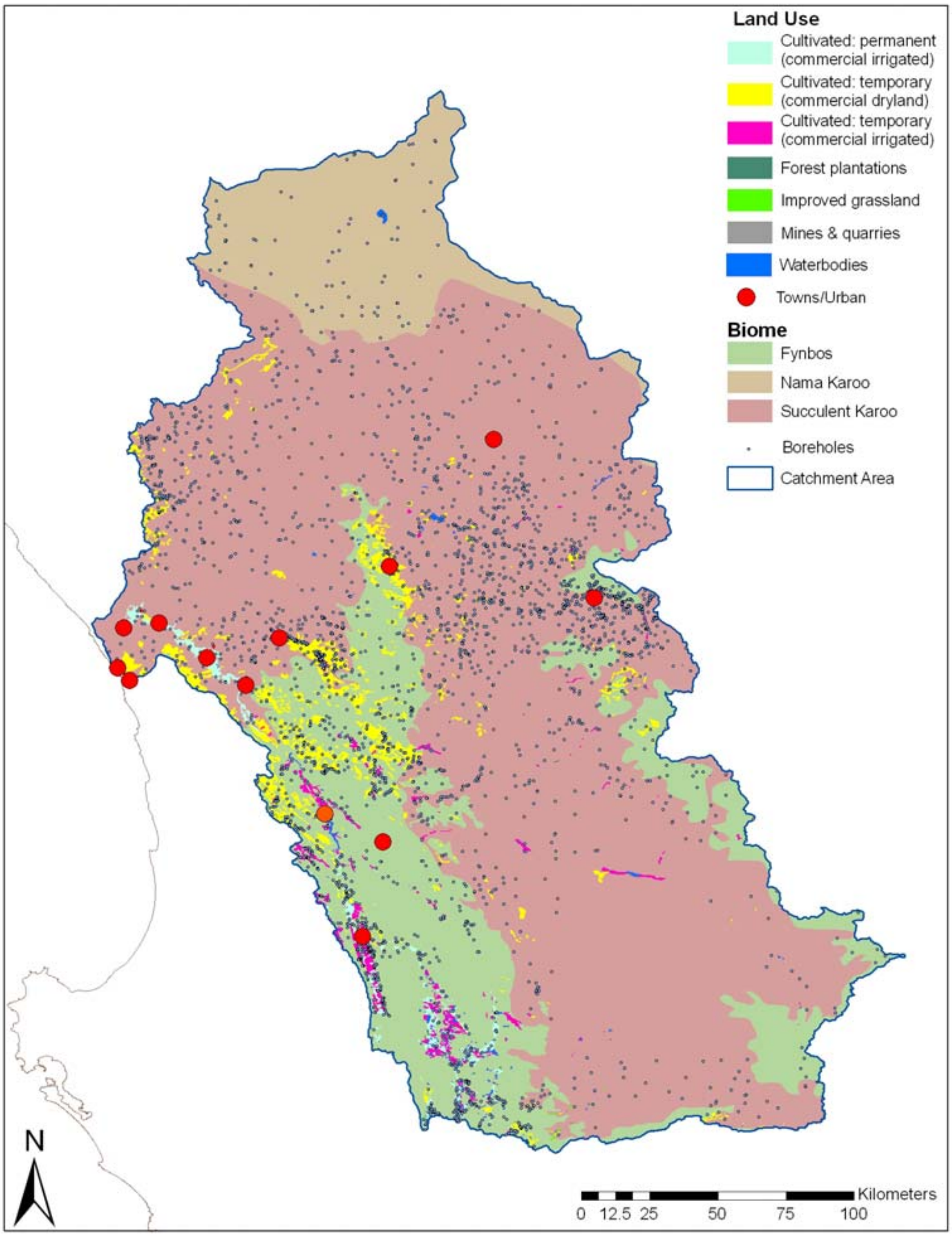

Figure 2.4 Vegetation and land use of the Olifants/Doring catchment (based on CSIR 1996 land cover).

The **tourism** industry is expanding and supporting economic development in the area. It is based mainly on the unique rugged landscape of the Cedarberg, the wide arid plains of “Bushmanland” and the spring displays of wildflowers throughout the region. Coastal resorts and relatively pristine rivers are also attractions. The Olifants estuary remains largely undeveloped as a tourist attraction.

Up to 4% of the WMA (219 000 ha) is used for **dryland farming**, although this would be expected to vary from year to year, depending on rainfall. Dryland crops are mainly wheat and rooibos tea. The total area under dryland crops is unknown, but likely to be much lower than the above estimate based on satellite images (CSIR 1996) and is probably in the vicinity of 100 000 ha for the whole WMA (DWAF 2002). There is no sugar grown in the catchment area.

Irrigation agriculture is well developed in the WMA, and new areas for irrigation have been investigated. Irrigated crops, including citrus, deciduous fruits, grapes and potatoes (mainly in the Sandveld), are grown on a large scale in the south western parts of the WMA (DWAF 2002). Estimates of the area of irrigated crops vary. DWAF (2002) estimated that a total area of 46 700ha of land was under irrigation in the WMA, of which an average of about 40 000 ha are harvested because much of the area is only used in years of plentiful water supply. Of the total area under irrigation, some 45 300 ha is in the Olifants/Doring catchments (Table 2.2; DWAF 2002). DWAF (2003b) estimated that about 32 400 ha of land are under irrigation in the WMA, including private schemes and the Olifants Government Water Scheme. DWAF (2004b) estimated a total irrigated area of 28 600 ha (Table 2.3), and the ISP (DWAF 2005b) estimates a total area of 49 700 ha under irrigation.

Table 2.2 Land use 1995 (DWAF 2002).

Area (km^2)	Irrigation	Dryland crops	Affore-station	Nature Reserves	Urban	Total area
Total in Doring catchment	116	860	2	560	6	24 042
Total in Olifants catchment	221	720	8	509	17	23 549
Total	337	1580	10	1069	23	49 066

Table 2.3 Areas under irrigation (DWAF 2004b).

Area	Ha under irrigation	Main crops
Koue Bokkeveld	9000	Deciduous fruit
Witzenberg and Bo-boskloof	2700	Deciduous fruit
Citrusdal	5400	Citrus and wine grapes
Vredendal	11500	Wine and table grapes

Irrigated agriculture is found mainly within the Western Cape portion of the catchment (97%), along the Olifants River and in the southern elevated areas of the basin (the Koue Bokkeveld: Table 2.2, Table 2.3), with about a quarter to a third of the irrigated area occurring in the Doring catchment. In the Doring catchment, cultivation tends to be confined to hilltops and the flatter areas next to major tributaries, and at Elansvlei, Bos River and Doringbos along the Doring River. There is comparatively little suitable area for cultivation along the Doring River. Potential for further irrigation in the WMA has been identified as 134 500 ha, of which 42300 ha is in the Doring River catchment (DWAF 2003b).

There are a total of 997 ha of **tree plantations** in the high-rainfall, mountainous parts of the catchment. These are located at the headwaters of the Olifants river (380ha of pine), in the

Cederberg (385 ha) and on the mountain slopes fringing the Koue Bokkeveld (232 ha of pine).

Mining is relatively limited, and includes gypsum mining, a saltworks near the estuary mouth, sand and diamond mining. Apart from the Namakwa Sands heavy minerals mine on the northwestern coast of the WMA, mining operations are small and mainly comprise quarrying or dredging marine diamonds (DWAF 2002).

Urban areas are small and only cover about 31km^2 (DWAF 2005b).

2.7 WATER SUPPLY AND USE

2.1.1 Impoundments

More than 90% of water use is for irrigation in summer, and storage is thus very important. The two major impoundments in the basin are the Clanwilliam Dam (121.8 Mm^3), and the Bulshoek Barrage (5.7 Mm^3)[2] (DWAF 2002, DWAF 2004b).

The **Clanwilliam Dam**, on the Olifants River, was completed in 1935 and raised in 1966. It supplies water to the Clanwilliam Irrigation Board.

The **Bulshoek Barrage**, 23km downstream of Clanwilliam town and 20m upstream of the confluence with the Doring, was completed in 1923. The latter, a diversion weir, is used for balancing storage and gives rise to a network of 260 km of main canal and 60 km of branch canals. These are primarily for irrigation in the Lower Olifants River Government Water Scheme. Towns along the route (Clanwilliam, Klawer, Vanrhynsdorp, Vredendal) also now obtain water from the canals. The canals were improved in 1993 to enable water to be provided for the Namakwa Sands heavy minerals mine (DWAF 2002).

The **Oudebaaskraal Dam** on the Tankwa River has a capacity of 34 Mm^3/a, is privately owned and used for irrigation.

In addition, a large number of **farm dams** capture substantial proportions of winter flows from mountain streams for the cultivation of fruit and vegetables, especially in the Koue-Bokkeveld area (the middle reaches). There are also **direct abstractions** by farmers along the lower Olifants River. These abstractions result in severely depressed flows in the summer months, reducing the Olifants River to a trickle between large pools, and the river sometimes stops flowing altogether (King & Tharme 1994). The numerous farm dams, together with the Clanwilliam and Bulshoek Dams and extensive agriculture in the Clanwilliam and Witzenberg Valleys, have considerable negative impact on the riparian ecosystems.

Groundwater provides a significant component of the urban and rural water requirements of the WMA. Most towns in the catchment obtain their water from groundwater, except for those towns near the canal system.

Several options have been considered for further dam development in the catchment, of which raising the Clanwilliam Dam is considered the most viable in terms of minimising environmental impacts (DWAF 2005c).

[2] these are slightly lower estimates of capacity than other estimates of 127 and 7.5 Mm^3, respectively – Pitman *et al.* 1981, Southern Waters' reports

2.1.2 Water availability

The available water or allocable yield (based on 98% assurance of supply) of the Olifants/Doorn WMA was estimated to be about 339 Mm^3 per year for the year 2000 (Internal Strategic Perspective - DWAF 2005b, which updates the estimates provided by the National Water Resources Strategy - DWAF 2002). This takes into account the impacts of the ecological reserve, river losses, alien vegetation, rain-fed agriculture and urban runoff (BKS-DWAF 2003)

Table 2.4. Yield of the Olifants-Doorn WMA and Olifants/Doring Catchment (WMA minus the Sandveld area), in Mm^3/a (ISP - DWAF 2005b)

Yield	Olifants-Doorn WMA	Olifants/Doring Catchment
Natural MAR	1068	1013
Ecological reserve[1]	189	181
Surface water yield (2000 at 1:50 assurance)	257	255
Groundwater yield	62	32
Useable return flows	17	17
Total yield	339	307

[1] Based on a Rapid Reserve determination, to be updated.

2.1.3 Water quality

The water from this catchment is naturally fairly saline due to the Karoo sediments which occur in the catchment. While the Olifants River within the gorge and mountain reaches have good quality water, agriculture in the upper catchment has led to elevated salt and nitrogen concentration, particularly in summer. The middle reaches are impacted by agricultural activities, with higher concentrations of dissolved and suspended solids and nutrients. Near the two large instream dams, water quality varies both spatially and seasonally. Downstream of the confluence of the Olifants River with the more saline Doring River, alkalinity and concentrations of dissolved and suspended solids increase considerably, while nutrient concentrations decrease only marginally.

2.1.4 Water use

Existing water users and their use estimates are summarised in the Olifants/Doorn Water Management Area (WMA) Internal Strategic Perspective (DWAF, 2005b) per sub-area (similar to but not the same as the socio-economic zones used in this study), based on a 1:50 year (98%) level of assurance of supply (Table 2.5). This is considered to be the best estimate of current water usage in the WMA (Mallory *et al*. 2006).

According to DWAF (2002) current water use is less than the yield, but does not leave enough for the Ecological Reserve. According to the ISP (DWAF 2005b), total water requirements of the WMA exceed available water by 34 Mm^3, with a deficit of 29 Mm^3 in the Lower Olifants ISP sub-area. There is a possibility of augmenting water supply from the Table Mountain Groundwater resource. The National Water Act requires that the reserve be taken into account prior to any licensing of future water use, and the National Water

Resources Strategy (NWRS) requires that the needs of resource poor farmers be given highest priority when allocating water.

Table 2.5 Water volume requirements (in million m³/a, for the year 2000) at 1:50 year assurance for different areas within the WMA (DWAF, 2004b, DWAF 2005b).

Sub-area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Afforestation (3)	Total local requirements	Transfers out	Grand Total
Upper Olifants	100	1	1	0	1	**103**	94 (4)	**197**
Koue Bokkeveld	65	0	1	0	0	**66**	0	**66**
Doring	13	1	1	0	0	**15**	0	**15**
Knersvlakte	3	0	1	3	0	**7**	0	**7**
Lower Olifants	140	3	1	0	0	**144**	4 (5)	**148**
Sandveld	35	2	1	0	0	**38**	0	**38**
Total for WMA	**356**	**7**	**6**	**3**	**1**	**373**	**0**	**373**
Total for catchment	**321**	**5**	**5**	**3**	**1**	**335**	**0**	**335**

1) Includes component of the Reserve for basic human needs at 25 litres / person / day.
2) Mining and bulk industrial water uses, which are not part of urban systems.
3) Quantities given refer to impact on yield only.
4) Transfers out of the Upper Olifants of 94 million m^3/a for downstream irrigation, mainly via the Lower Olifants River canal.
5) Transfers out of the lower Olifants of 4 million m^3/a consist of a transfer of 2.5 million m^3/a to meet the Namakwa Sands mining requirement, and 0.4 million m^3/a to northern Sandveld urban use. The rest is provision for losses.

3.1.1 Domestic water users

The main towns in the lower and upper Olifants areas rely on water from the Olifants River Government Water Scheme, which draws water from Clanwilliam Dam or the canal system. These include Citrusdal that gets water from the Olifants River (as well as groundwater), Clanwilliam that gets water from Clanwilliam Dam and the Jan Dissels River, and the towns of Vredendal, Vanrhynsdorp, Lutzville, Ebenhaesar and Klawer that abstract water from the canal. Other towns obtain their water from groundwater sources.

3.1.2 Agricultural water users

The irrigation agriculture sector is by far the largest water use sector with estimated requirements of about 96% (321 million m^3/a) of the total requirements within the catchment. Although it is estimated that a total area of about 45 300 ha of land is under irrigation, some of this is irrigated only in years when sufficient water is available. The Olifants River Government Water Supply canal system has a scheduled irrigation area of 11 500 ha with an irrigation quota of 12 200 m^3/ha/a.

Grapes and deciduous fruits are the most important irrigated crops (Table 2.6). Assurance of supply is low for lucerne, medium for vegetables and high for the remaining irrigation crops.

The nature of irrigation practices varies throughout the catchment. Upstream of the Doring River confluence, the **upper Olifants Valley** is intensively cultivated with about 10 670 ha under irrigation. Most of this is under citrus trees, with a smaller area of deciduous fruit orchards. Drip irrigation is widely used in the orchards. Upstream of the dam, irrigation water is either stored in farm dams or is pumped from the river. Downstream of the dam, water is supplied by canal from the dam. Most of the land developed for irrigation is irrigated every year because of the crop type (orchards) and the reasonably reliable water supply (DWAF 2002).

Table 2.6 Irrigation area 1995 (DWAF 2002). Note that confidence in the accuracy of the areas under different crop types is low (DWAF 2002).

		Area in km2	**Deciduous fruit**	**Grapes**	**Citrus**	**Pasture/ Lucerne**	**Other veg**	**Other crops**	**Total harvested in average year**	**Total irrigated area**
E1	**Upper Olifants**		10.7	0	74	0	19	3	106.7	106.7
E2	**Doring**									
	E21	Kouebokkeveld (all W Cape)	70				16		86.0	86.0
	E22	Upper Doring (W Cape)			0.6		1		1.8	3.9
		Upper Doring (N Cape)					0.7		0.5	1.6
	E23	Tankwa (W Cape)							0.4	0.8
		Tankwa (N Cape)					2.2		1.8	3.2
	E24	Lower Doring (W Cape)		1.7	0.4		3.1	3.2	7.8	11.9
		Lower Doring (N Cape)					1.6		2.2	4.1
E4		Oorlogskloof (W Cape)							0	0
		Oorlogskloof (N Cape)				4.3		0.3	4.6	4.6
E3	**Lower Olifants**									
	E31	Kromme (All N Cape)							0	0
	E32	Hantams (All N Cape)				1.4			1.4	2.7
	E33	Sout (W Cape)	2	102		3.0	8.4		115.4	111.7
		Sout (N Cape)							0	0
TOTAL			**82.7**	**103.7**	**75**	**8.7**	**52**	**6.5**	**328.6**	**337.2**

At the head of the Doring catchment, the **Koue Bokkeveld** area is extensively cultivated with about 9000 ha under irrigation (DWAF 2004b), mainly for deciduous fruit and some vegetables. Irrigation is mainly from farm dams. The orchards are generally under drip irrigation, while the vegetables are under sprinklers (DWAF 2002).

The **Upper Doring** area is dry, and an average of 230ha, up to 450ha of mainly lucerne and pasture are irrigated, much of this with water imported from the Breede River Basin via the Inverdoorn Canal (DWAF 2002).

The **Tankwa** area receives some summer rain as well as winter rainfall. An average of 220 ha and up to 400 ha of mainly lucerne and pasture is irrigated from farm dams and the privately owned Oudebaaskraal Dam (DWAF 2002).

In the **lower Doring** area, most irrigation occurs in the western portion, which has winter rainfall. About 1000 ha, and up to 1600 ha are irrigated. Most of this is lucerne and pasture, apart from the up to 300 ha of vegetables in the Brandewyn River valley (DWAF 2002).

In the **Oorlogskloof** area there are several farm dams in the headwaters of the Oorlogskloof river and tributaries which irrigate a relatively constant area of about 460 ha of mainly lucerne and pasture (DWAF 2002).

Downstream of the Olifants – Doring confluence, the **lower Olifants** valley has about 11 200 ha of land irrigated from canals from the Bulshoek Barrage using mostly water released from the Clanwilliam Dam. The main crops are grapes (wine, table and raisins), deciduous fruits and vegetables. As a result of some double cropping of vegetables, the area harvested is about 11 500 ha on average (DWAF 2002). In addition, about 270 ha of land (mostly lucerne) around the upper Sout and Vars Rivers is irrigated using the “saaidam” method. This involves abstracting floodwater for irrigation via a series of parallel bunds almost at right angles to the river. These divert floodwater onto the lands both to wet the lands and to deposit the rich silt in the water as fertilizer. This method is not possible in the lower reaches of these rivers due to salinisation.

3.1.3 Plantation forestry

There are a total of 997 ha of tree plantations in the high-rainfall, mountainous parts of the catchment. These are located at the headwaters of the Olifants River (380ha under pine), the Cederberg (385 ha) and on the mountain slopes fringing the Koue Bokkeveld (232 ha of pine).

3.1.4 Livestock

There are about 11 780 large stock (mainly cattle), 336 000 small stock (sheep and goats) and 10 930 pigs in the Olifants/Doring catchment (DWAF 2002, based on 1994 livestock census).

3.1.5 Alien vegetation

The Olifants/Doring catchment has an estimated total of 3000 ha in terms of condensed area cover of alien vegetation. Most of this (2240 ha) is located within the Lower Olifants secondary catchment. The alien vegetation is very roughly estimated to result in an average reduction in runoff of about 1.6 million m^3/a (DWAF 2002).

3.1.6 Hydropower

A small hydropower installation at Clanwilliam Dam uses about 75 million m^3 per year. However it relies entirely on overflows from the dam or releases for irrigation, and does not affect availability of water for other uses (DWAF 2002). This facility is not functioning at present (F. van Heerden, DWAF, *in litt*.)

3.1.7 Mining and industrial water users

The only major mine in the area is the Namakwa Sands heavy minerals mine which is situated on the coast in the northwest of the WMA (outside the Olifants/Doring Catchment) and is supplied with water via an allocation out of the Olifants River canal. There are also several granite-quarrying operations in the vicinities of Vredendal and Vanrhynsdorp. Dredging for marine diamonds occurs offshore. Industries in the WMA are small and the majority of them are concerned with the processing and packaging of agricultural products. Approximately 3 million m^3/a of water is currently required by the mining and industrial sectors.

2.8 OVERVIEW OF THE ECONOMY

Because economic statistics are collected at the district level, they do not correspond with catchment boundaries, and estimates of the contribution of the catchment are approximate. The Olifants-Doorn WMA has been estimated to contribute under 0.5% of the national economic output and less than 1% of formal employment, making it the smallest contribution of any WMA in the country (DWAF 2001, DWAF 2003b). Nevertheless, it had the highest growth rate of any WMA between 1988 and 1997, of just under 4% (DWAF 2001). Based on Based on the percentage area of each magisterial district lying within the WMA, Vredendal, Ceres and Clanwilliam Magisterial Districts have been estimated to contribute about 75% of the economic output in the Olifants-Doorn WMA DWAF (2001)[3]. The agricultural sector was estimated to contribute as much as 43% of the economic output of the WMA in 1994 (Schlemmer 2001, DWAF 2005). The WMA contributed almost 3% of the agricultural output of the national economy, and 1.5% of trade output, with most other sectors contributing less than 0.3% (DWAF 2001). In 1994, 75.5% of the labour force was formally employed, 16.4% was informally employed and 8.1% was unemployed (DWAF 2001)[4]. This is much lower than the national unemployment figure of 29.3% (Schlemmer 2001, DWAF 2005).

The economic characteristics of the Olifants/Doring Catchment are similar to the WMA. An analysis of more recent data at the catchment level suggests that agriculture contributed at least 36% to total output in 2001 (Figure 2.5). This is in stark contrast to the national agricultural contribution of 3.4% to the economy. The proportional significance of this sector is thus about ten times higher than in the national economy.

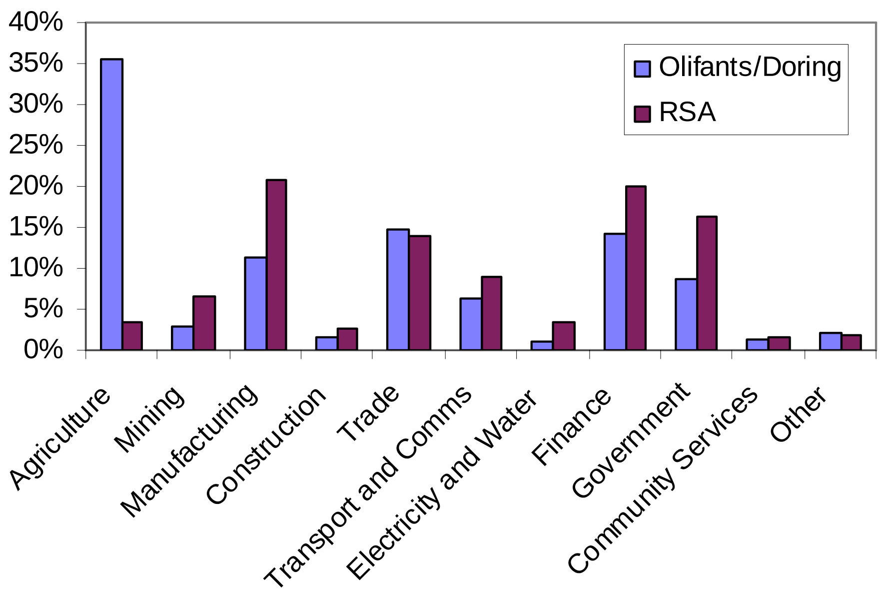

Figure 2.5 Proportional contribution by sector to the Olifants/Doring Catchment and national economy (source EIS 2004).

The importance of the **agricultural** sector is attributed to the high value products cultivated in the area as well as the low level of activity in other sectors. The sector is relatively stable

[3] This is)

[4] Formally employed includes employers, employees or self-employed who are registered tax-payers. Informally employed includes employers, employees or self-employed in unregistered economic activities. Unemployed includes those actively looking for work but not in any type of formal or informal employment.

due to the diversity of products produced. The agricultural sector includes production of wine and table grapes, oranges, potatoes and tomatoes, and the production of wine, rooibos tea, fresh fruit, dried fruit, wheat and fisheries (DWAF 2002). Expansion is limited by the availability of water for irrigation. Growth in this sector will require improved water use efficiency and further value adding through increased processing.

Trade, which includes much of the tourism 'sector', contributes some 15% to the economy of the catchment, and is the second-most important activity. This sector mainly comprises wholesale in wine, fruit, wheat and other agricultural products, as well as tourism and trade services to the local community. Tourism has been identified as the sector '*with the greatest anticipated growth between 2000 and 2025*' (DWAF 2001:15).

The **manufacturing** sector (11.3%) is based mainly on food and beverage processing activities, particularly in Vredendal, as well as on steel and minerals.

The **mining** sector is small, centred mainly on the Namakwa Sands mine north of the Olifants River mouth, where titanium slag and other minerals are mined.

The Olifants/Doorn WMA is considered to have a comparative advantage[5] in Electricity, Mining and Agriculture, with location quotients[6] of 4.0, 2.8 and 1.4, respectively (DWAF 2002). The Olifants/Doring is the only catchment in South Africa where Rooibos tea is produced, with over 300 commercial growers and 200 smaller growers.

[5] Comparative advantage of a region means that it has a more competitive production function for a specific product or service than other regions in the economy.

[6] A location quotient is a measure of comparative advantage which compares a sector's share in gross geographic product (regional output) with its percentage share in the national economy. A value >1 indicates comparative advantage.

2.9 DIVISION OF CATCHMENT INTO SOCIO-ECONOMIC ZONES

For the purposes of this study, the Olifants/Doring catchment was divided into the following relatively homogenous socio-economic zones (Figure 2.6). This subdivision was based on considerations of land tenure, land use, ecosystem use and water use within the study area.

8. Koue Bokkeveld:
   High altitude irrigation farming area, characterised by relatively high winter rainfall and use of numerous farm-dams for irrigation.
9. Doring rangelands:
   Relatively mountainous area characterised by conservation and livestock farming and low population density.
10. Knersvlakte:
    This is an arid area characterised by very low population density and extensive rangelands as the main land use.
11. Upper Olifants:
    Irrigation farming area along the Olifants river valley, with major urban areas.
12. Olifants/Doring dryland farming:
    This area is characterised by a relatively higher proportion of land under dryland farming, but with livestock still an important activity.
13. Lower Olifants:
    Irrigation farming area along the lower Olifants river valley and floodplain down to the estuary, with several small urban areas.
14. Estuary
    Communal land area comprising the poor fisher-farming community of Ebenhaesar. This is identified as an important target area in terms of resource-poor irrigation farmers. This area falls within the previous area and is associated with the Olifants estuary.

These socio-economic zones form the basis for the description of the communities of the study area in the following section.

Figure 2.6 Socio-economic zones identified for the Olifants/Doring catchment, showing the quarternary catchment areas included in each zone.

3 DESCRIPTION OF THE AFFECTED COMMUNITIES

3.2 GENERAL OVERVIEW

3.2.1 Population

The estimated population of the Olifants/Doring catchment is 83 200 people with approximately 50 percent of the population defined as urban, living in the small towns and villages in the catchment (Table 3.1).

Table 3.1 Population of the Olifants Doring by socio-economic zone (Estuary zone is included within the Lower Olifants) based on estimates of population per quarternary catchment.

	Koue Bokkeveld	Doring Rangelands	Knersvlakte	Upper Olifants	Dryland farming	Lower Olifants	Grand Total
Urban population	411	7,150	1,900	8,150	4,850	18,950	41,411
Rural population	9,292	4,092	2,952	10,722	4,611	10,126	41,796
Total	**9,703**	**11,242**	**4,852**	**18,872**	**9,461**	**29,076**	**83,207**

There is reportedly (DWAF 2005b) a decreasing rural population because of a lack of economic stimulants, migration of young people and because of the impact of HIV/AIDS. The northern and eastern parts of the WMA are characterised by highest levels of unemployment and these parts are sparsely populated, have poor infrastructure and high poverty levels (DWAF 2005b).

The characteristics of the populations of each zone are described below on the basis of Census 2001 data, for which Sub-place level data were adjusted on the basis of percentage area falling within each zone. Estimates of the rural and urban proportions thus differ slightly from the quarternary-based estimates.

A number of general points are relevant across all the socio-economic zones, as follows. Following this, descriptions are provided for each zone, organised under the general topics of income, services and infrastructure, education, community cohesion and organisational skills ad Relationships with water and aquatic resources.

3.2.2 Gender Issues

3.1.1.1 POPULATION SKEWS

The DWAF (2004) report presents a gender balance of 50/50 in the WMA as a whole but the figures presented in the affected areas show a slightly higher bias towards males. This does not follow the national trend where women outnumber men, on average 51% of the national population is female and 49% is male. In the affected areas this skew is reversed. Goldin's (1998) observations are confirmed by the WODRIS study cited in Cullis (2005), notably that the bias towards males is likely to be due to migratory patterns where males are attracted to the towns. Because the overall skew is reflected in both the rural regions and in the towns the migratory pull is also towards farms. These migratory patterns also do not correspond to seasonal demands for farm labour because the population figures are stable, reflecting a permanent and not temporary labour force. However, DWAF (2005b) also notes that there is strong in migration of seasonal workers during harvest and planting seasons and this would have effects on population figures at given times of the year.

3.1.1.2 GENDER DISCRIMINATION

Women have been under-estimated in decision making structures and traditional and social barriers limit women's participation and widen power gaps (DWAF 2005b). There is gender discrimination in the labour economy and this, according to the Internal Strategic Perspective on the Olifants/Doorn (DWAF 2005b) limits economic growth, not only in the Koue Bokkeveld region but also in other affected areas in the WMA.

3.2.3 Employment and income

According to DWAF (2005b), about 8% of the total labour force are unemployed (DWAF 2005b) but figures from Census 2001 data are a little higher, at 10%,[7] but it is possible that different definitions of unemployment have been used. The 10% unemployment is calculated using an expanded definition of unemployment that includes those who are unemployed but choose not to work and those who can't find work. Both the DWAF (2005b) and the percentage reflected show a much lower unemployment percentage than the National figures. According to the Census 2001 figures, as many as 68% of people are employed and approximately 2% are seasonal workers. Contrary to the DWAF (2004) statement that unemployment in the WMA is high, it is in fact comparatively low but annual household incomes remain low because of the poor remuneration for work.

Although unemployment in the Olifants/Doring catchment is relatively low, wages are low and the annual household incomes reflect high levels of poverty. In the following descriptions, households are divided into categories of poor and non poor and subcategories are defined within these categories (Table 3.2).

Table 3.2 Definition of income categories used.

Category	Disaggregated Levels of Poverty	Annual Household Income in Rands
Poor	Very Poor	No income - 9600
	Poor	9601 – 38 400
Non-poor	Tolerable	38 401 – 76 800
	Comfortable	76 801 – 153 600
	Wealthy	153 600 and above

3.2.4 Services and Infrastructure

Adequate housing and access to productive land as key development needs amongst the disadvantaged majority in the Olifants-Doorn WMA (DWAF 2005b).

Three indicators were selected to describe levels of services and infrastructure: access to water, sanitation and security of tenure. Within each socio-economic zone as well as within each individual indicator (tenure, sanitation, water) there are considerable fluctuations and these are discussed in the descriptions that follow.

[7] Also confirmed by Cullis (2005).

3.2.5 Education

A skewed age and skills profile exists with decreasing numbers of young educated people remaining in the area as they seek jobs elsewhere. Only 4% of the population are educated beyond Grade 12 (DWAF 2004b) and this is confirmed in the data presented on each socio-economic zone. Very few individuals have attained tertiary education or even have diplomas or certificates. The rural/urban divide is significant and race plays a key role because those with tertiary education are mainly white. However, despite this comparative disadvantage in terms of education levels, there is potential for the transfer of knowledge from the pool of existing well-educated individuals.

3.2.6 Community Cohesion and Organisational Skills

Non Governmental and community based organisations play a key role in the development of holistic and sustainable practices in water resource management (DWAF 2004b). DWAF (2004b) reports that a number of organisations and institutions, including all three government tiers, are currently actively engaged in aspects of water management. The Danida/DWAF project in the WMA was designed to popularise Integrated Water Resource Management (IWRM) and to build capacity among stakeholder forum members and the community at large. Courses that were implemented included planning in Water Resource Management, Water Cycle, Communication, Conflict Resolution, and Leadership. DWAF (2004b) notes that the Danida initiative included micro project funding where small grants (between R3000 and R5000) were made available to applicants so that they could solve water issues or/and raise awareness amongst consumers. Under this drive, newly formed Forum Champions were encouraged to take the lead in water awareness competitions in schools, community river clean ups, bridge building and Water Week and Weed Buster Week Celebrations, all of which have the potential to enhance social cohesion and build capacity whilst also raising awareness about IWRM matters. A Communication Workshop was also held and it was decided that information could be disseminated through Women's Group newsletters, Radio Namakwa, Farmers Association newsletters and so forth. Whether or not this communication plan was implemented has not been verified. In August 2001 a 'Forum Member to Catchment Management Information Stakeholder Meeting/Rollout Workshop' was held to improve communication on Water Resource Management (WRM) because it was noted that in general the topic of water resource management was not well understood. DWAF (2004b) draws attention to the fact that the consequences of raising the Clanwilliam Dam wall or building a new dam above Citrusdal were generally poorly grasped and it is likely that this statement holds true for all the affected areas.

Thus there are positive signs that there is considerable effort being made to build capacity and to enhance networks between different water consumer groups. The National Project Steering Committee, formed to evaluate WMA's noted that the Olifants Doorn was doing well in terms of racial representation in forums but was not yet achieving gender representation. There are now eleven catchment forums in the WMA. To encourage participation and continuity in these forums, members have been asked to contribute to the State of Rivers Report. DWAF has also appointed a dedicated service provider to support the Western Cape Regional Office in Clanwilliam and to assist in IWRM matters. Concerted efforts are being made to boost social capital.

The building of water user associations engages a broad stakeholder group and this process therefore builds organisational capacity in the region. Negotiations between different user groups and government has provided an opportunity for 'ordinary' water users to gain expertise in technical matters and to learn how to negotiate with different government departments, for instance with the Department of Environmental Affairs and Tourism (DEAT) or the Department of Land Affairs. Co-ordinating Committees for Agriculture Water (CCAW), subcommittees have also been formed, based at Elsenberg (provincial Department of Agriculture).

The establishment of water user associations – and forums – provides an ideal opportunity for acquiring a wide range of skills and knowledge and these institutional settings contribute, or have the potential to build 'social capital' and to strengthen organs of civil society. In the long run it is these skills that assist the community in adjusting and adapting to changes and in responding in a coherent manner to opportunities and threats by using the individual and collective skills and knowledge that is available locally.[8]

Certainly, DWAF's water policy has the potential to enhance community cohesion and to build capacity as well as to encourage relationships between commercial and emerging farmer segments. For instance, the access to licences will be far easier for small scale farmers and it is possible that the small scale farmers can then trade water rights for improved living conditions, such as educational support for families, better housing or higher wages. In this way DWAF's policy provides a potential framework for improved living standards.

The frequency of more general community meetings, representativity of members inside these meetings and the ability of community members to assimilate information, as well as the feedback mechanisms of committees, forums and associations to community members, are all critical indicators of the quality of the institutional setup. In the case of Ebenhaesar, this information is available but in other instances gaps in information are obvious and it is difficult to make a reliable judgement with scarce available information on the quality and nature of the institutional settings. Goldin (2004, 2005) goes into considerable detail about this matter, stressing that representation or institutional settings (forums, committees, institutional bodies) do not in themselves reflect high levels of trust or good social capital because the claims of some can be silenced whilst the claims of others can be over emphasised.

[8] See Goldin 2005 for a better understanding of water user associations as platforms for building trust, an important component of social capital. Goldin warns that WUAs can only provide this opportunity if the playing fields are leveled and that if they are not, participation is often merely token

3.3 THE KOUEBOKKEVELD IRRIGATION FARMING AREA

3.3.1 Population

This area lies between the Koue Bokkeveld and Southern Cedarberg mountain range and forms the southern boundary of the WMA. The total population in this socio economic zone is about 9700 people. Only 6% of this population occurs in the built-up areas of Op-die-Berg and in the Hexberg State Forest, thus this zone can be defined as essentially a rural one. The main local authority is Witzenberg LM, while the southern parts of the zone fall under the Breede River LM.

The gender skew is biased in favour of the male population who make up 51%, a reverse of the national skew. Afrikaans is the dominant language and most of the people are Coloured although 21% of the population are Xhosa speaking which is higher than in both the Upper and Lower Olifants Irrigation Zones. Five percent of the population are White, a lower percentage than in the Upper or Lower Olifants Irrigation zones.

The population is dominated by rural people, most of whom are poor (Figure 3.1).

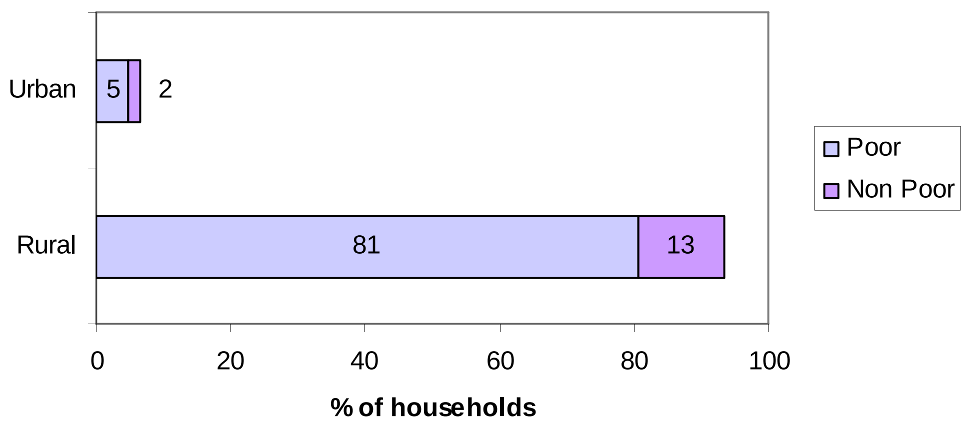

Figure 3.1 Percentage of households in the Koue Bokkeveld falling into four broad categories relating to location and income

3.3.2 Income

Poverty levels are high in this zone and there are only 5% of households who are not poor. This means that the majority of households earn less than R38 400 per annum. Amongst the households who are poor, 24% are extremely poor and earn less than R9600 per annum. Most (61%) of households are poor, in other words they earn between R9601 and R38 400 per annum (Figure 3.2).

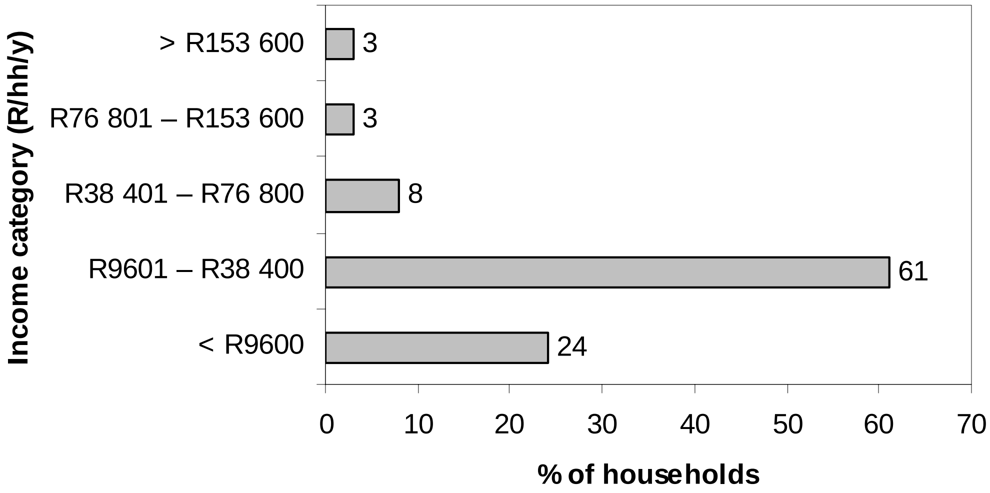

Figure 3.2 Extent of poverty in the Koue Bokkeveld.

Despite the potential for income generation through the value added dried fruit or wine industry or the citrus and rooibos crops, very few people are benefiting economically. By far the largest number of individuals are working in agriculture, fishery or related industries where labourers are often earning an individual monthly income as low as R4 - 800.

3.3.3 Services and Infrastructure

Most households in the Koue Bokkeveld, whether classified as poor or non poor have piped water at the dwelling as well as flush toilets (Figure 3.3). Nonetheless there are 14% of households that fall into the 'bucket/none' category. DWAF (2005) reports that the lack of adequate sanitation for farm workers creates water quality concerns in the Koue Bokkeveld and that this problem is exacerbated by the influx of seasonal workers during harvesting (*ibid*). Piped water is probably supplied by the farmers because there are no towns and thus no municipal supply schemes in this area (DWAF 2005b).

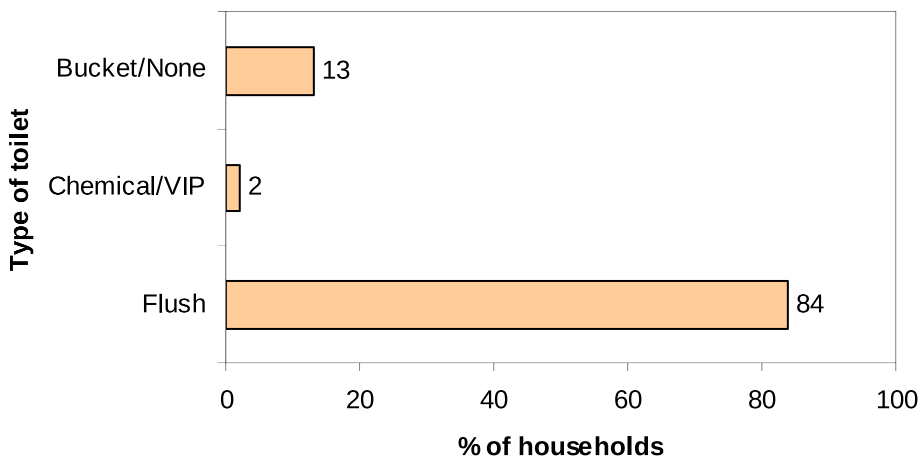

Figure 3.3 Access to sanitation services.

The status of home ownership suggests generally poor security of tenure in this zone. Overall 85% of households live in dwellings that they occupy rent free, while only 7% of all households own and have fully paid off the house that they live in (Figure 3.4). Cullis (2005) notes that intensification of agriculture in the Koue Bokkeveld could have a positive effect on tenure because people would not have to relocated. But, unless the issue of security of farm workers is addressed directly, this will not necessarily result in better security of tenure for farm workers.

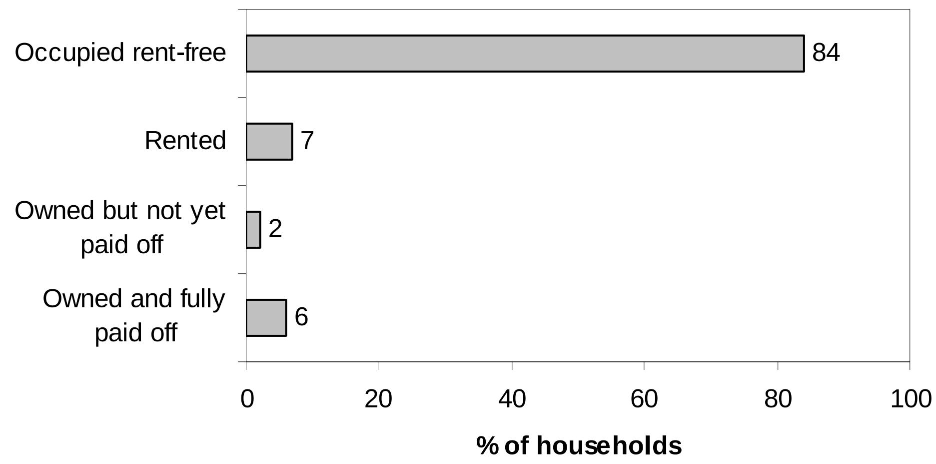

Figure 3.4 Security of tenure for households.

3.3.4 *Education*

For the zone as a whole, under 1% of all individuals have obtained tertiary education levels and 43% have no education at all or only some primary level of education (Figure 3.5). Only 9% of the population have obtained a matric level of education, tertiary education or have a diploma or certificate. Those individuals who are classified as poor have much lower education levels than those who are non- poor.

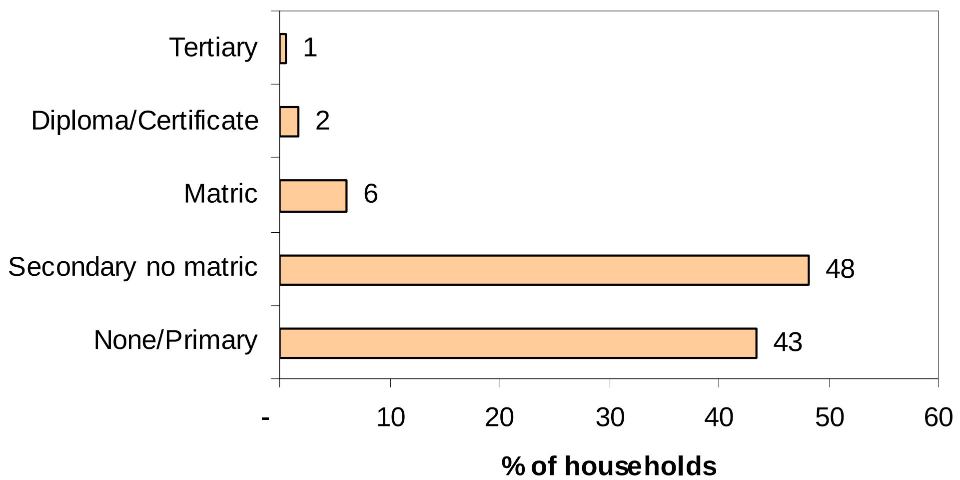

Figure 3.5 Education levels attained

Deprivation in terms of education is determined by residency and income and those living in the rural area that are poor are more deprived in this respect. For instance, amongst the rural poor only 5% have attained matric levels of education. Race is a significant factor, with Whites having achieved the highest levels of education.

3.3.5 Community Cohesion and Organisational Skills

There are, according to the Olifants/Doorn Internal Strategic Perspective (DWAF 2005) a number of privately owned irrigation schemes in the Koue Bokkeveld and in the Witzenberg area. Much of the Koue Bokkeveld (E21A and E21D) is extensively developed for fruit and vegetables and there are many small dams and privately owned irrigation schemes. However, there are also opportunities for co-operation, for instance DWAF (2004b) reflects on an informal private water management committee that is formed at the Houdenbeks River and notes that negotiations were successful between the water users involved in this system and the Koue Bokkeveld Catchment Forum. Cullis (2005) notes that there is expertise in this region and that if agriculture was promoted it could improve living conditions for those who were previously disadvantaged if 'experts' share their knowledge. Four WUAs will be established in the Koue Bokkeveld where each major river will have its own WUA. There are two forums, Koue Bokkeveld and Witzenberg and according to the DWAF (2005) report, the Danida IWRM project played a key role in developing these forums. The Co-ordinating Committee for Agricultural Water (CCAW) is based in Bellville and its sub-committees, that used to be known as Irrigation Action Committees, provide information and support in agricultural related matters.

3.3.6 Relationships with water and aquatic resources

The Swartruggens and Cederberg Conservancies are in this region and there is a proposed Koue Bokkeveld conservancy. Because of intensive agriculture impact on the environment there is a siltation problem in the region. The Koue Bokkeveld has been described as a '*highly utilised, complex system which has a unique natural environment*' (DWAF 2005). This unique pristine environment provides an opportunity for tourism, an already growing industry in the area. Threats to the natural environment in the area are siltation from intensive agriculture and invasive alien vegetation.

The zone contains the Groot, Matjies and Riet rivers, which feed into the Doring River. Irrigation makes the highest demand on water from these rivers. Some 98% of the water is allocated to the irrigation of approximately 8600 ha of deciduous fruit and vegetables, although much of the area is only irrigated when there is sufficient water. According to the Olifants/Doorn ISP (DWAF 2005) there is a demand for development in the region but between 1998 and 2005 an embargo was placed on development in the Koue Bokkeveld to ensure that any development that might take place there would not affect potential larger schemes on the Doring. New allocations are unlikely but DWAF (2005) recommends trading should be encouraged and that compulsory licensing might be considered for this region.

3.4 DORING RANGELANDS

3.4.1 Population

The total population in this socio economic zone is about 11 200, which is fairly evenly distributed between the town of Calvinia and Newtown and the rural areas. As is the case in other socio-economic zones, the vast majority of the population is poor (Figure 3.6). As is the case in other socio-economic zones the vast majority of people are Coloured. The towns and rural areas fall under the Hantam and West Coast District Councils. After Vredendal, Calvinia is the largest town in the Olifants/Doring catchment.

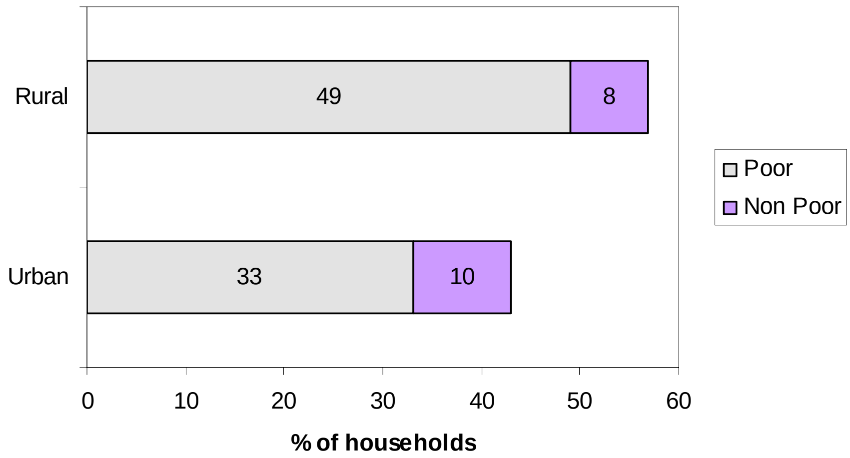

Figure 3.6 Percentage of households falling into four broad categories relating to location and income.

The towns, such as Calvinia and Newtown are dependant on groundwater. Water resources in this zone are stressed

3.4.2 Income

As is the case for most of the catchment, in the Doring Rangelands almost all the households are poor, with 45% categorised as poor and 37% being extremely poor (
Figure 3.7).

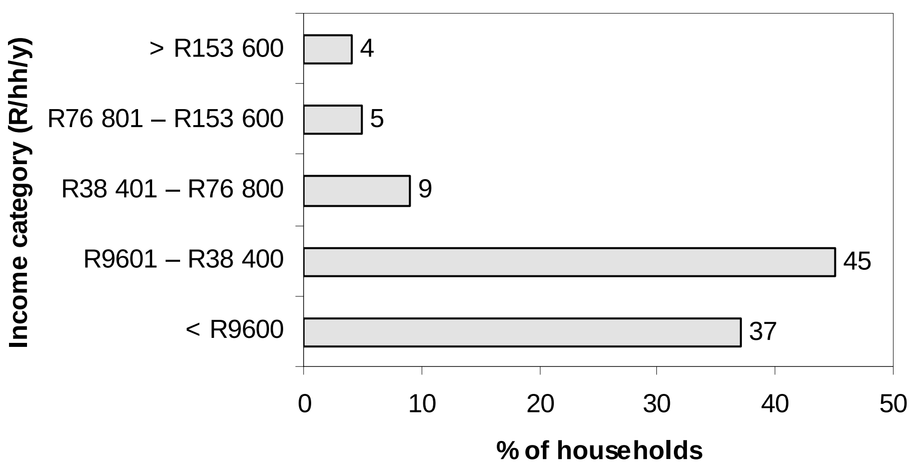

Figure 3.7 Extent of poverty.

3.4.3 Services and Infrastructure

The vast majority of households, whether in the poor or non poor urban or rural categories have piped water at the dwelling but only 67% of households have flush toilets and 20% fall into the bucket/none category (Figure 3.8).

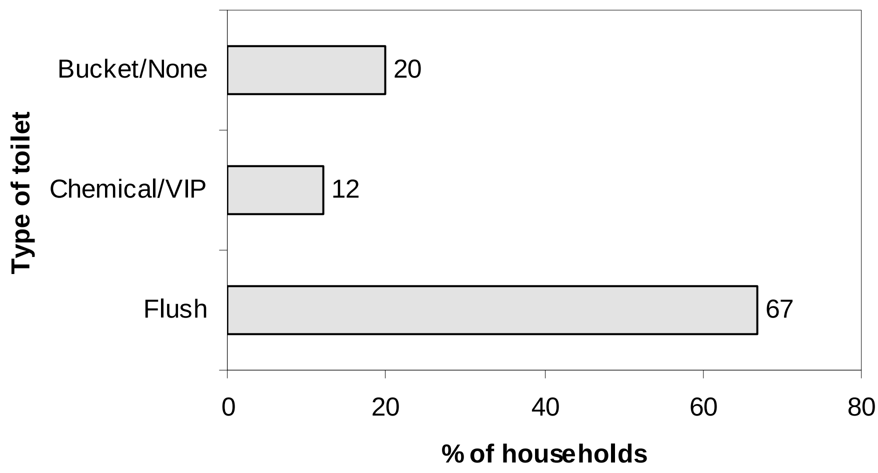

Figure 3.8 Access to sanitation services.

Security of tenure is relatively low in this socio-economic zone because there are only 37% of households that are fully owned and paid off and 40% are living in dwellings rent free (Figure 3.9). This means that many individuals have very little security.

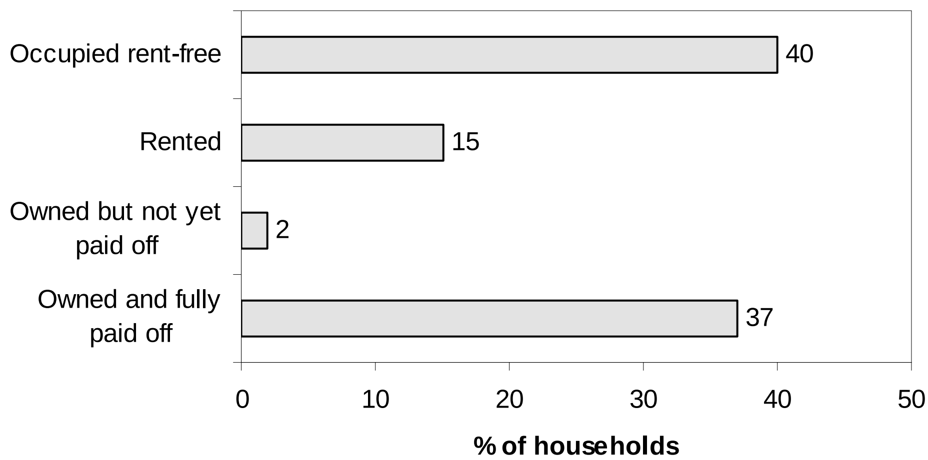

Figure 3.9 Security of tenure for households.

3.4.4 Education

The overall education level in this zone is very low with almost half of the people not having any education at all or only some primary level of education (Figure 3.10). Only 10% of poor people in the towns and 3% of poor rural people have a matric or higher level of education, while amongst the non poor these percentages are much higher at 45% and 49%, respectively. This reflects the relationship between level of education and income.

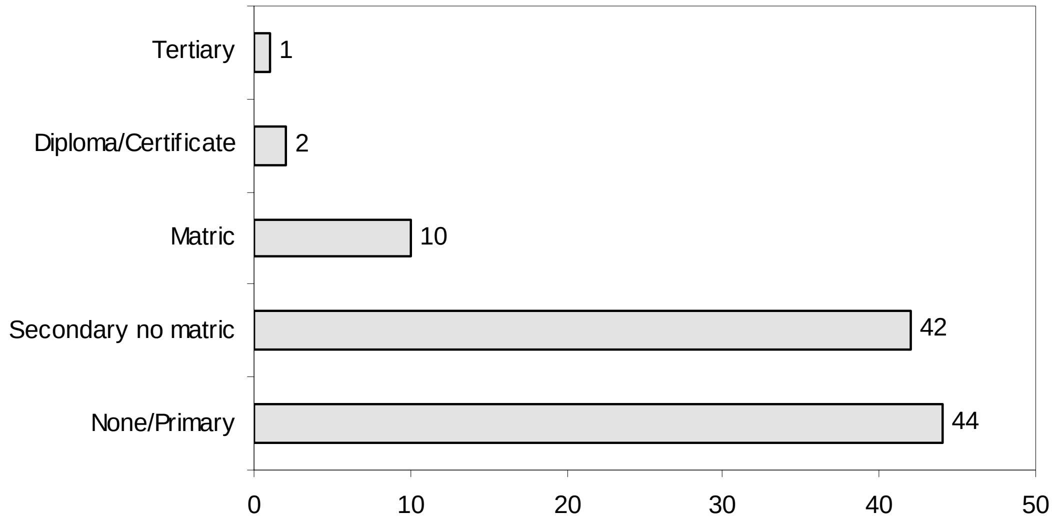

Figure 3.10. Education levels

3.4.5 Community Cohesion and Organisational Skills

The Working for Water has implemented projects in the vicinity of Calvinia. Provincial Department of Agriculture is leading Resource Poor Farmers in the region (DWAF 2005). According to the DANIDA/DWAF report (2004) there have been public meetings around catchment issues in Calvinia and there is a Calvinia's Farmer's Union as well as the Calvinia Karoo Farmers Association and a Calvinia Small Farmers Association. According to the same report a Calvina Business Association has been founded. There is also a Hantam Forum (Cullis 2005)

3.4.6 Relationships with water and aquatic resources

There is no existing information on the relationships between communities in this zone and environmental resources, or aquatic resources in particular. It is assumed to be minimal.

3.5 KNERSVLAKTE

3.5.1 Population

This is a sparsely populated area. The total population in this socio economic zone is small with only about 4900 people, more or less evenly divided between the towns of Kliprand, Nuwerus and Loerisfontein and the rural parts of Knersvlakte, with most households being poor (Figure 3.11). Loeriesfontein is a water stressed urban area and relies on ground water supplies. This area is under the jurisdiction of the Hantam, Matzikama and West Coast Municipalities.

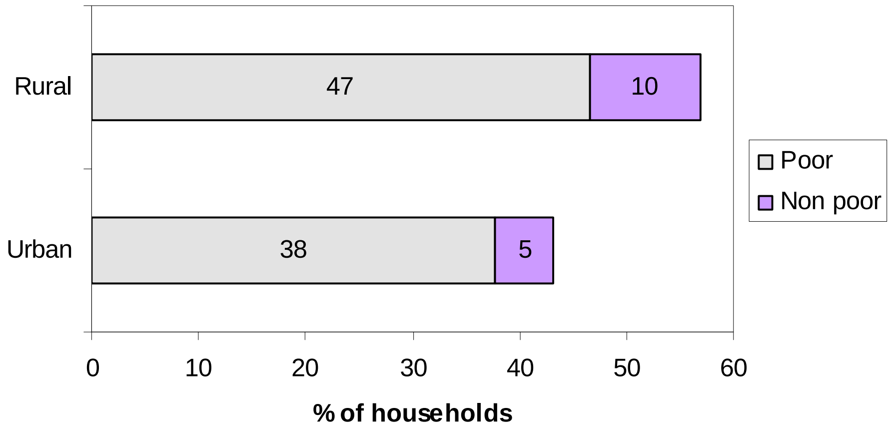

Figure 3.11 Percentage of households falling into four broad categories relating to location and income.

3.5.2 Income

Almost all households are poor, with 82% of rural households and 87% of urban households falling into the poor or very poor categories. Even the proportion of very poor households is very high, with 50% of urban households and 40% of rural households earning less than R9600 per annum (Figure 3.12).

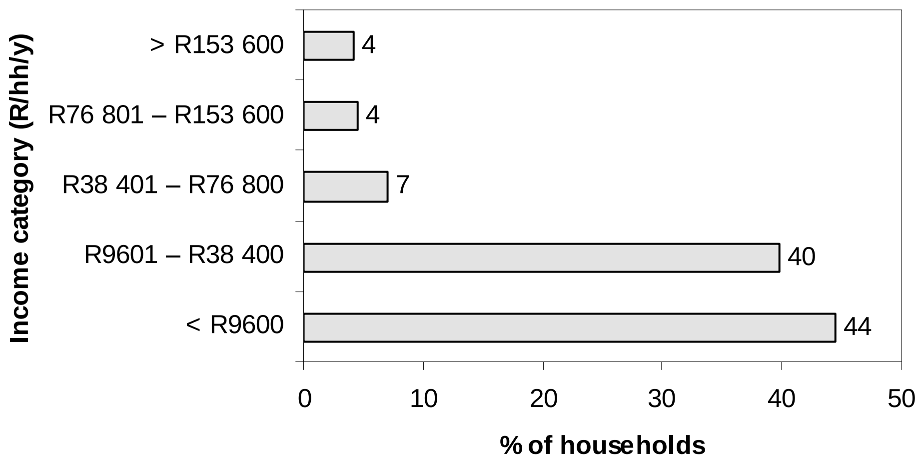

Figure 3.12 Extent of poverty.

3.5.3 *Services and Infrastructure*

The vast majority of households, whether in the poor or non poor urban or rural categories have piped water at the dwelling but only 45% of households have flush toilets and as many as 39% fall into the bucket/none category (Figure 3.13).

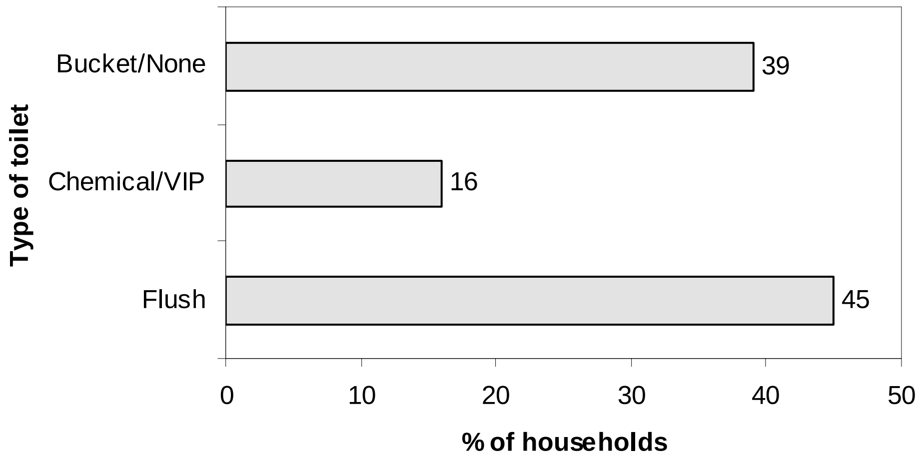

Figure 3.13 Access to sanitation services.

All of those in the category bucket/none are poor both in the town of Loeriesfontein and Nuwerus and in the rural areas.

Security of tenure is relatively high in the towns of Knersvlakte where almost everyone owns their own home and has fully paid for it but in the rural parts there is much less security of tenure. In the zone as a whole there are 50% of homes that are owned and fully paid for and 33% where security of tenure is poor because the dwellings are occupied rent free (Figure 3.14).

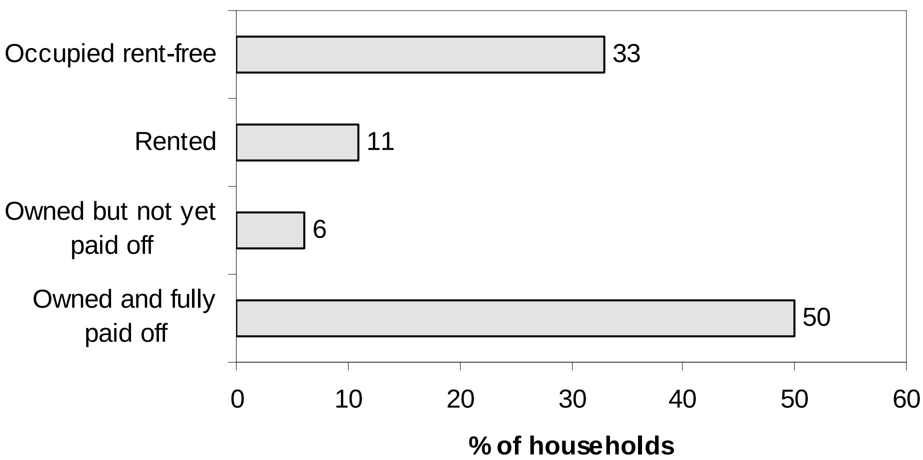

Figure 3.14 Security of tenure for households.

Unsurprisingly, the dwellings that are occupied rent free are occupied by those who are poor and live in the rural parts of the Knersvlakte.

3.5.4 Education

The overall education levels in this zone are very low with almost half the people not having any education at all or only some primary level of education. Only 13% of the population have matric or higher level of education, and no one has a tertiary level of education (Figure 3.15).

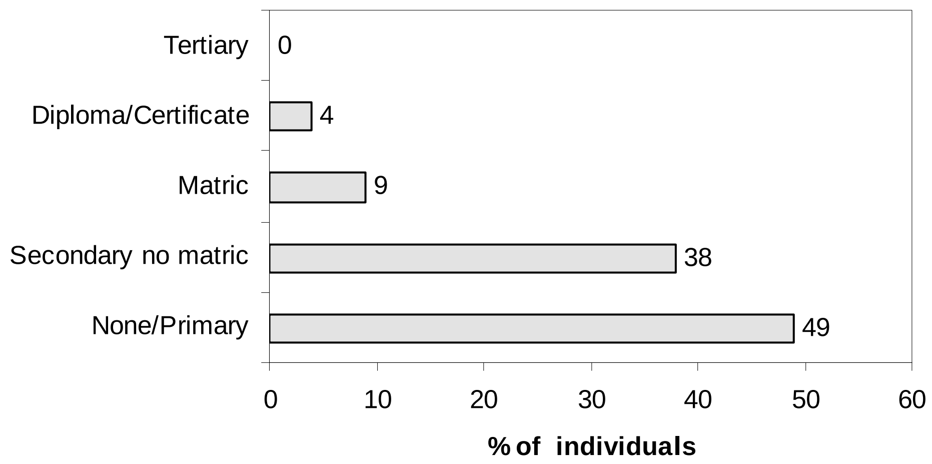

Figure 3.15 Education levels attained by 'poor'

3.5.5 Community Cohesion and Organisational Skills

The WODRIS study (PGWC 2004) identifies 42 small farmers in this dry area. The farms are the Rooiberg, Grasduin and Hol River farms also referred to as the Knersvlakte Farmlands (PGWC 2004). The history of these farmer communities dates back to the Griqua Trek in the early part of the 20^{th} Century. Some members of the Griqua community established themselves in Beeswater and later moved to Rooiberg which is state-owned land. The African Methodist Episcopal Church started with missionary activities and a school in the area and later the South African Defence Force used the land for training and people were removed to surrounding towns. The land is now owned by the state and mining companies. A land restitution claim was lodged in 1998 and according to the community has been accepted but the process of restitution has not yet been concluded (DWAF 2002b) and it is processes such as this that have the potential to build social capital and to encourage co-operation between stakeholders involved in the negotiations.

3.5.6 Relationships with water and aquatic resources

The area is known for its succulent vegetation which is of high conservation priority, but there is no known use of aquatic ecosystems. This zone is water stressed and the towns rely on ground water supplies.

3.6 THE UPPER OLIFANTS IRRIGATION FARMING AREA

3.6.1 Population

The total population in this socio economic zone is about 18 900, with about half of this population living in the small towns of Citrusdal and Clanwilliam and the remaining population in the rural areas. Most households are poor, both in the towns and in the rural areas (Figure 3.16). The Upper Olifants socio-economic zone is under the jurisdiction of Cedarberg Municipality.

In this zone there is the typical gender bias towards males that has been discussed in the introductory section. Afrikaans is the most widely spoken language although 15% are African and speak Xhosa as a first language which is a higher percentage than in the Lower Olifants. The population is mostly Coloured but as many as 27% of individuals are White.

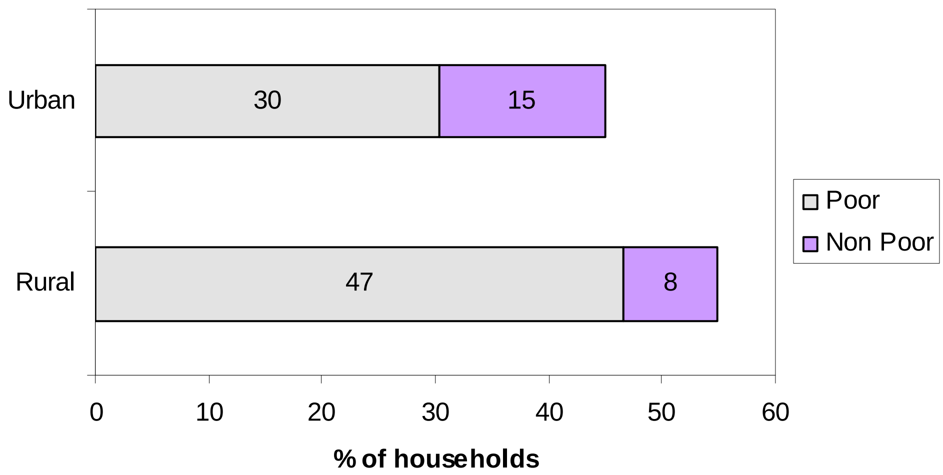

Figure 3.16 Percentage of households falling into four broad categories relating to location and income.

3.6.2 Income

In this part of the catchment, 23% of households have been classified as not being poor, in other words they are earning more than R38 401 per household per annum (Figure 3.17). In the rural parts 85% of the households are poor and earn R38 400 or less per annum. Of these 32% are very poor and earn less than R9600 per annum.

The poverty profile presented here is a typical profile for a region where the majority of workers are involved in income generation that has a high seasonality to it and where farm wages are known to be low. Compared to the Lower Olifants, more households are poor – with population figures very much the same, only slightly lower. In both zones this means that there are a lot of people who are likely to experience low levels of well-being.

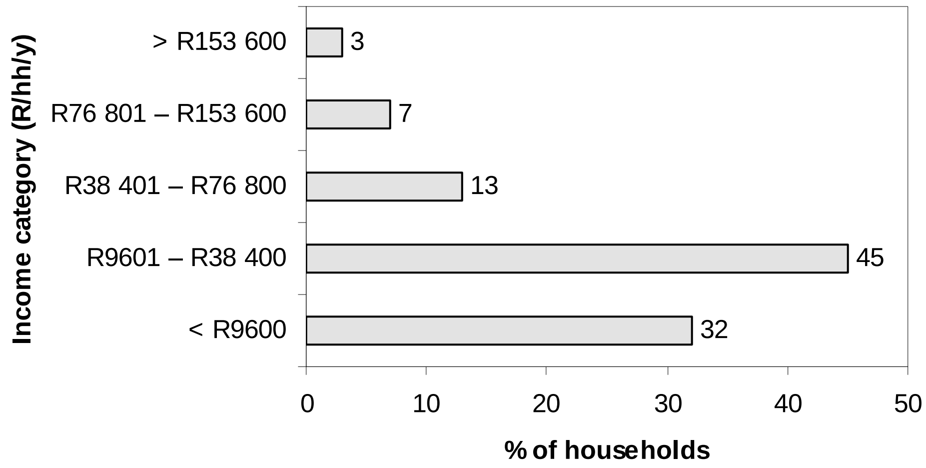

Figure 3.17 Extent of poverty.

Much of the economic activity of the zone is concentrated in the towns of Citrusdal and Clanwilliam. The urban areas have a slightly higher percentage of households that are not poor (14%) than the rural areas. However, the overall living standards in both towns and rural areas are extremely low.

3.6.3 Services and Infrastructure

Within this socio-economic zone as well as within each individual indicator that has been selected for this study (tenure, sanitation, water) there are considerable fluctuations. Although the vast majority of rural households have flush toilets (Figure 3.18), in the rural Clanwilliam or Piketberg there are as many as 14% of households who fall in the substandard category bucket/none. Unsurprisingly in the Upper Olifants, the households, both in the towns and rural parts, who fall into the category bucket/none are poor.

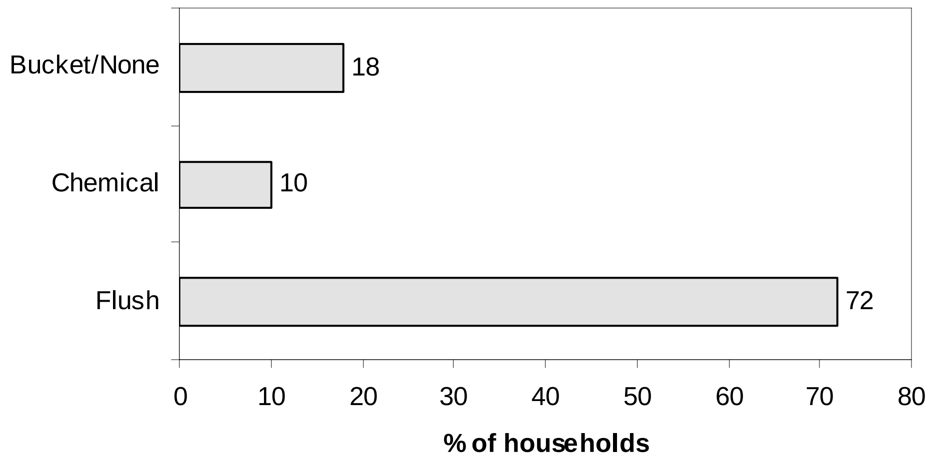

Figure 3.18 Access to sanitation services.

Tenure is another critical determinant of vulnerability. Less than half of houses are owned (Figure 3.19).

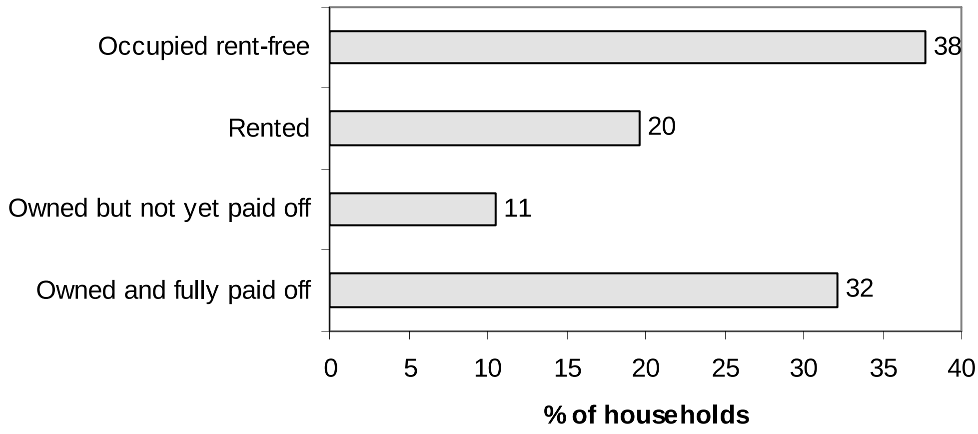

Figure 3.19 Security of tenure.

The rural poor are the most vulnerable in terms of security of tenure because 70% occupy rent-free dwellings and only 14% fully own their homes. Amongst those living in the small towns, security of tenure is better, and about 45% own their homes and have fully paid for them. Those who are better endowed in terms of annual household income and fall into the category non poor, are more likely to own their homes. Thus security of tenure is generally lacking, particularly in the rural area and noticeably, as would be expected, amongst the poor in the rural parts.

3.6.4 Education

Some 36% of individuals have no education at all or only some primary level of education (Figure 3.20).

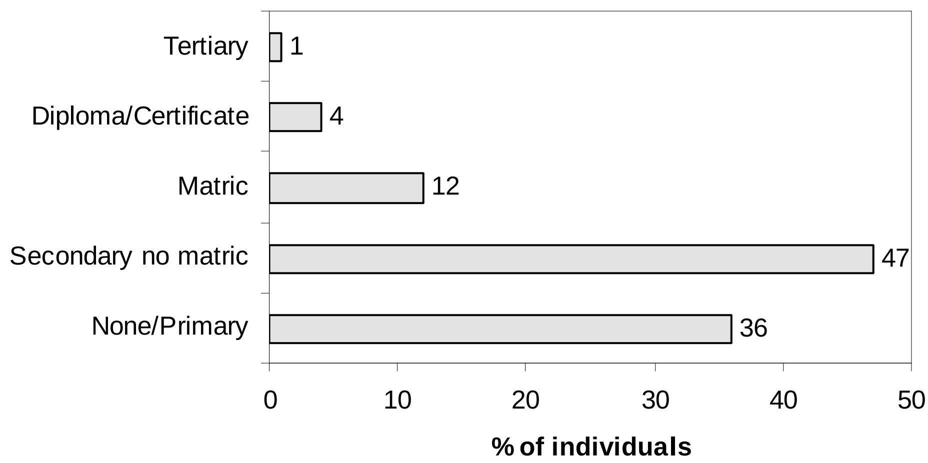

Figure 3.20 Education levels.

Those who are not poor have far higher levels of education, for instance in the rural area there are 12% who have a tertiary education and only 2% have no education or only some primary level of education. This is much the same in the towns although there is a higher percentage of individuals who have tertiary education (16%). The rural poor are the most deprived in terms of education with 43% in this category who have no education at all or only some primary and only 7% have attained a matric level of education (Figure 3.21). In the towns, those who are poor are not much better off in this respect with 32% who have no education at all or only some primary and only 13% have attained matric.

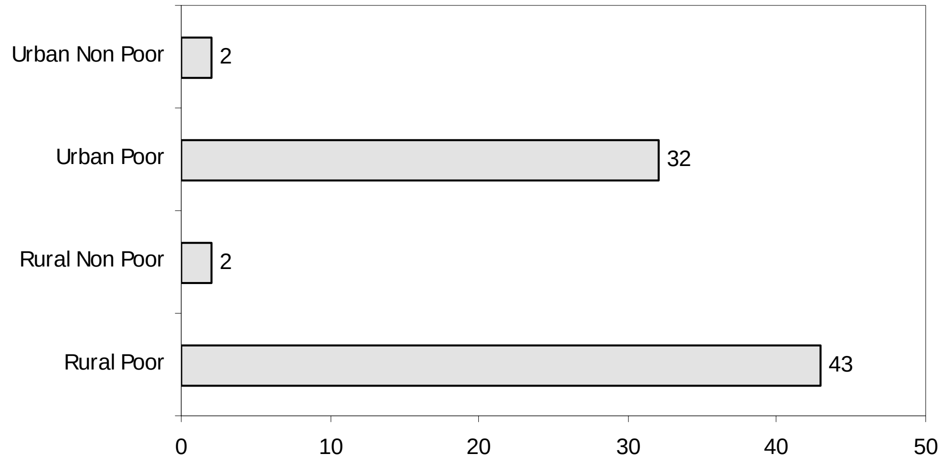

Figure 3.21 Percentage of individuals in different income groups who have no education at all.

The rural/urban divide is significant but race also plays a key role because amongst those who have tertiary education almost all are White.

3.6.5 Community Cohesion and Organisational Skills

Citrusdal and Clanwilliam were one of the three irrigation areas of the Olifants/Doring Catchment in 1995 and in 1995 there was a Citrusdal Irrigation Board and a Clanwilliam Irrigation Board. There are the two water user associations, the Citrusdal WUA and the Clanwilliam WUA. There is also a stakeholder forum called the Upper Olifants. There is an extension office in Clanwilliam for the Department of Agricultures Regional Agricultural Development Centre (RADC) and the objective of this centre is to promote sustainable agricultural systems in order to ensure prosperous communities and rural livelihoods (Cullis 2005). Within the context of the DANIDA/DWAF initiative a capacity building needs analysis workshop was held in Clanwilliam in April 2002 and a two day workshop was also held in Clanwilliam during the same month to provide support for the secretariat within the context of the Catchment Management Process (DWAF 2004b). There is also an agricultural school in Clanwilliam which could help with skills development. The area has a large number of privately owned irrigation schemes in the Witzenberg area and along the Olifants upstream of Clanwilliam Dam. Whether or not these schemes provide an opportunity for co-operation around water matters is not certain.

3.6.6 Relationships with water and aquatic resources

There is a demand for growth in the Upper Olifants from resource poor farmers. Cullis (2005) notes that assurance of supply in Citrusdal is low although the availability of water is high. Land, although available, is not currently being used and there are no small scale farmers practising yet although there is considerable interest expressed in farming. The small scale farmers were dissatisfied that commercial farmers had better access to water and a greater assurance of supply even though they lived much further from the Clanwilliam Dam (Cullis 2005).

3.7 OLIFANTS/DORING DRYLAND FARMING AREA

3.7.1 Population

The total population in this socio-economic zone is about 9 500 people. The population is fairly evenly distributed between the towns (Vanrynsdorp, Nieuwoudtville and Wuppertal) and the rural areas (Figure 3.22). Most of the people are poor. These towns are mainly dependant on ground water supplies.

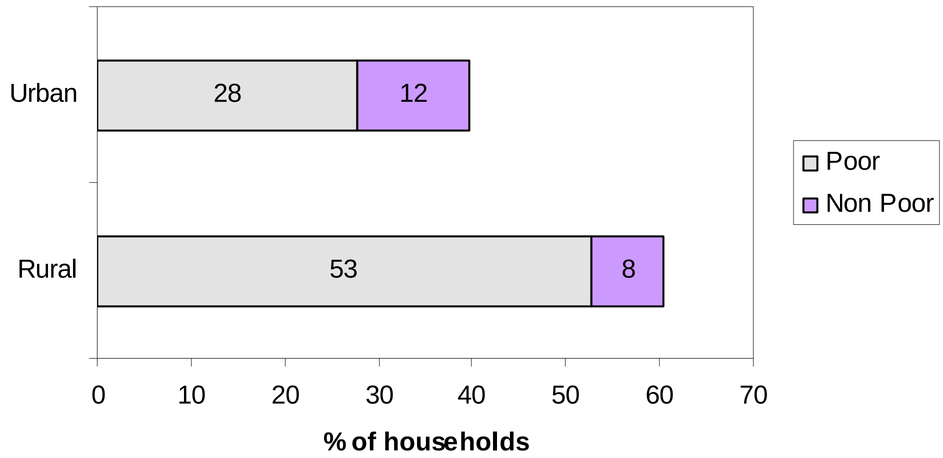

Figure 3.22 Percentage of households falling into four broad categories relating to location and income.

3.7.2 Income

Some 35% of households earn less than R9600 rand and 49% earn between R9801 and R38 400 per annum (Figure 3.23). Only 16% of the population of the zone earn more than this.

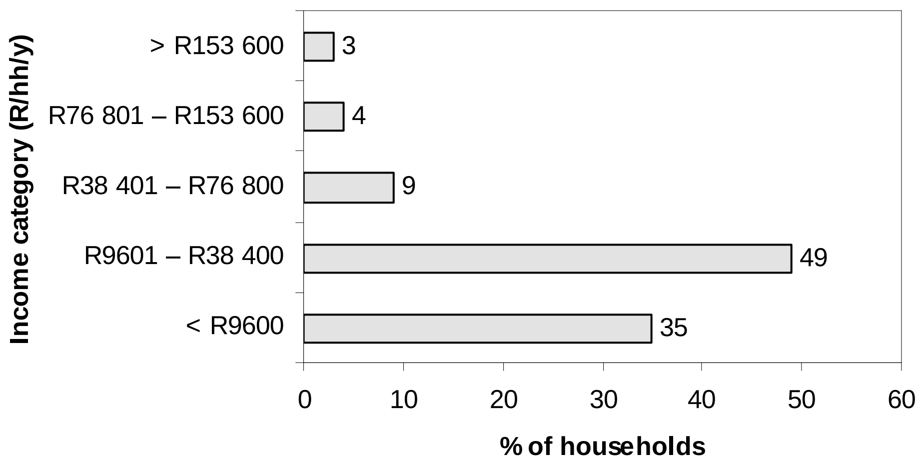

Figure 3.23 Extent of poverty.

3.7.3 *Services and Infrastructure*

Almost all the dwellings have piped water and 70% of the dwellings have flush toilets. Nonetheless there are 22% without these facilities and these are houses that fall into the category bucket/none (Figure 3.24).

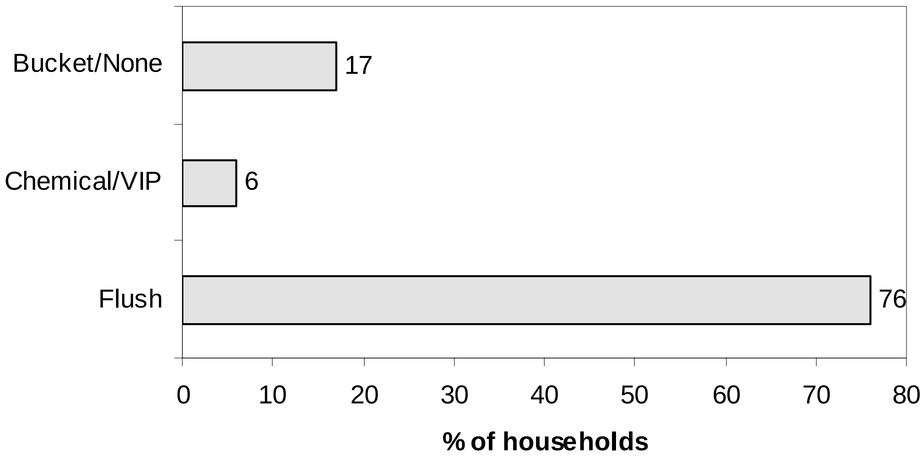

Figure 3.24 Access to sanitation services.

Tenure is another critical determinant of vulnerability. A high percentage (67%) of households are occupied rent free (Figure 3.25) and this means that 67% of households in the zone are vulnerable because they lack security of tenure.

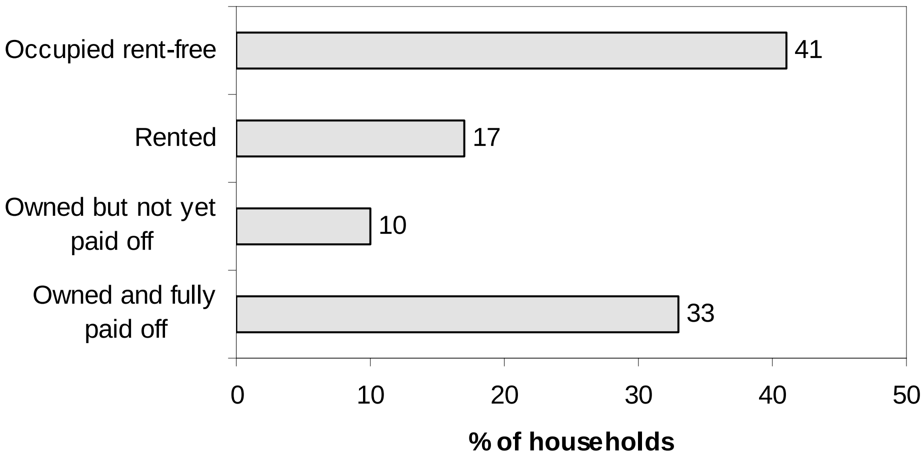

Figure 3.25. Security of tenure for households.

3.7.4 *Education*

Fifteen percent of the population has obtained higher levels of education than the secondary level (Figure 3.26).

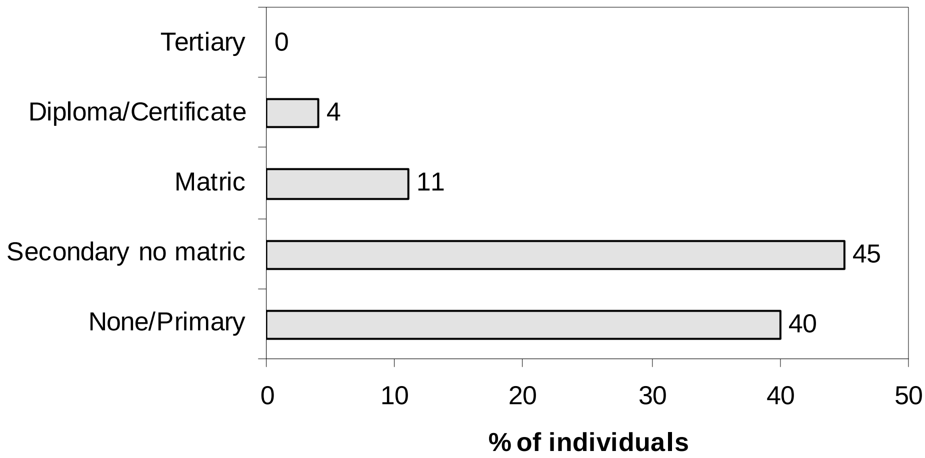

Figure 3.26 Education levels.

Amongst the rural poor, the percentage is higher and 50% of individuals who fall into this category have no education or only some primary level of education and under 6% have matric.

3.7.5 Community Cohesion and Organisational Skills

Little information is available for this socio-economic zone. There is a Vanrhynsdorp Farmers Association and the Vanrhynsdorp Water User Association has been established.

3.7.6 Relationships with water and aquatic resources

Dryland crops are grown in this area in conjunction with livestock farming. Many farmers are involved in ecotourism, and the area includes a waterfall attraction near Niewoudtville, but specific relationships with aquatic ecosystems environment have not been documented and are probably minor.

3.8 LOWER OLIFANTS RIVER IRRIGATION AREA

3.8.1 Population

The total population in this socio economic zone is about 29 000 people. Two thirds of the population in this zone are urban (Figure 3.27). The urban population is mainly in Vredendal, which is the largest town in the catchment (DWAF 2004b). Between 1980 and 1990 Vredendal grew faster than any other town in the Olifants Doring WMA with a reported 7% growth during that decade (DWAF 2005). The majority of the population in all the towns in this part of the catchment are Coloured and speak Afrikaans although 19% of people are classified White[9] and 6% are Black (Xhosa speaking).

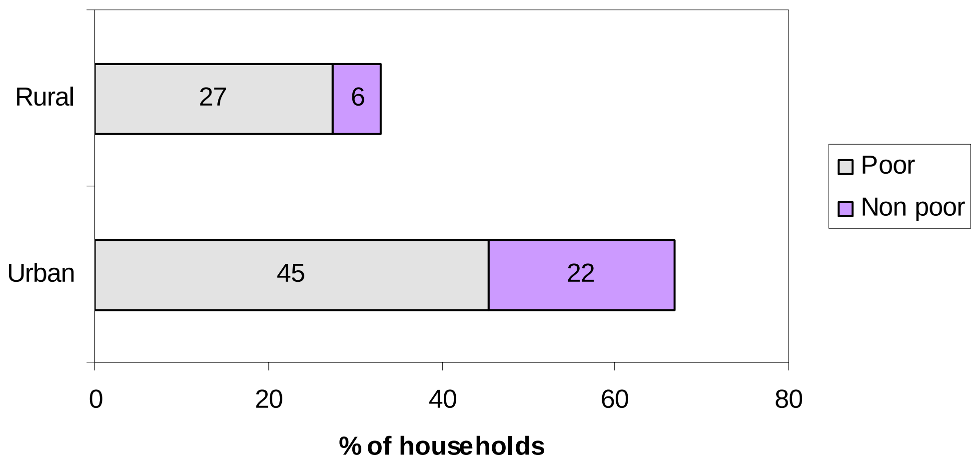

Figure 3.27 Percentage of households falling into four broad categories relating to location and income.

3.8.2 Income

Some 73% of households are poor, earning less than R38 401 per annum, and about 27% are very poor, earning less than R9601 (Figure 3.28). This zone has a high proportion of very poor people compared with other zones. .

[9] In Lutzville West and parts of Klawer this is reversed with most of the population in these towns classified as White.

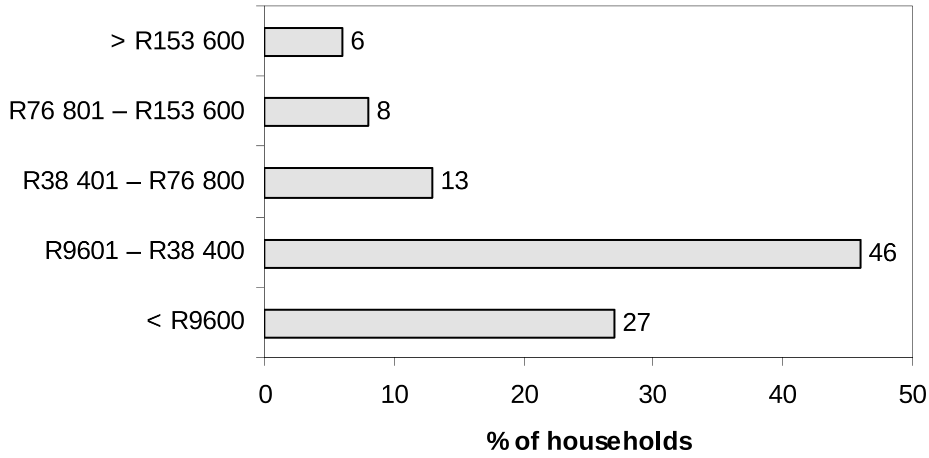

Figure 3.28 Extent of poverty.

About 56% of the population between the ages of 15 and 65 are employed and 16% are unemployed.[10] Even though unemployment rates are better than the national average, employment status can be misleading, in that in many cases the incomes of the employed are very low. Eleven percent earn less than R401 as their monthly income and 39% earn R401 to R800 a month, with 22% of these groups working as labourers in fishery or agricultural related activities.

Despite this picture of poverty, there is considerable economic activity concentrated in this zone with Vredendal reportedly contributing 33.2% of the GGP of the total WMA in 1997 (DWAF 2005). The focus in Vredendal is on manufacturing and these activities are linked to the region's agricultural activities with a large percentage of activity in the food and beverage subsections (DWAF 2002). There are also several quarrying operations in the vicinity of Vredendal and VanRhynsdorp, for instance the Namakwa Sands mining operation is near Vredendal where titanium slag and other minerals are mined (*ibid*). These mining activities use relatively small volumes of water.

3.8.3 Services and Infrastructure

The vast majority of households, whether in the poor or non poor urban or rural categories have piped water at the dwelling and decent sanitation as well as relatively secure tenure.

Most households have flush toilets but 12% fall into the category bucket/none (Figure 3.29). Amongst the rural poor, 36% fall into the latter category.

[10] Using the expanded definition of unemployment that includes those who are disillusioned and are not looking for work and those who are looking but could not find work

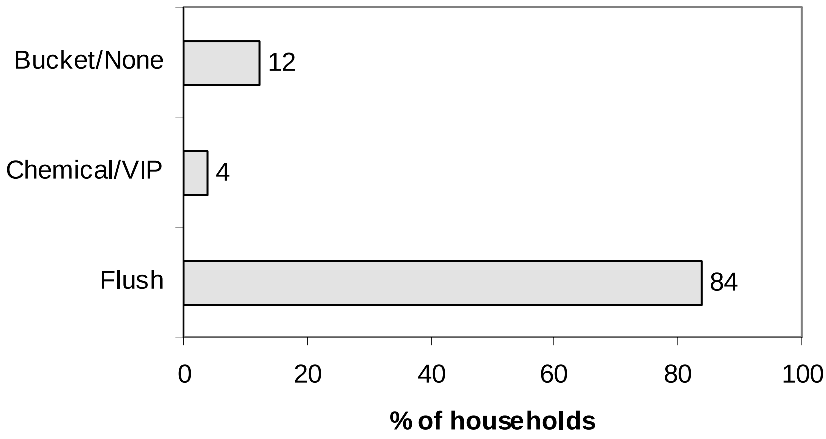

Figure 3.29 Access to sanitation.

Security of tenure is not good but 35% of households are owned and fully paid off but there are 33% of households occupied rent free, mainly in the rural part of the region (Figure 3.30).

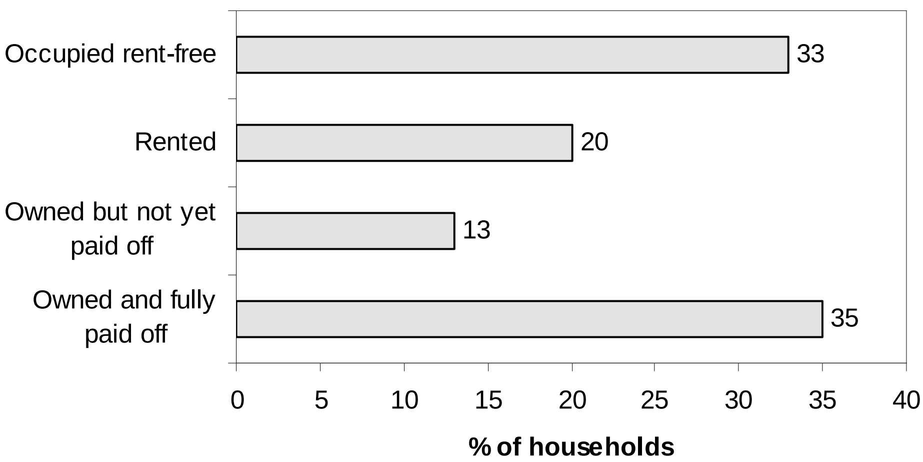

Figure 3.30 Security of tenure for households in the Lower Olifants Irrigation zone.

3.8.4 Education

As many as 12 462 people, or 35% of the individuals, have no education or only some primary More people have attained a secondary education level, 47%, but very few, only 13%, have obtained matric. As is to be expected, the poor are the most deprived of education and amongst this category less than 1% has a tertiary education and only, 12% have matric. Low education levels make it difficult to build and manage institutions and to cope with external stressors such as water scarcity, job loss, disease and so forth.

As many as 12 462 people or 35% of the individuals have no education or only some primary level of education (Figure 3.31). Most people have attained a secondary education level but very few have obtained a matric of higher level of education. As is to be expected, the poor are the most deprived of education and amongst this category less than 1% have a tertiary-level education and only 12% of the urban poor and 6% of the rural poor have attained a matric level of education. Amongst the smaller group who fall into the non poor category there is a bigger percentage, 48%, who have matric. In this category of individuals who are better off economically, 22% have a diploma or certificate and 7% have achieved tertiary education. Low education levels make it difficult to build and manage institutions and to cope with external stressors such as water scarcity, job loss, disease and so forth.

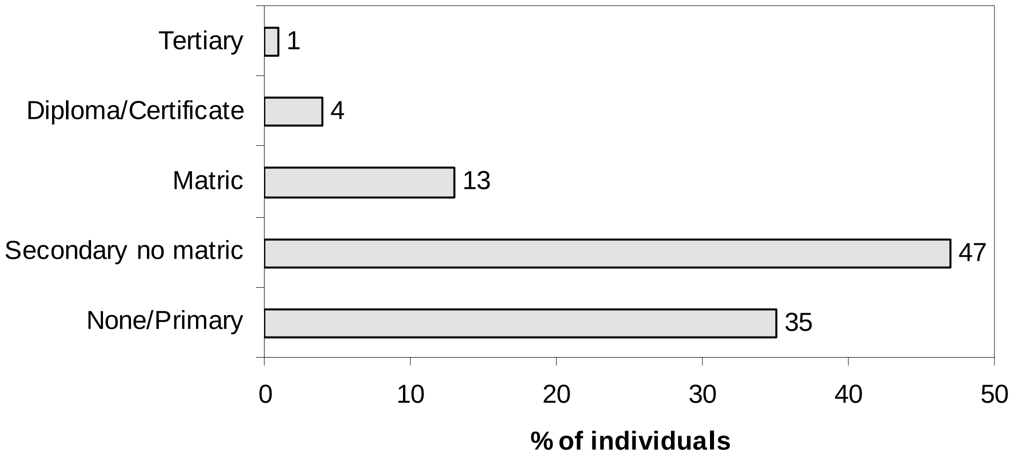

Figure 3.31 Education levels attained by 'poor' (% households).

3.8.5 *Community Cohesion and Organisational Skills*

The Vredendal Irrigation Board was one of the Irrigation Boards serving the three irrigation districts in 1995.[11] The Lower Olifants River Water Users Association (WUA) has been established in the area and the VanRhynsdorp WUA is in the process of being established. The proposal for this latter WUA was submitted in April 2001 but returned for revision. The Lower Olifants and Middle Olifants stakeholder forums represent this area.

The Bulshoek Weir and a canal system have been used to irrigate land along the Olifants River for as far back as 1923 and the Clanwilliam Dam was built in 1935. The Lower Olifants River Water User Association (LORWUA), established in January 2000 (and originally known as the Vredendal Irrigation Board), operates the Bulshoek Weir and this responsibility has demanded skills and knowledge that also builds up capacity and organisational skills for this region (DWAF 2005). Sixteen people have been elected to the Steering Committee of the WUA (DWAF 2004b). Other institutional settings are: Vredendal Farmers Association, Klawer Small Farmers Association, Lutzville Farmers Association and a Small Farmers Association. There is also the development initiative, called the Vredendal Saamwerk Boerdery which is an emerging farmer programme that has been transferred to the beneficiaries (Cullis 2005). However, there are no monitoring and check operations to assess whether or not there has been any meaningful benefit to the previously disadvantaged. All towns do not have the same levels of organisation, for instance, in Lutzville the small farmers are disorganised, thus, although the concern of these farmers is

[11] The other two were Citrusdal and Clanwilliam

that land costs are too high and inhibit their further development, they do not yet have an adequate forum or 'voice' for expressing their concerns Cullis (2005).

The Vredendal Farmers Union is a local farmer's union that has expressed willingness to help with the establishment of activities for poor farmers (Cullis 2005). In the town of Klawer, there is the same good faith and willingness to co-operate that exists between small and commercial farmers (*ibid*). There is also land available around Klawer for development as well as a good market for fruit and vegetables. The 'emerging' farmers in this area are not only interested but also knowledgeable about farming matters. Water is being transferred to Namakwa-Sands and to the Sandveld sub-areas but it is not certain whether or not these transfers result in discussions that strengthen community social cohesion because there is no information on the nature or quality of 'voice' in these institutional settings.[12]

3.8.6 Relationships with water and aquatic resources

This socio economic zone has major conservation areas such as the Moedverloren Nature Reserve and the Lutzville Conservation Area (DWAF 2005) and also the Op-die-Berg Private Nature Reserve. This 'natural capital' does not necessarily benefit local residents and could have a negative effect on them if they are not allowed to harvest seeds, plants and so forth in these areas. Another natural asset is the availability of water – and reportedly in 1995, in Vredendal and VanRhynsdorp, water availability exceeded the minimum standard set by the Reconstruction and Development Programme. The Hol River flows into the Olifants between Vredendal and Lutzville (E33E) with its main tributaries the Kromme, the Hantams, the Sout and the Vars rivers. The Olifants River flows downstream from Clanwilliam through to the wide floodplain downstream of Klawer. Lucerne is grown by the 'saaidam' method when there are strong flows in the rivers. The commonage is not being utilised for small scale farmers, but, according to the report by Cullis (2005) this is potentially exploitable for farming purposes.

The development of suitable soils in Vredendal would be dependant on raising the Clanwilliam Dam Wall and extending existing canal systems (Cullis 2005). There is possible expansion of existing wine grape farms on the farms around Klawer/Vredendal region and this expansion has been identified as a viable development option. The most viable development scenario for emerging farmers would be, according to Cullis (2005) a joint venture with existing farmers in Melkboom or Klawer. Access to land has been noted as a problem for small-scale farmers in Vredendal where existing commercial farmers are the '*exclusive owners of both water and land rights'* (Cullis 2005: 11). According to this same author and already noted above, there is a high level of interest in farming in the region and there are dams and functioning canal systems.

3.9 THE ESTUARY ZONE

The Estuary zone contains the Ebenhaesar community, which stretches along the estuary and includes the main settlement about half way along the estuary and the much smaller settlements of Papendorp and Viswater at the mouth.

The Ebenhaesar community is one that has attracted a lot of attention in the study area. This is a largely poor coloured community, that has a long and interesting history in the area, and which is particularly important in this study because of its relationships to land, water and the estuarine fish resources.

[12] Also see comments on the topic of 'social capital' that has been expanded in the introduction to this section

During the mid 18th Century, Ebenhaesar was a thriving mission settlement and typical of mission stations throughout South Africa, it fostered positive cultural, economic and human attributes (Goldin 1998). After 1948 the mission stations stagnated and today people living in the place reflect little of the achievements in human and financial gain, though not all mission stations have stagnated economically to the same extent.[13]

Until the early 1900's Ebenhaesar was located on fertile land near present day Lutzville with access to fresh water from the Olifants River and the people were farmers (January 2004). Indeed, the Ebenhaesar community owned much of the arable land in the district. In terms of an agreement with the Dutch Reformed Church (the trustees of the land), they were removed to a site further down the river in 1925, under the Ebenhaesar Exchange of Land Act No 14 and occupied the land about halfway down the estuary where they live currently. The seized land was extremely valuable alluvial soils of the Lower Olifants River Valley, whereas the land they received in return was of much lower potential. The 300 morgen (260 ha) of irrigation land secured in terms of the agreement was divided among 150 residents. Over time, these sites became badly salinized and farming activities ceased (Goldin 1998, January 2004). No outsiders came to settle in Ebenhaesar (Goldin 1998).

The forced removal was designed as part of the government policy to uplift Afrikaner communities (Goldin 1998), and was justified at the time on the basis that the land was needed for an irrigation scheme in which the costs of water would be beyond the means of the Ebenhaesar community. The requirement for irrigation farmers to pay for water was later removed.

Today the Ebenhaesar community is involved in a land claim, in terms of the Land Restitution Act of 1994, seeking compensation for removal from their land in 1925. The small plots that were divided for production are inadequate for agriculture because the plots were not large enough to be economically viable (De Klerk 1996 cited in Goldin 1998 postulated four ha as a feasible size for small scale fruit farming).

The Ebenhaesar community is also well known for its small scale fishery on the Olifants estuary. The fishing community is largely associated with the people of a sub-economic part of the Ebenhaesar settlement called Olifantsdrift, as well as the people of the very small communities of Papendorp and Viswater located at the mouth of the estuary.

Isolating the Ebenhaeser - Papendorp - Viswater community, or even just the Ebenhaesar community, from Census data is virtually impossible. The information below is based on analysis of the population from the Ebenhaeser Sub-place census area. However, the total population of this Sub-place is much smaller than the population of the Ebenhaeser community.

3.9.1 Population[14]

The total population of the Ebenhaesar community is about 3 500 people. The people of this community are relatively homogenous in that they are all Afrikaans, Christian and Coloured (January 2004).

[13] The mission station of Wupperthal has much the same history but no data is available from Census 2001 on this town. Although it lies closer to Ceres in the south eastern part of the WMA it falls into the same socio-economic zone because it is a town whose land tenure patterns are similar to Ebenhaesar, namely that of a communal land tenure system.

[14] There are many different spellings for Ebenhaesar. This report adopts the StatsSA spelling

3.9.2 Income

Based on analysis of the Ebenhaeser Sub-place (which only appears to contain a subset of the community), some 71% of the households are poor, earning less than R38 400 per annum, and 32% are very poor with incomes of under R9601 (Figure 3.32).

The full-time employment figures are provided by StatsSA Census 2001 indicate that only 29% of the economically active population is employed. Fishing and subsistence farming are the main economic activities in the community. Income tends to be quite erratic, with many households relying on seasonal work as farm labourers. Income from fishing is also seasonal, mainly in summer, and harvest-time work is taken in preference to going fishing. Fishing activities are described in more detail below. Households rely heavily on government grants, such as the old age pension and child grant. There are community projects, such as the 'Dam stabilizing project' and the 'Coast Care project' or the 'Road maintenance project' and the 'Canal Upgrading project' (DWAF 2004b: 38) as well as other equity initiatives that bring in additional income flows.

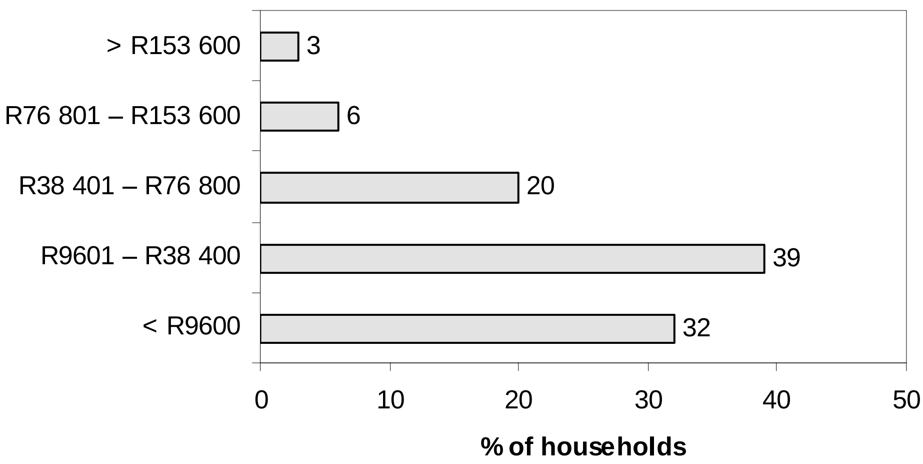

Figure 3.32 Extent of poverty.

3.9.3 Education

Most individuals have only secondary and no matric and only 9% of the population have attained matric and 14% have a diploma or certificate of some kind (Figure 3.33). No one in the Ebenhaesar Sub-place was recorded as having a university education, though it is known that there are members of this community that do.

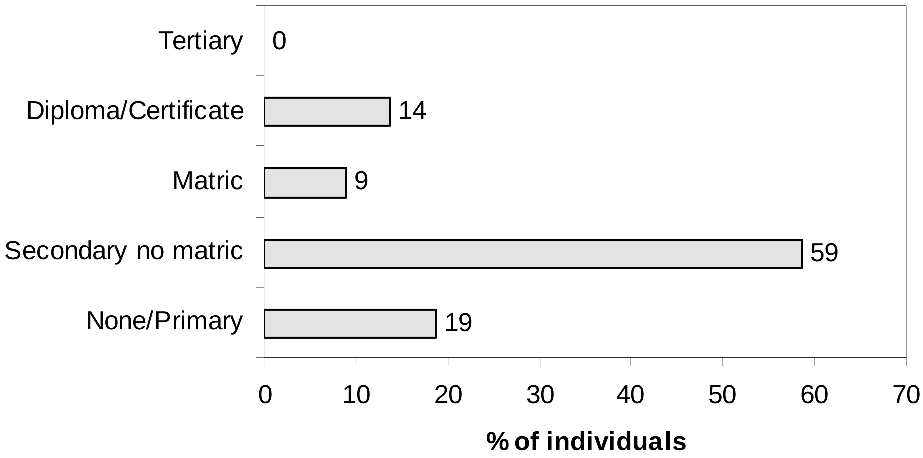

Figure 3.33 Education levels attained.

3.9.4 Services and Infrastructure

Almost all households have piped water and sanitation at the home. However, 12% of households use ventilated pit latrines and 3% fall into the bucket/none category (Figure 3.34).

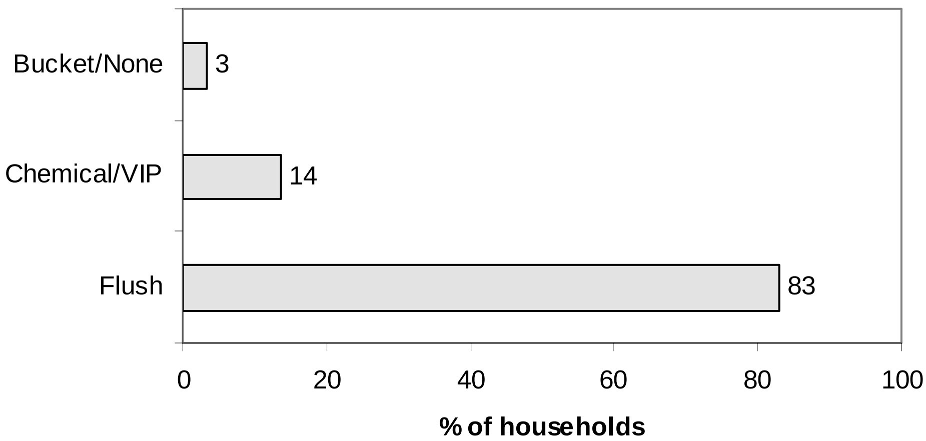

Figure 3.34 Access to sanitation services.

In 1999 almost every household relied on communal taps with an average of one tap for every five houses but all houses (except 11) now appear to have clean running water (January 2004). On the whole residents say that the quality of services is 'fair' to 'good' (*ibid*) although there are complaints about the price of water. Piped water is provided through the Olifants River Government Water Scheme and the scheme for this part of the catchment is operated by the West Coast District Municipality.

Individuals seem to be secure in terms of tenure because no one occupies a dwelling rent free and most of the households are owned and fully paid off.

3.9.5 Relationships with water and aquatic resources

Since each permit holder has an assistant, there are some 90 people legally involved in the fishery, but many more fish illegally. It is estimated that there are as many as 200 fishing households in the Ebenhaesar community.

Two thirds of the fishing community do not use the land (January 2004). This is because either these households do not have access to land or they do not have the necessary implements to work the land (*ibid*). The same source notes that the members of the community that do utilize the land either use it for livestock or crop farming but only 18% of fishers grow crops such as lucerne that is used in fodder (cash crop) or potatoes, sweet potatoes, beans, pumpkin onions and other garden vegetables that are used for household consumption. Another 18% of fishers are involved with livestock farming (January 2004).

Fish catches are sold within the local community and in the nearby towns. The latter activity is hindered by the difficulty in getting fish to these markets because of a lack of transport.

Most (85%) fishing households earn less than R500 per month from fishing. The expenditure on fishing equipment (anchors, buckets, oars, nets, ropes, boats) means that the net income generated by the fishery is extremely low (January 2004). Fishing contributes less than half of monthly income for most households (76%), but there are some fishers that have no other alternative source of income. In addition, income from fishing is erratic and mainly during summer months.

Furthermore, income from the fishery may be declining, as fishers report declining catches. The decline is mainly perceived to be due to upstream water abstraction and constriction of the mouth, as well as water quality (January 2004). While there are numerous perceptions as to the reasons for declines in harder catches in the estuary, most of these have been tested, and the evidence is overwhelmingly in favour of overexploitation being the main reason.

Of particular relevance to this study is that MCM has the intention to phase out the fishery on the Olifants estuary over the next decade, using an alternative livelihoods approach.

3.9.6 Community Cohesion and Organisational Skills

The resettlement of the Ebenhaesar community remains embedded in the historical memory of the community. Other issues of social mobilisation have also pivoted around issues to do with natural resources. After complaints of depletion of fishing stock in 1993, the authority for conservation at the time, Cape Nature Conservation (CNC) set objectives to address the situation that included amongst other objectives 1) building capacity of the local fishers organisation and 2) development of a monitoring and evaluation system that would enable the community to participate in the management of the harder fishing resource. The creation of Marine and Coastal Management (MCM) which took over the responsibility for the estuary from CNC under the Marine Living Resources Act (No 18 of 1998) resulted in confusion around authority and management issues and led to the ‘demise of the partnership agreement between CNC and the Olifants River Fisher Association although the CNC continued as *de facto* managers of the estuary until the end of 1999’ (January 2004).

The current situation is that fishers have interaction around fishing matters with the local compliance officer but very little interaction with the community is taking place. At the time of January’s study, there had been only one reported meeting with the community between the

Olifants River Fisher Association and the (then) CNC and a few more informal discussions between community members about the harder fishing resource. There have been at least annual meetings with MCM since 2000 to discuss fishing rights allocation issues. The community sees the value of co-operation with MCM, and this willingness to co-operate indicates high enough levels of trust between the community and an authority body, in this case MCM.

The fishing community is represented by the Olifants Fishing Association and feedback between this committee and the community is reportedly 'good' although there are also a fair number of the community who perceive reporting mechanisms as 'bad' (EEU 2004: 29). January (EEU 2004) notes that there is a '*need for a stronger committee'* (2004: 31). This report shows how important it is to evaluate the quality of representation and not to assume issues of community cohesion merely because institutional arrangements have been established, in this case that between the Olifants River Fisher Association and MCM. Despite cautionary notes on participation and issues of social cohesion that have been described in the introductory part of this section, the fact that there has been ongoing negotiation and that there are institutions that represent the community, puts Ebenhaesar in a good light as far as community cohesion and organisational capacity goes.

There are also equity initiatives that have been tabled in DWAF's ISP (2005) that are worth noting:

- Urban WC Awareness
- Irrigation Water Use Plan
- Water-Wise Community Organic Food Garden
- Testing of Micro-Flood Irrigation Methods for Water Efficiency and Effectivity
- Water Conservation Awareness – Alien Invasive Vegetation Removal
- Water Awareness Ebenhaesar Wetlands Project
- Water Awareness – Assessing Water Quality at the Olifants River Mouth

All of the above have the potential to enhance organisational skills and social cohesion.

4 DESCRIPTION OF SCENARIOS

4.1 INTRODUCTION

As part of the Olifants/Doring Catchment Ecological Water Requirements (EWR) Study, a number of scenarios were developed in order to evaluate the ecological implications for each resource unit. The scenarios were based on a combination of water resource development options and targets for meeting the recommended ecological category at different points in the river system. Thus each scenario has different implications for (a) the water yield of the system and (b) the health of the aquatic ecosystems. The following is a brief description of the scenarios and how they affect these two parameters.

4.2 SCENARIOS

The Olifants/Doring Catchment EWR Study evaluated a total of 16 scenarios (in addition to the natural conditions and present day scenario). These included a range of water resource development options, including raising the wall of the Clanwilliam Dam by 10 m (additional 143 Mm^3) or 15 m (additional 240 Mm^3), a dam on the Olifants at Keerom (153 Mm^3), additional farm dams in the Koue Bokkeveld (50 Mm^3), Melkboom or Melkbosrug dam (470 Mm^3), a dam at Aspoort on the Doring or at De Mond on the Groot (159 Mm^3), and a weir near Melkbosrug (5 Mm^3). They also included various options for the Reserve.

After due consideration, five of the scenarios were selected for analysis in the estuary RDM study and in this study (Table 4.1). The EWR sites mentioned in the scenarios are shown in Figure 4.1 and described in Table 4.2.

Table 4.1 Scenarios considered in the socio-economic study, and the mean annual runoff (MAR in Mm^3/y) at the estuary associated with each scenario.

Scenario	Description	MAR
0	Naturalised conditions. Representative of flows before agricultural developments and impoundments in the catchment	1070.1
1	Present day conditions, i.e. with no Reserve releases	715.0
2	Present Day level of development and meeting the Reserves for the REC (recommended ecological category) at each of eight EWR sites along the river	800.3
7	Raising Clanwilliam wall (15 m) and meeting the Reserves for the REC (recommended ecological category) at each of eight EWR sites along the river	741.5
5	Raising Clanwilliam Dam by 15 m and meeting the Reserves for the REC at 5 of the 8 EWR sites along the river, excluding sites 2, 7 and 8	605.7
17	Raising Clanwilliam Dam by 15 m, plus an abstraction weir at Melkbosrug (Brandewyn option) in the Doring catchment and meeting the flow requirements of the Reserve at 4 of the 8 EWR sites, excluding sites 2, 5, 7 and 8.	529.3
10	Raising Clanwilliam Dam by 15 m, plus an abstraction weir at Melkbosrug (Brandewyn option) in the Doring catchment, but with no River EWR releases. This development would maximise the yield from the Olifants / Doring River system.	423.5

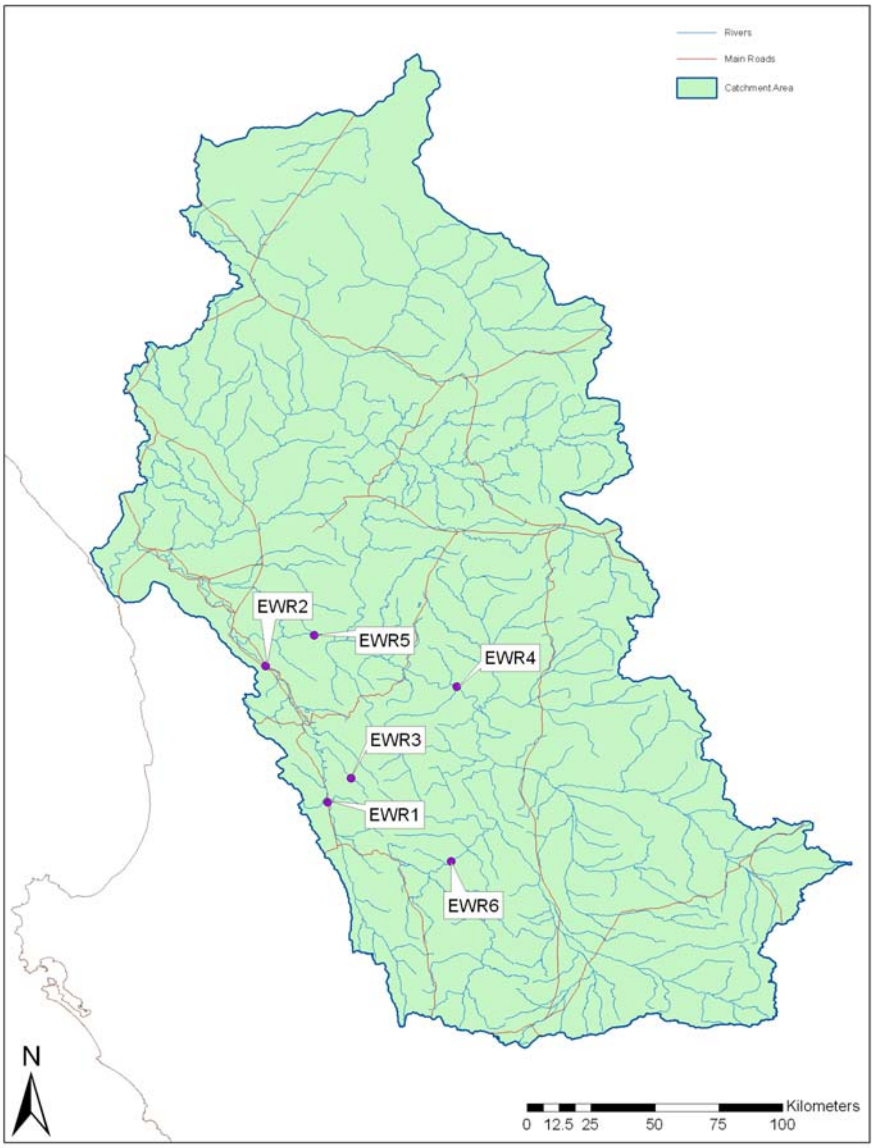

Figure 4.1 Map showing the location of the EWR sites (OD Delineation report – DWAF 2004a).

Table 4.2. EWR sites, their location, present ecostatus (PES) and recommended ecological category (REC). Note that sites 7 and 8 are extrapolated sites.

EWR Site	Location	Present Ecostatus	REC
1	Olifants downstream of confluence with Hex	D	D
2	Olifants downstream of Bulshoek Barrage	E	D
3	Rondegat upstream of Algeria	B	B
4	Doring upstream of confluence with Biedou	B/C	B
5	Doring at Ou Drif	B	B
6	Groot at Mount Cedar	B/C	B/C
7	Downstream of the Olifants – Doring confluence	D/E	D
8	Between Clanwilliam Dam and Bulshoek Barrage	D-	D

4.3 WATER YIELD UNDER EACH SCENARIO

The change in water supply (Mm^3 per annum) under the different scenarios is described in Table 4.3. Irrigation schemes receive approximately 148 Mm^3 under the present scenario. This is substantially reduced under scenario 2 and slightly reduced under scenario 7, both of which require environmental releases, but increases under scenarios 5, 17 and 10. For the purposes of this study it is assumed that the assurance of supply remains constant.

Table 4.3 Changes in supply (Mm^3/a) under different scenarios (source: Olifants/Doring Catchment EWR Study Scenario Report).

Scenario				Natural	Present Day	Present Day	Maximise Olifants	Maximise Olifants	Intermediate Doring	Maximise System
Scenario ID				0	1	2	7	5	17	10
Variant				Max available for IFR		EWR releases	Raise CwD 15m + EWR releases	Raise CwD 15m	Off-channel Brandewyn : No IFR ds Brandewyn	No EWR ds Doring confluence
Schemes			Clanwilliam Dam (CwD)	-	0	0	240	240	240	240
Schemes			Melkbosrug	-	-	-		-	-	470
Schemes			Brandewyn	-	-	-		-	160	-
Schemes			Groot	-	-	-		-	-	-
Schemes			Farm dams in Kouebokkeveld							
Schemes			Keerom Dam	-	-	-		-	-	-
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Clanwilliam / Bulshoek canals	0	139	75	122	237	237	237
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Betw Clanwilliam & Bulshoek	0	27	19	29	52	52	52
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Clanwilliam Return	0	-18	-9	-16	-31	-31	-31
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Melkboschrug	0	0	0	0	0	0	150
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Brandewyn	0	0	0	0	0	59	0
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Groot	0	0	0	0	0	0	0
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Farm dam - Kouebokkeveld	0	0	0	0	0	0	0
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	Scheme supply subtotal	0	**148**	**84.6**	**135**	**258**	**317**	**408**
Modelled flows and supplies	Selected demands and outflows	Scheme Supply	*Supply subtotal wrt present day*	*-148*	*0*	*-64*	*-13*	*109*	*169*	*259*
Modelled flows and supplies	Selected demands and outflows	Outflows	Evap Clanwilliam Dam	0	11	9	14	19	19	18
Modelled flows and supplies	Selected demands and outflows	Outflows	Evap other	0	0	0	0	0	20	25
Modelled flows and supplies	Selected demands and outflows	Outflows	Estuary	1055	716	782	725	597	518	422
Modelled flows and supplies	Selected demands and outflows	Estuary + scheme supply/evap		1055	875	876	874	873	875	873

Although the water quality issues in the Olifants/Doring are not well understood, effects on water quality in the rivers are unlikely to be significant, except for the lower Olifants River and possible the lower Doring River (C. Brown, pers. comm.). The main water quality issues are increased salinisation in the lower Olifants River and the chance of toxic algal blooms in the impoundments on the Doring River. The latter would effectively lower the assurance of supply for irrigation users. No reliable quantitative predictions have been made for the different scenarios, however.

4.4 ECOLOGICAL CHARACTERISTICS UNDER EACH SCENARIO

It is important to note that the REC of the EWR sites is similar to the present ecostatus in all cases except site 2, currently an E, and with an REC of D (Table 4.2). Thus scenarios in which the REC is met effectively entail the rivers remaining in a similar state of health to the present day, and scenarios in which REC does not have to be met means that the river could degrade. The degree to which the flow requirements of the REC are met under the different scenarios is summarised in Table 4.4.

Table 4.4 Degree to which instream flow requirements (in terms of overall volume Mm^3) are met under different scenarios (Olifants/Doring Catchment EWR Study Scenario Report).

Scenario			Natural	Present Day	Present Day	Maximise Olifants	Maximise Olifants	Intermediate Doring	Maximise System
Scenario ID			0	1	2	7	5	17	10
Variant			Max available for IFR		EWR releases	Raise CwD 15m + EWR releases	Raise CwD 15m	Off-channel Brandewyn : No IFR ds Brandewyn	No EWRs
Active EWR Sites	Olifants	1 : ds Hex	-	-	d	D	d	d	-
		8 : 1.45x IFR 1 ds CwD	-	-	D	D	-	-	-
		2 : ds Bulshoek	-	-	D	D	-	-	-
	Doring	3 : on Rondegat trib	-	-	b	b	b	b	-
		4 : us Biedou	-	-	b	b	b	b	-
		5 : Oudrif	-	-	b	b	b	-	-
		6 : on Groot trib	-	-	bc	bc	bc	bc	-
EWR portion of flows @ EWR Sites	Olifants (O)	1	106	100	101	101	100	100	100
		8	154	115	159	158	82	82	82
		2	161	101	170	170	54	54	54
	Doring (D)	3	2.9	2.9	2.9	2.9	2.9	2.9	2.9
		4	156	145	145	145	145	145	145
		5	193	178	178	178	178	152	96.5
		6	50.3	46.2	46.4	46.4	46.2	46.4	46.2
	ds D& O con	7	364	300	370	377	265	228	169
		Estuary	1055	716	782	725	597	518	422
Clanwilliam Dam Inflow			431.4	368	368	368	368	368	368
Doring tributary inflow			515	405	405	405	405	327	231

Note: If IFR requirements are set to "-" these requirements will not be actively supplied, however the volume contributed toward the IFR will be monitored. If a lower case letter is used no additional schemes were introduced upstream of the site to help meet the IFR

The resultant condition of each river reach is summarised in Table 4.5. These changes in health have implications for the abundance of indigenous and exotic fish, described as percentage changes in Table 6.11 and Table 6.12.

Changes in estuary health are summarised in Table 4.6.

Table 4.5. Resultant condition of reach represented by EWR Site

Scenario	EWR Site							
	1	2	3	4	5	6	7	8
0 (Nat)	A	A	A	A	A	A	A	A
1 (PD)	D/E	E	B	B/C	B	B/C	D/E	D
2	D	D	B	B	B	B/C	D	D
7	D	D	B	B	B	B/C	D	D
5	D	E	B	B	B	B/C	D	D
17	D	E	B	B	C/D[1]	B/C	E	E
10	E[2]	E[3]	B[4]	C	D[5]	B/C	E	E

[1]Barrier effect not considered, optimal temporal distribution assumed
[2]Assume current trends continue - i.e., no restitution of summer flows
[3]Assume optimal distribution of remaining flows.
[4]Assume no additional developments u/s of EWR Site 2.
[5]Assume optimal distribution

Table 4.6. Estuarine health scores (% similarity to natural) for different abiotic and biotic components and overall health score for the different scenarios.

Variable	Weight	Present	Runoff Scenario				
			2	7	5	17	10
Hydrology	*25*	69	77	74	64	61	38
Hydrodynamics/mouth condition	*25*	100	100	100	100	100	100
Water quality	*25*	50	61	56	46	41	34
Physical habitat alteration	*25*	78	78	75	75	70	50
Habitat health score	***50***	**74**	**79**	**76**	**71**	**68**	**47**
Microalgae	*20*	70	80	75	70	50	40
Macrophytes	*20*	58	70	55	49	47	40
Invertebrates	*20*	65	75	70	55	45	25
Fish	*20*	40	50	52	40	30	25
Birds	*20*	95	94	95	95	90	78
Biotic health score	***50***	**66**	**74**	**69**	**62**	**52**	**33**
Estuarine Health Index Score		**70**	**76**	**73**	**67**	**60**	**40**
Ecological Reserve Category (ERC)		**C**	**B**	**C**	**C**	**D**	**E**

In **Scenario 2**, the rivers are expected to be similar to under present conditions, except reaches 2 and 1 which are expected to improve in condition (from condition E to D). While the system would be slightly better from an ecological and aesthetic point of view, the latter changes are not expected to make an appreciable difference to the supply of goods and services. The health of the estuary is expected to improve slightly but significantly, in that the condition of the estuary changes from a C to a B.

In **Scenario 7,** the rivers are expected to be in a similar condition to Scenario 2, and the health of the estuary is expected to improve very slightly relative to present conditions.

In **Scenario 5,** Site 1 improves slightly because of the inclusion of the reserve; site 2 declines slightly but not appreciably; site 8 changes very little as it is well watered by a supply of water from Clanwilliam Dam to Bulshoek. There is no appreciable change at site 5 from present – the reserve just stops a negative trajectory of change. The health of the estuary is expected to decrease very slightly.

Scenario 17 is identical to Scenario 5 except for inclusion of the Brandewyn weir, which affects the Doring. The same applies to Sites 2 and 8 as in Scenario 5. At Site 5 downstream of the Brandewyn confluence, the dam and barrage affects the fish. The impacts are largely determined by how the water is transported (in stream or via canal). We assume that the water is released down the river, and that it is all taken out before the estuary. The environmental impact of the instream transfer of water is that of seasonal reversal, with too much water in summer. The health of the estuary is expected to decrease signficantly.

In **Scenario 10**, condition in most river reaches declines, with sites 1, 7 and 8 dropping to an E, such that river function is severely impacted. The health of the estuary is expected to decrease dramatically.

The above estimates of condition do not consider barrier and other effects in the case of scenarios with the Melkboom or Brandewyn barrage on the Doring (**Scenarios 17 and 10**). If the Melkboom is dammed then the EWR reach 5 will no longer exist, and the dam will probably carry alien fishes, so the changes could be large. However there are no data to support an estimate of this. The effects for the barrage would be similar but smaller. In other words there would be a barrier to migration and a refuge for alien fishes. The impacts of this could extend beyond EWR reach 5 into 4, and possibly even beyond.

Impacts on the main fish of the different fisheries associated with the estuary are described in detail under the Section on natural resource values.

5 THE VALUATION FRAMEWORK AND METHODS

5.1 AQUATIC ECOSYSTEM VALUES

5.1.1 The concept of ecosystem goods, services and attributes

Natural systems represent the 'natural capital' that, together with man-made capital and human capital, produce goods and services that are consumed by households in the economy. The classification of ecosystem characteristics in terms of economic commodities (goods and services) may be thought of as follows (Table 5.1):

4. goods are the tangible products provided by ecosystems, such as timber;
5. services encompass benefits such as those associated with ecosystem functioning, for example, water purification; and
6. attributes, such as biological diversity and scenic beauty, which contribute to their potential, such as ecotourism value, or sense of place, adding to overall quality of life.

Table 5.1 A comparison of ecological and economic characteristics of ecosystems (adapted from Aylward and Barbier 1992).

System characteristics	Ecosystem characteristics	Economic characteristics
Stocks	Structural components	Goods
Flows	Environmental functions	Services
Organization	Biological and cultural diversity	Attributes

The main types of ecosystem goods, services and attributes that would be associated with aquatic ecosystems are listed in Table 5.2. Note that water is included in the sense of use of aquatic ecosystems for watering cattle, in-situ washing and for collection of water directly for domestic use.

5.1.2 Types of value generated by ecosystems

The notion of 'ecosystem goods and services', while being useful in communicating the idea that ecosystems have economic value, has led to much confusion and needless debate in the scientific arena, particularly when it comes to their quantification and valuation. The Total Economic Value framework (Figure 5.1), is the more commonly-used framework in resource economics analyses, and has been instrumental in the development of valuation methodology.

Total Economic Value of natural resources is divided into use and non-use values. Consumptive use values, for example from livestock grazing or resource harvesting, and non-consumptive use values, for example from recreation and tourism, are the most tangible and commonly-measured values. Indirect use values, which arise from ecosystem functioning, are the cost savings due to services performed (such as water purification, carbon sequestration), or the inputs provided into production processes elsewhere (such as fish recruitment into marine fisheries from estuarine nursery grounds).

Table 5.2 Ecosystem goods, services and attributes of aquatic and water-dependent ecosystems, adapted from Costanza *et al.* (1997).

	Ecosystem Goods, Services & Attributes	Ecosystem Functions	Examples
Goods	**Water**		Direct provision of water for domestic use
	Food, medicines and grazing	Ecosystem production	Production of fish and food plants; medicinal plants
	Raw materials	Ecosystem production	Production of craftwork materials, construction materials and fodder
Services	**Gas regulation**	Regulation of chemical composition of the atmosphere	Carbon sequestration, oxygen and ozone production
	Climate regulation	Regulation of temperatures, precipitation at local levels	Urban heat amelioration, wind generation
	Disturbance regulation	Regulation of episodic and large environmental fluctuations on ecosystem functioning	Flood control, drought recovery, refuges from pollution events
	Water regulation	Regulation of water flow	Provision of dry season flows for agricultural, industrial and household use [spatially and temporally]
	Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of soil loss by vegetation cover, and capture of soil in wetlands
	Nutrient cycling	Storage, recycling, capture and processing of nutrients	Nitrogen fixation, nitrogen cycling through food chains
	Waste treatment	Recovery of nutrients, removal and breakdown of excess nutrients	Breaking down of waste, detoxifying pollution; dilution and transport of pollutants
	Amenity	Shade or shelter	Riparian trees providing shade for livestock and people
	Biological control	Trophic-dynamic regulation of animal and plant populations	Predator control of prey species, maintain population balance
	Refugia	Habitat for resident and migratory populations	Habitat for migratory fish and birds, important habitats for species
	Nursery areas	Nursery habitat for species that complete their lifecycle elsewhere	Nurseries for marine fish
	Export of materials and nutrients	Export of materials and nutrients to other ecosystems	Export of nutrients to marine ecosystems
Attributes	**Genetic resources**	Unique biological materials and products	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species
	Structure and composition of biological communities	Species diversity and habitats providing opportunities for recreational and cultural activities	Ecotourism, sport fishing,.. Aesthetic, educational, spiritual and scientific values of ecosystems

In addition, system attributes such as genetic diversity and organization contribute option value, a measure of potential future use of biodiversity, and existence value, which is a measure of the satisfaction that people gain from knowing that a system or element thereof is protected. The alteration of catchment hydrology changes the structural make-up of its aquatic and water-dependent ecosystems, their genetic diversity and organization of biodiversity, effectively altering the foundations of these ecosystems. In so doing, ecosystem functioning and resilience, and ecosystem productivity are affected. The ecological Reserve can thus have implications for all the values described above.

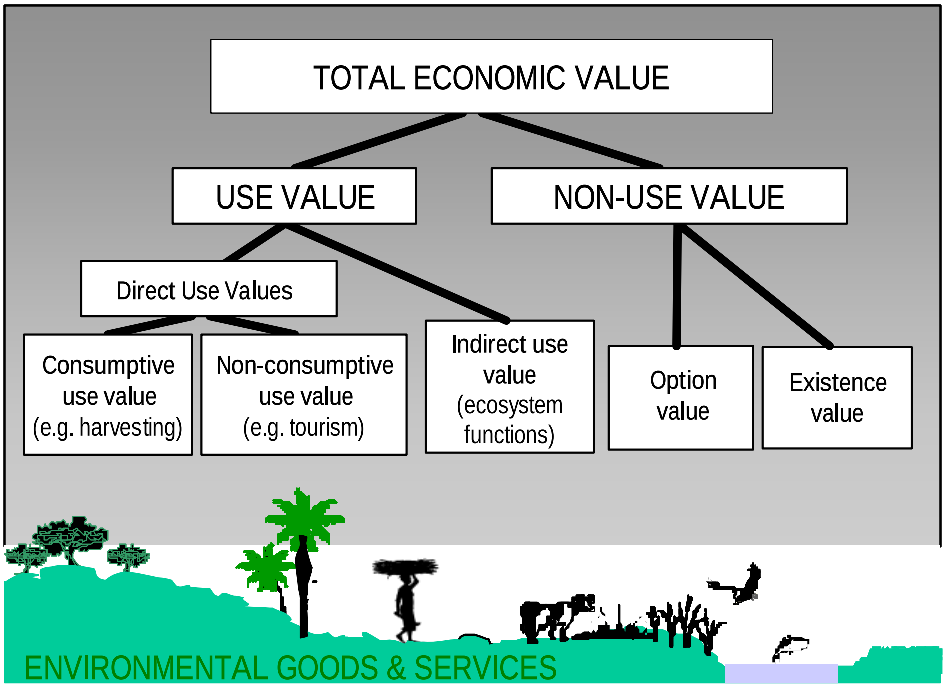

Figure 5.1 Total Economic Value (Turpie *et al*. 1999).

Total economic value encompasses all the measures that affect human welfare. Nevertheless, it is currently only those values that are relatively tangible (direct and indirect use values, akin to goods and services) that carry any weight in the political arena. Option value cannot be measured, and existence value is measurable at considerable cost (requiring survey-based methods).

5.1.3 Measuring environmental values

Aquatic ecosystem values are measured using a number of methods that are applicable to different types of value or circumstances, and depending on availability of information and budget. Direct use values (of goods and attributes) are ascertained by estimating total usage and the market value of that use, or by estimating consumer surplus where there is market failure (prices do not reflect true Willingness to Pay), using methods such as the Travel Cost Method. Indirect values (of services) are typically measured using replacement cost estimates, such as the engineering costs required to replace an environmental function, or change in productivity estimates, in cases where an ecosystem output (e.g. water or fish) forms an input into a production process elsewhere. Option value cannot be measured, but proxies can be used, such as income generated by bio-prospecting. Existence values are measured using stated preference techniques such as the Contingent Valuation Method which elicits the public willingness to pay for environmental amenities. Option and existence values were not considered in this study.

Measures can be expressed in a number of ways, such as Willingness to Pay (aggregate willingness to pay of the whole affected population, once off or per year), or in terms of expenditure, change in economic output, etc. In this study, ecosystem values are expressed in terms of total expenditure or turnover in a particular sector, as far as possible, and the economic impacts of this turnover was estimated in a macroeconomic model (see next section). These measures are thus compatible with the more conventional measures of value of the use of water yielded from the catchment area.

5.2 ESTIMATION OF MACROECONOMIC IMPACTS

5.2.1 Water Impact Model

This section provides a detailed overview of the customised Water Impact Model modelling system that has been developed for the purpose of calculating the economic value of water in a catchment. 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.

The Water Impact Model is a dynamic modelling system specifically developed to quantify the economic impacts (positive or negative) resulting from the allocation of water to any of the following water users:

- Agriculture
    - Perennial crops: Apples, citrus, wine and table grapes, litchis, mangoes, papayas and sugar cane
    - Annual vegetables: Maize, wheat, cucurbits, brassicas, potatoes, lucerne and pastures
- Commercial forestry
    - Gum
    - Pine
- Domestic Users
    - Low-income households

- High-income households
- Industrial water users
  - Industry
  - Mining
  - Eskom
- Transport, Construction, Finance and Services industries
- Commercial tourism (excluding eco-tourism)
- Ecology
  - Food Production: Fishing by the community, fish farming, cultivated floodplains, medicinal plants, hunting smaller animals and wetlands.
  - Raw Material: Thatch grass, reeds, wood gathering and sand mining.
  - Recreational Activities: Recreational fishing, recreational boating and recreational swimming.
  - Dis-benefits: Black flies (and other bugs), livestock diseases, malaria, bilharzia (snails), crocodile and hippo incidents.
  - Water regulation: Waste assimilation, waste dilution.

5.2.2 Sub-systems

The model makes provision for sub-systems, depending on climatic, geographical, socio-economic and other considerations:

A separate dynamic Water Impact Model can be developed for each of identified sub-systems. These separate models only feature the water users that are relevant for each sub-system, i.e. in Sub-system 1, only pastures is included in the Agricultural Water Impact Model since that is the only crop that is 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 the various users can be performed in terms of the economic impacts emanating from each water re-allocation change.

3.1.1.3 ECONOMIC IMPACTS

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.

3.1.1.4 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 and water assurance guarantee, i.e. the "Current Situation". Each new water allocation and assurance scenario will generate a "New Situation". 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 "Current Situation" 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 "New Situation" 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.

3.1.1.5 SECONDARY INPUTS MODEL

In addition to the Primary Impetus Model drivers, a next level of Secondary Inputs has been identified. Table 5.3 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.

3.1.1.6 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.

3.1.1.7 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".

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.

Table 5.3 Secondary inputs.

Water Users	Secondary Inputs
Agriculture	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] Water Production Elasticities [%]
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 Households	Total population [Numbers] Water use per person per annum [m^3] Current economic value of water Current cost of supply of water [R/kl] Direct labour multipliers [Numbers] Direct capital multipliers [R million]
Industry	Current water usage [Mm^3] Current GDP [R million] Number of tourists Water per tourist Spending per tourist [Rand per tourist per day] Direct labour multipliers[Numbers] Direct capital multipliers [R million]
The Ecosystem	Current water usage [Million cubic metres] Current production value [R million] Current cost of water Direct labour multipliers [Numbers] Direct capital multipliers [R millions]

3.1.1.8 THE SOCIAL ACCOUNTING MATRIX

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 got permission to use the Western Cape regional SAM. The WC SAM is based on input from the official 2000 SAM for South Africa, which is based on the official 2000 Population Census published by Stats SA. Conningarth Economists have calculated sectoral multipliers for a number of economic variables in the WC SAM.

By applying the sectoral SAM, 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.

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.

3.1.1.9 ECONOMIC VARIABLES INCLUDED IN THE WESTERN CAPE SAM

The following economic variables have been included in the WC SAM that were developed for the catchments analyzed 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.

3.1.1.10 METHODOLOGY FOR CALCULATING SECTORAL MULTIPLIERS

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

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

GDP multiplier = Value Added/Production

Labour multiplier = Employment/Production

Capital multiplier = Capital stock/Production

3.1.1.11 MULTIPLIERS INCORPORATED INTO THE WATER IMPACT MODEL

By using the WC SAM applicable for the studied area, multipliers are 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)

5.2.3 Scenario analysis

So far, the discussion presented in this report has focused on providing a detailed description of the Water Impact Model in terms of its structure and its ability to reflect the current water usage situation in the catchments being investigated. The next step in the process is to present the modelling system used to calculate the new (adjusted) water usage situation. This new water use situation differs from the current situation in respect of the following:

- The volume of water used by each water user, and

- The water provision assurance given to each water user

As such, the model caters for changes in water usage by each water user, as well as a change in the water assurance associated with this particular usage. It should be noted that, for the purposes of this particular study, the water assurance of only the agricultural water users was varied across the "Current" and "New Situations". In the case of all other water users, water assurances remained constant across both situations, even though provision has been made in the model to accommodate such changes.

Given the new water usage and assurances, the model produces new economic and socio-economic impacts for each of the water users that can be compared to the results generated under the current water usage situation. This makes it possible to compare the two water usage options, and to determine the size of the impacts (positive or negative) that a change in water usage by various water users will have on the economy.

3.1.1.12 WATER DEMAND SCHEDULES

Each water user has its own particular pattern of production output relative to the volume of water it uses, and the level of water provision assurance it has. For most users, a specific change in the volume of water available for productive usage or the level of water provision assurance does not have a directly proportional affect on the volume of output produced. For instance, a 5% increase in water availability may only have a 3.5% increase in the output of citrus fruit per hectare over the long term. For this reason, two unique demand schedules (so-called elasticity curves) have been embedded into the Water Impact Model frameworks for each individual water user, one that accommodates changes in the volume of water available, and another that accommodates changes in water provision assurances, i.e.

- Volume of water elasticity's that reflect the productivity of water usage
- Water provision assurance elasticity's that reflect the effective utilization of water

In the discussion of these two curves, the emphasis will be on water used for agricultural activities since these are the activities that are most affected by changes in the volume of water available and variances in water provision assurances.

3.1.1.13 CHANGES IN THE VOLUME OF WATER AVAILABLE

When the volume of water available to a farmer is changed, it has a definite impact on the quantity of hectares that can be maintained, i.e. once water is in short supply, the number of hectares that can be cultivated is jeopardized. However, the farmer will strive to sustain as many as possible of the existing hectares currently under production.

In order to do so, the farmer can invest in new, technologically advanced irrigation equipment that will apply the water at his disposal more effectively. This implies that the number of hectares under irrigation will not be as badly effected as they may have been had technological changes not been allowed for. For this particular exercise, four alternative irrigation technologies have been identified, namely:

- Flood irrigation
- Non-mechanized sprinklers (i.e. drag lines)
- Mechanized sprinklers (i.e. centre pivots)
- Micro irrigation (i.e. drip systems)

Starting with flood irrigation, each system becomes technologically more advanced. This implies that micro-irrigation distributes water more efficiently than, for instance, the flood irrigation system, making it possible to use the same amount of water for a larger number of hectares under irrigation.

In developing water provision assurance demand schedules, the following aspects of each of these irrigation systems have been included in the calculation process:

- The efficiency of each system (as a percentage)
- The average hectares per labourer
- The life expectancy of the irrigation system
- The capital cost of the system

For this specific study it was assumed that the composition of irrigation systems would not change in the case of any volume changes.

3.1.1.14 CHANGE IN THE ASSURANCE OF WATER PROVISION

In terms of water assurance, the assumption is made that farmers will protect their crops over the long-term. They will rather suffer losses in production per hectare (yield) than losses in terms of the number of hectares under irrigation. For this reason, younger trees that are less sturdy than older, more rooted trees and will enjoy preference when water is allocated. This will lead to a drop in the yield per hectare since younger trees are traditionally less productive than older specimens. This results in a non-linear relationship between changes in water provision assurances and subsequent changes in the yield per hectare.

The annual yield per crop as well as the annual water usage is an important aspect when considering changes in the yield per hectare per type of crop.

However for this study it was assumed that the assurance of water provision would not change.

6 VALUES OF AQUATIC ECOSYSTEMS AND IMPLICATIONS OF SCENARIOS

6.1 INTRODUCTION

A preliminary assessment suggests that several ecosystem goods, services and attributes are of medium to high significance in the Olifants/Doring Catchment. This study concentrates on those that are of medium to high significance and that are measurable. The following is an overview of all the values, providing information on the goods, services, attributes and their values wherever possible, or giving reasons why they are not valued. The main effort is spent on the valuation of estuarine fisheries and the estuary as a nursery area, and estimated changes in these values under the different scenarios. It was decided to concentrate on the estuary fishery values and the nursery value of the estuary for marine fisheries, since these are the values most likely to be impacted by the scenarios to a measurable degree, and for which enough information was available to assess the impact of the scenarios.

6.2 WATER FOR BASIC HUMAN NEEDS

Based on the socio-economic profiles, it would appear that very few people in the Olifants/Doring Catchment depend on collecting water from rivers or boreholes for their domestic water supplies, with the vast majority having piped water to their dwellings.

6.3 ESTUARINE FISHERIES

6.3.1 Introduction

There is some use of fish resources, mainly in the estuary, by the Ebenhaesar Community, and also reportedly in the rivers by poorer members of the community (Lamberth 2005). There is no information on the latter activity.

South Africa has roughly 258 functioning estuaries along its approximately 3100 km coastline, of which 27 are permanently open estuaries. However, the density of estuaries increases around the coast from west to east, with only nine along the west coast. The Olifants estuary is one of only four permanently open estuaries on the west coast.

One of the most important values of estuarine systems is their contribution to recreational, commercial and subsistence fisheries. West coast estuaries have the highest yields per ha in the country (Table 6.1), reflecting the generally high fishery productivity of this region. Indeed, the high overall catch comes from a small number of large estuaries, mainly the Berg and Olifants estuaries.

Table 6.1 Estimated total catches (tons) per fishery for all estuaries in each of five coastal regions in South Africa (Lamberth & Turpie 2003).

	Estuaries	Ha	Angling	Castnet	Gill-net	Seine	Trad	Total	kg/ha
West	9	5 884	14.0	2.2	625.0	-	-	**641.2**	109.0
South	52	12 866	409.6	31.1	151.6	12.0	-	**604.3**	47.0
East	54	3 764	223.5	19.9	51.5	-	-	**294.8**	78.3
T/kei	67	2 612	141.1	12.5	32.5	-	-	**186.1**	71.2
KZN	73	46 811	245.4	52.4	296.5	72	89	**755.3**	16.1*
TOTAL	**155**	**71 936**	**1033.6**	**118.1**	**1157.0**	**84.0**	**89.0**	**2481.7**	**34.5**

There are five main categories of fish in estuaries, grouped according to their level of estuarine dependence (Whitfield 1994).

Table 6.2 The five major categories and subcategories of fishes that utilise southern African estuaries (Whitfield 1994).

Category	Description
I	Estuarine species that breed in southern African estuaries. Ia. Resident species that have not been recorded spawning in marine or freshwater environments. Ib. Resident species that also have marine or freshwater breeding populations.
II	Euryhaline marine species which usually breed at sea with the juveniles showing varying degrees of dependence on southern African estuaries. IIa. Juveniles dependent on estuaries as nursery areas. IIb. Juveniles occur mainly in estuaries, but are also found at sea. IIc. Juveniles occur in estuaries but are usually more abundant at sea.
III	Marine species that occur in estuaries in small numbers but are not dependent on these systems.
IV	Freshwater species, whose penetration into estuaries is determined primarily by salinity tolerance. This category includes some species that may breed in both freshwater and estuarine systems.
V	Catadromous species that use estuaries as transit routes between the marine and freshwater environments but may also occupy estuaries in certain regions. Va. Obligate catadromous species that require a freshwater phase in their development. Vb. Facultative catadromous species which do not require a freshwater phase in their development

Catches within estuaries in South Africa are dominated by harders *Liza richardsonii* (category IIc), most of which are caught on the west coast. On the west coast, harders make up 86% of catches, and elf *P. saltatrix* make up most of the remaining catch (10%).

6.3.2 The Olifants estuary gill-net fishery

There are approximately 1200 gill-netters operating in estuaries in South Africa. On the west coast, legal gill-netting only takes place in the Olifants estuary, having been discontinued on the Berg. On the Berg River estuary, there were 120 gill-net permit holders, plus about 100 illegal operators, and annual effort was about 13 230 net days of legal effort plus at least 4000 net days of illegal effort (Hutchings & Lamberth 1999). The Rietvlei/Diep system is fished by about 10-12 poachers (Lamberth 2000a).

There are 45 gill-net permit holders in the Olifants estuary, and an estimated additional 10-30 people operating without permits (Sowman *et al*. 1997, MCM Netfish System). Annual effort is about 15 300 net days/year (Lamberth 2006).

The Olifants gill-net fishery targets harders. Mean annual landings of harders by the fishery are in the region of 100 t with a further 5 - 20 t of by-catch species such as elf and silver kob *Argyrosomus inodorus* (Lamberth & Hutchings 2003, MCM Netfish System). The annual tonnage from the Olifants Estuary comprises 1 – 2 % of the national catch by the inshore beach-seine and gill-net fisheries (Lamberth *et al*. 1997). The nets used are restricted to 45 m in length and a minimum mesh size of 48 mm. All the fishers use rowing boats, the use of motors being frowned upon either because the fishers cannot afford them or due to the perception that they scare the fish. Fishing is seasonal, being confined mostly to summer (October - April) during low flows. Although abundance and/or catchability of harders may be lower in the winter months, making fishing un-worthwhile, any attempt at setting nets is usually impeded by water borne debris.

Sixty percent of the fisher households rely on fishing for 25-50% of their summer income, whereas for the remaining 40%, fishing comprises 75% of household income (Sowman *et al*. 1997). A large part of the catch is consumed with more than 50% of households eating fish very day.

The low flow experienced during 2004 saw the fishery active throughout the winter months. However, despite the overall increase in effort throughout the year, total catch was 100 – 120 t, similar to the annual average. This suggests that catches were spread out over a longer period and that catch per unit effort declined with the increase in effort. Consequently, it appears that recruitment is low, fishing mortality high and the 45 operators are above the sustainable effort maximum, most fish entering the system being caught. While decreased flows are likely to lead to decreased catches, prolonged high flows or floods in winter may also result in extreme hardship for the families reliant on fishing for a livelihood.

6.3.3 Value of the estuarine fishery

The economic value of the fishery was considered in terms of the value of landed catches by small-scale fishers, income generated by commercial fishers.

Only the commercial income and recreational expenditure values contribute to standard measures of national income (e.g. GDP), although subsistence income should also be considered as value added to the economy.

The total value of fisheries within South African estuaries is estimated to be about R656 million per year (2005 Rands; based on Lamberth & Turpie 2003). This is based on an estimated total annual catch of 2 482 tons. Ninety-nine percent of this value (nearly R652 million) is the value of recreational angling, while net and traditional fisheries together make up the remaining 1% of value. Based on estimated catches of the gill-net fishery and the national average value per kg (Lamberth & Turpie 2003), the fishery is estimated to be worth about R491 400– R629 600 per annum (2005 rands). The gill-net fishery makes up about 33 – 50% of the total value of the estuary fisheries when the recreational fishery is also considered

6.3.4 Potential change in fishery value under different flow scenarios

The gill net fishery is dominated by category IIc species (predominantly marine species whose juveniles are found in estuaries), but category IIa species (marine species that are dependent on estuaries as a nursery area, such as White Steenbras) do feature (Table 6.3). Different categories of estuarine fish respond differently to changes in estuarine condition. These changes have been estimated for the different types of species in the Olifants, based on the present day relationships between abundance and salinity, and changes in salinity distribution under the different scenarios (Lamberth 2005). It should be noted that the degree of error in this model could be high, since other factors such as temperature and nutrients were not factored into the model.

The Category IIc species are predicted to decline under all the scenarios considered, although only very slightly under scenario 5 (Table 6.3, based on Lamberth 2005). Category IIa species are expected to increase under scenarios 2, 7 and 5, but decline under the remaining scenarios.

Table 6.3. Contribution of estuary associated species to the different fisheries and estimated percentage abundance of different categories of estuarine fish species under different scenarios relative to present conditions

Category of main species	**Contribution to gill-net catches**	**Contribution to recreational catches**	**Scenario**				
			2	7	5	17	10
IIa	0.2%	0.7%	130	128	112	60	50
IIc	94%	94%	88	88	97	81	84

Catches remain least affected under scenario 5 (about 97% of present). Under scenarios 2 and 7 catches are reduced to about 89% of present catches, while they are reduced to about 82% and 85% of present catches under scenarios 17 and 10, respectively (Table 6.4). A similar percentage change is applied to the value of the gill-net fishery (Table 6.5).

Table 6.4. Estimated estuarine fish catches (tons per year) under the different scenarios

Fishery		**Scenario**					
		Present	**2**	7	5	17	10
Olifants gill-net	Lower	105	93.2	93.2	102.1	86.2	89.1
	Upper	120	106.5	106.5	116.6	98.5	101.8

Table 6.5. Estimated value of the gillnet fishery under the different scenarios (R millions per annum)

Fishery		**Scenario**					
		Present	**2**	7	5	17	10
Olifants gill-net	Lower	0.491	0.436	0.436	0.478	0.403	0.417
	Upper	0.630	0.559	0.559	0.612	0.517	0.534

6.4 OTHER FOOD AND RAW MATERIALS

There is no recorded use of other foods or building materials (e.g. reeds) gathered from the aquatic ecosystems in the study area. This is unsurprising because of the population make-up and the lack of traditional dwellings in this catchment.

There is commercial harvesting of sand in the lower Doring River area ("near Klawer") by a single operator under permit from the Department of Mineral Affairs and Energy (J. Briers, DMAE, pers. comm.). This operator extracted 5482 cubic metres of sand during the last financial year, generating a gross income of about R35 600 (J.D. Stemmet, sand miner, pers. comm.). It is likely that the availability of sand in the Doring will be affected by the construction of an impoundment on that system (Scenarios 17 and 10), but it is not possible to estimate the degree to which sand availability would change from the results generated in the Reserve study (C. Brown, EWR specialist, pers. comm.), or whether the sand mining operation would be affected.

There has also been diamond mining and prospecting in the mouth region during the past 50 years or so. The mining concessions either side of the mouth probably have an impact on water quality and mouth dynamics.

6.5 CARBON SEQUESTRATION

Carbon sequestration is measured in terms of the net storage or loss of carbon that takes place as a result of a long-term increase or decrease in biomass. It is assumed that the aquatic ecosystems considered in this study are carbon neutral (biomass is neither being increased or decreased at present), and that the scenarios would not have a significant impact on this balance.

6.6 FLOW REGULATION, FLOOD CONTROL, SOIL RETENTION AND EROSION CONTROL

Wetlands in the upper catchment area might have an important flow regulation function, in that they absorb flows during wet period and release them during dry periods, hence maintaining dry season flows, when water is in demand. These wetlands may also be important for soil retention. However, these functions have not been investigated and the type of study required would be beyond the scope of this project. Nevertheless, the health of these wetlands is not affected by any of the flow scenarios considered in this study.

It is, however, important to note that a dam on the Doring River, which currently has a high silt load, would probably lead to significant scouring of the river downstream. Thus under scenarios 17 and 10, there could be bank erosion leading to loss of valuable agricultural lands. Land suitable for viticulture in the Vredendal-Lutzville area goes for about R80 000/ha (noble white cultivars) or R105 000/ha (noble red cultivars) on average, or about R16 000/ha for land suitable for irrigated vegetable production (Standard Bank Agricultural Advisory Unit). However, no estimates are available or possible at this stage of the potential losses that would be incurred under these scenarios.

6.7 WASTE ABSORPTION

Waste absorption is likely to be an important ecological service provided by the aquatic ecosystems of the study area, particularly in that agricultural return flows are diluted and assimilated by the system. The value of this function is usually estimated in terms of the cost savings of treating the water before it is released. However, the quantity of pollutants released into the system was unknown. It is important to note that the value of the system is only measured in terms of the amount assimilated by the system. This capacity would be reduced under certain scenarios, resulting in decreased water quality downstream and exacerbating the negative impacts on downstream users that would already be caused by increased pollution loads due to agricultural expansion.

6.8 REFUGE AREAS AND NUTRIENT EXPORT

Refuge areas are areas that help to maintain populations in a broader area. For example, wetlands within relatively arid areas may play an important seasonal role in the maintenance of wild herbivores that are utilised in tourism operations well beyond the wetland. This is probably not important in the study area apart from for fish. In the rivers, some of the smaller tributaries have become important as refuge areas for endemic fish, although their ability to repopulate the rest of the river system is low at present (see discussion below). In the estuary, some inshore marine fish populations may utilise the estuary as a warmer refuge during upwelling events (Lamberth 2005). The extent of this function in its contribution to marine populations is unknown.

The export of sediments and nutrients to the marine zone is an important function of some river systems. For example, the prawn fisheries of KwaZulu-Natal depend on such exports (DWAF 2004c). However, this function is far more important on the east coast, which is relatively nutrient-poor, than on the west coast, where the outputs of estuaries do not compete with the nutrients supplied by the Atlantic upwelling systems (Turpie & Clark 2006). Sediment exports could be important, however, but there is no information on this.

6.9 NURSERY VALUE

6.9.1 Introduction

Nursery areas are areas, which are used as breeding habitat for populations that reside elsewhere. The nursery function of the Olifants estuary is considered to be significant, in that many marine species caught in the surrounding marine fisheries are dependent on estuaries as nursery areas. This value is described in more detail below.

Estuaries provide nursery areas and habitat for numerous species of fishes which are exploited by recreational and commercial harvesting in the inshore marine environment. Different species are dependent on estuaries to different degrees for stages of their development and growth (Table 6.2). On the west coast, the Olifants estuary is thought to be particularly important as a nursery area since it is one of only four permanently open systems, and it accounts for 23% of the estuarine area on the west coast.

This assessment is based on existing literature describing estuarine and coastal fisheries and their values, as well as the nursery value of estuaries. The impacts of the scenarios are evaluated based on a model of fish abundance described in Lamberth (2005). The basic biology and ecology of estuarine fishes is described in Lamberth (2005).

6.9.2 West Coast fisheries, participation and effort

There are about 431 000 recreational fishers and well over 21 000 commercial fishers active in the inshore marine environment in South Africa. Beach seine and gill net fisheries on the west coast are likely to be the fisheries that are most affected by changes in the Olifants estuary. The commercial line fishery, recreational shore angling and recreational boat angling fisheries could also be affected to a small extent.

COMMERCIAL GILL-NET AND BEACH SEINE NETTING

Gill-net fisheries on the West Coast target harders and St Joseph sharks *Calorhynchus capensis*, as well as species on the "bait list" such as maasbanker *Trachurus trachurus*. All gill-net permits issued for the marine environment are on the west coast, from Yzerfontein northwards (approximately 118 permits), apart from occasional experimental fisheries elsewhere. In addition, illegal gill-netting occurs throughout the South African coastline, though mostly on the west and south coasts. There are an estimated 268 illegal gill-nets on the west coast, 60 on the south coast, and 120 on the KwaZulu-Natal coast.

Some 28 of the 60 beach seine permits in the country are held on the West Coast.

There are approximately 2 700 people who derive some sort of income in the legal inshore net fisheries along the west and south coasts, with a total effort of approximately 32 000 net-days per year.

COMMERCIAL BOAT-BASED LINEFISHING

There are approximately 18 533 commercial line fishers operating from 2 581 registered boats in South Africa, for 380 800 boat-days per year (Lamberth & Turpie 2003). Some 9000 of these are the West Coast (Brouwer *et al.* 1997, Sauer *et al.* 1997), though at least half of these may have become recreational line fishers since the number of licences were reduced in 2003.

RECREATIONAL SHORE ANGLING

There are an estimated 412 000 regular shore anglers in South Africa (McGrath *et al.* 1997), 26 000 of whom are on the West Coast (Brouwer *et al.* 1997, Sauer *et al.* 1997). The majority of anglers come from the upper two quintiles of income earners in South Africa (McGrath *et al.* 1997).

RECREATIONAL BOAT ANGLING

There are an estimated 12 054 recreational boat anglers, operating from 3 444 boats (McGrath *et al.* 1997), on 92 988 boat-days per year. Some 210 of these are on the West Coast (Brouwer *et al.* 1997, Sauer *et al.* 1997). However, in many cases, the distinction between commercial and recreational boat fishermen is blurred, ranging from purely recreational fishers to those selling some catches to finance boating expenses or to supplement an existing income, to those who fish on a permanent commercial basis. The situation has changed since the allocation of fishing rights began in 2001, with many "part-time" fishers being removed from the fishery.

6.9.3 Inshore Marine Catches

The total inshore marine catch in South Africa is estimated to be 28 107 tons per year (Lamberth & Turpie 2003). Of this 60% is made up by the commercial line fish sector and 23% by the commercial net fishery, the remainder being made up of recreational fisheries. Inshore fishery catches on the West Coast account for about 15 000 tons, and make up 53% of the total catch. In contrast to the rest of the country, these catches are predominantly commercial, whereas recreational catches are more important than commercial catches in the rest of the country.

6.9.4 Utilised species, their distribution and dependence on estuaries

Of the approximately 160 species that occur in South African estuaries, about 80 species are utilised in coastal fisheries. Some 19 of these species occur in the estuaries of the West Coast region. Of these, 8, 9 and 2 species fall into categories II, III and IV, respectively (Table 6.2; none in I or V). Of particular importance are the category II species, for which management of estuaries plays a crucial role in inshore fisheries.

The catches of estuarine-associated fish species differ from west to east around the coast, following biogeographical changes from the Cool Temperate region on the west coast through to the Subtropical region north of the Bashee River in the Transkei. Numbers of estuarine species in catches increase from west to east around the South African coast. Within regions, species composition of catches within estuaries also differs between estuaries of different types and sizes, with greater species richness associated with larger and permanently open estuaries such as the Olifants (Lamberth & Turpie 2003).

6.9.5 Estuary-associated species in marine catches

Numerous estuary-associated species have been recorded in all types of inshore marine fisheries. The contribution of different categories of estuary-associated species to inshore marine fisheries on the West Coast is summarised in Table 6.6. Category IIa species (e.g. White Steenbras), which are entirely dependent on estuaries, generally make up a relatively small percentage of catches, ranging from 0.5% of recreational boat and spear fishing catches to 1.05% of commercial net catches. Historically, prior to stock collapse, IIa species (white steenbras and dusky kob) made up a substantial part of catches. T he proportion of category IIb species in catches is generally lower than of category IIa species, but category IIc species are highly important in the commercial net fisheries and recreational shore fishery (Table 6.6). The category IIc species are dominated by harders in the commercial net fisheries. The main species in these fisheries are shown in Table 6.7.

Table 6.6 Percentage contribution of different categories of estuarine associated fish to the inshore marine fisheries on the west coast. All percentages in terms of biomass except recreational shore angling, in terms of numbers.

	Estuary dependence category*				
	IIa	IIb	IIc	III	Total
Recreational shore	0.51	0.17	41.26	13.81	55.75
Recreational boat	0.02	<0.01	0.80	0.10	0.92
Recreational spear	0.05		0.09	0.09	0.23
Commercial boat	0.09	<0.01	0.80	0.10	0.91
Seine & gill-net	1.05	0.04	80.86	1.10	83.06

*IIa Juveniles depend on estuaries; IIb juveniles occur mainly in estuaries; IIc juveniles occur in estuaries; III Marine species that occur in but not dependent on estuaries.

Table 6.7 Contribution of the main estuary associated species to West Coast fisheries (% catch).

	Category	Commercial Gill/seine	Commercial boat	Recreational shore	Recreational boat
Harders	IIc	79	0.1	9.5	0.1
Elf	IIc	1	0.1	0.1	0.1
Strepie	IIc	0.1	0.1	0.3	0.1
Dassie	IIc	0.1	0.1	1	0.1
White Steenbras	IIa	0.1	0.1	0.5	0.1

6.9.6 Estuarine contribution to inshore marine fishery values

The total value of inshore marine fisheries in South Africa is about R3.64 billion per year (2005 Rands, of which about R647 million is attributable to West Coast fisheries (based on Lamberth & Turpie 2003; Table 6.8). Approximately 53% of the West Coast value is the value of the recreational fisheries, the remainder being commercial value.

Estuarine fish make up about 25% of the value of the gill- and seine-net fisheries and 0.3% of the value of the commercial boat fisheries on the west coast, or about 8% of the overall value of West Coast inshore marine fisheries (Table 6.8). However, not all of these fish are equally dependent on estuaries. Category IIa species are 100% dependent on estuaries to complete their life cycles. Because the juveniles of Category IIb species are largely confined to estuaries, their level of dependence on estuaries was considered to be very high, and was estimated as 90%. The overall numbers of Category IIc species, whose juveniles mainly occur in marine environments, are augmented by the presence of estuarine habitat areas. Estuarine area comprises about 30% of the juvenile habitat available to these species, and those juveniles using estuaries are frequently in better condition than those in marine habitats (De Decker & Bennett 1985). It is thus estimated that 30% of the marine catches of Category IIc species can be attributed to estuarine export. Thus in calculating the contribution of the different types of species to fishery values, estuaries are assumed to account for 100%, 90, and 30% of the value of Category IIa, IIb and IIc species, respectively. Category III species are not included in this value.

Table 6.8 Percentage contribution of estuarine associated fishes to the total value of the inshore marine fishing sectors on the West Coast, the total annual values of the fisheries, the amount and % of total which is comprised of estuary-associated species, and the contribution of estuaries to total fishery values (2005 rands).

	% Estuary-associated species				Total value	Estuary fish contribution		Value due to estuaries	
	IIa	IIb	IIc	III	R million	R million	%	R million	%
Recreational shore	0.60	0.03	18.05	2.24	160.53	33.59	20.92	9.7	6
Recreational boat	0.00	0.00	0.39	0.01	170.18	0.68	0.41	0.2	0.1
Recreational spear	0.12		0.06	0.12	11	0.03	0.3	0.02	0.1
Commercial boat	0.04	0.00	0.78	0.05	286.87	2.52	0.88	0.8	0.3
Seine & gill-net	3.89	0.02	72.90	1.86	18.1	14.23	78.67	4.66	25.8
TOTAL					**646.68**	**51.05**	**7.90%**	**15.38**	**2.40%**

Thus, adjusting values according to the level of contribution that estuaries make to the catches of species of different categories, the estimated contribution from estuaries to inshore marine fisheries on the West Coast is 2.4% of the total value, or about R15.2 million per year (2005 rands, Table 6.8). The contribution on the West Coast is somewhat smaller than the 21% of total value for the country as a whole. The latter estimate is the value that would be lost if estuaries were ‘removed’ from the coastline.

6.9.7 Nursery value of the Olifants estuary

The portion of the West Coast inshore fishery value that is due to estuaries (R15.2m) is the nursery value of estuaries on the West Coast. How much of this comes from the different estuaries is unknown, and depends on several factors such as estuary size and mouth status, as well as geographical location. The Olifants estuary makes up about 23% of the estuary area on the West Coast (not including the upper Berg estuary floodplain which is largely a freshwater habitat). This is a conservative estimate because the Olifants and Berg estuaries probably contribute more than the Orange, due to the location of the fisheries. Thus a conservative estimate of the nursery value of the Olifants estuary is some **R3.45 million** per year (2005 rands; Table 6.1).

Figure 6.1 Annual values of fisheries that benefit from the Olifants estuary, and the total value attributed to the estuary.

Fishery	Fishers	Total value (millions)	Value from Olifants estuary* (millions)
West coast gill & seine	321 gill + 84 seine (+ crew)	R18.1	R1.07
West coast commercial boat	9000	R286.87	R0.18
West coast recreational shore and boat	210	R341.71 million	R2.28 million
Total nursery value of Olifants estuary fish			**R3.45 million**

6.9.8 *Potential change in nursery value under different scenarios*

Estimated changes in the abundance of different estuary associated species are shown in Table 6.9. It is assumed that the contribution of these species to estuarine stocks would change by the same degree.

Table 6.9 Estimated percentage abundance of different categories of estuarine fish species under different scenarios relative to present conditions.

Estuary association category	% of contribution to marine catches attributed to estuary	Scenario				
		2	7	5	17	10
IIa	100	130	128	112	60	50
IIb	90	97	100	91	77	76
IIc	30	88	88	97	81	84
III	0	86	86	95	82	88

Based on the above, the expected change in value of the west coast fisheries under different scenarios is summarised in Table 6.10. Upper and lower bound estimates are based on the fact that the magnitude of change is unlikely to affect recreational fisher behaviour (and thus actual expenditure, although their utility may be affected. The lower-bound values estimate the change including the loss of utility. The nursery value of the estuary changes least under scenario 5 (a loss of R10 – 50 000), and most under scenario 17 (a loss of R0.28 – 0.76 million). While some scenarios significantly impact on the nursery value of the estuary, these changes represent a very small percentage of the overall value of the fisheries (Table 6.10).

Table 6.10 Estimated change in value of the recreational and commercial West Coast fisheries under different flow scenarios (R millions).

	Scenario					
	Present	**2**	**7**	**5**	**17**	**10**
Recreational fisheries*	341.7	341.5	341.5	341.7	341.2	341.5
Commercial fisheries	305.0	304.9	304.9	305.0	304.7	304.9
Total fisheries value (lower bound)	646.7	646.6	646.6	646.7	646.4	646.6
Total fisheries value (upper bound) **	646.7	646.4	646.4	646.6	645.9	646.4
Change from present (lower bound)		- 0.07	- 0.08	- 0.01	- 0.28	- 0.07
Change from present (upper bound)		- 0.25	- 0.26	- 0.05	- 0.76	- 0.25
Nursery value (lower bound)	3.45	3.38	3.37	3.44	3.17	3.38
Nursery value (upper bound) **	3.45	3.20	3.19	3.40	2.69	3.20

*estimated maximum change assuming anglers respond to changes in catch rates
** upper bound estimates assume no change in recreational value

6.10 GENETIC RESOURCES

Genetic resources are valuable in many systems, but probably least valuable in freshwater and estuarine systems, where most species are extremely widespread. There are also few species that have widespread commercial potential (e.g. for agriculture or horticulture). Nevertheless, there are endemic species, and there is a possibility that these may become useful. It is not possible to determine this value. Nevertheless, it is also unlikely that any of the scenarios considered in this study would impact significantly on South Africa's genetic resource base (i.e. due to extinctions).

6.11 TOURISM AND RECREATION VALUE

6.11.1 General overview of tourism in the study area

The Olifants/Doring Catchment has become an increasingly popular tourist destination for South Africans and overseas tourists. Much of the appeal is lies in the natural features of the area, particularly the mountainous areas which provide opportunities for peaceful getaways or adventure holidays involving a variety of aquatic and non-aquatic outdoor activities. The Cederberg Wilderness Area is well known for its rugged beauty, features rare species such as the elephant's foot plant and the snow protea, and the best examples of San rock art in the Western Cape. The Namaqualand flower displays are possibly one of the biggest attractions to the area during early spring and several tour operators offer tours to view flowers. Aquatic ecosystem-based activities in the area include river rafting, canoe trails (near Citrusdal), fly fishing, coarse fishing, and estuarine angling, as well as viewing the Nieuwoudtville Falls, a 100 metre high natural feature on the Doring River.

Accommodation facilities in the Catchment range from extremely isolated and rustic camping facilities to self catering chalets to luxury guesthouses either in towns or in the middle of wilderness areas. Due to the hot, dry climate during the summer months, most of the out-of-town accommodation facilities and many of the hiking trails are located within short distances of streams and natural swimming holes.

The towns in the catchment offer their own attractions, as well as using natural attractions (including river- and dam-based activities) within their vicinity as a large part of their marketing strategy. **Citrusdal** is famous for its citrus products and wines and the Goede Hoop Citrus Co-op is the largest single packing facility in South Africa. **Clanwilliam** attractions include the rooibos tea and veldskoen shoe factories and the grave of the well-known South African poet Louis Leipoldt, as well as historic architecture, and the nearby Clanwilliam and Bulshoek dams. **Vredendal**, at the centre of the Lower Olifants River Valley, is home to the Vredendal Wine Cellar, the largest co-operative wine cellar under one roof in the southern hemisphere. At **Wupperthal**, at the foot of the Cederberg Mountains, is the oldest Rhenish Mission Station. Proceeds from 4x4 trails in the area go to community coffers for new hiking trails and building more overnight huts and guest-houses. **Klawer** is in the midst of a flower tourism area, and is also a main start and end point for hiking trails and river-rafting along the Doring River. **Vanrhynsdorp** houses the largest succulent nursery in South Africa, the Latsky Radio Museum, and the Troe-Troe and Rietpoort mission stations. **Lutzville** and **Koekenaap** offer wine and flowers in season and visitors can also view the Sishen-Saldanha Railway Bridge, the longest of its kind in the world. **Niewoudtville** offers flower-viewing and the waterfall. **Loeriesfontein** is near one of the largest quiver tree forests in the world. The Hantam Flower trail starts south of Loeriesfontein and heads to Calvinia. **Calvinia** is strongly surrounded by Anglo-Boer war history and 4x4 and hiking trails visit historical sites. The Akkerdam Nature Reserve contains interesting plants such as the sterboom (star tree).

Unlike most large estuaries in South Africa, there is no major urban settlement around the mouth of the Olifants estuary, apart from the tiny village of **Papendorp**. There is a guesthouse at Papendorp, and at **Ebenhaesar**, about 10km up the estuary, locals have established a guest house and camping area. The nearest resort town is **Strandfontein**, situated on the coast just south of the estuary. Visitors to this area fish in the estuary as well as off the coast.

6.11.2 Freshwater angling

Invasive alien species were introduced to the Olifants River System between 1920 and 1940 in order to “improve the fishing”. Unfortunately, all of these species had a devastating effect on small and large indigenous cyprinid species. In particular, wherever the smallmouth bass occurred after introduction, the smaller redfin minnows were eliminated and larger cyprinids suffered from poor recruitment. The indigenous fishes have been further impacted by the expansion of agricultural development in the Olifants system and the small and large dams in the system, particularly the Bulshoek and Clanwilliam dams, which prevent upstream spawning, and the loss of water quantity and quality due to abstraction (Impson 2004). In the Doring River, indigenous species now occur in very low numbers, while alien invasive species such as bass and bluegills are abundant (Impson 1999).

Fresh water angling is an important attraction to the Olifants/Doring catchment area and both locals and tourists visit the area specifically for fishing. Freshwater angling takes place at sites throughout the catchment, and some accommodation enterprises offer fishing in their farm dams and smaller streams running through their properties. All fresh water fishing can only be done with a permit, regulated by Cape Nature Conservation who sells licences directly and also indirectly through some tourism bureaus for the Western Cape. Freshwater anglers are encouraged to catch and kill alien species such as bass, bluegill and carp but fishing for yellowfish and sawfin has to be practiced on a catch and release basis.

Freshwater fishing comprises coarse fishing for the exotic species (bass, bluegill and carp) throughout much of the catchment, but mostly in the dams (small or large), and flyfishing for indigenous species, such as Clanwilliam yellowfish and Clanwilliam sawfin, mostly in the smaller stream in the upper parts of the catchment. Rainbow trout have been introduced into dams in the headwaters of the Doring in the Kouebokkeveld as the highlands are cool enough even in summer for trout. The trout are kept in dams that are almost entirely syndicate/privately owned and are therefore not generally accessed by public, and flyfishing for trout is therefore a very small industry. Brown trout are found in the Olifants gorge.

The recreational fishery is dominated by the exotic fishery, and is mainly for black bass in Clanwilliam Dam, and to a lesser extent in Bulshoek dam. The section of the Olifants River near Citrusdal and the Clanwilliam Dam is also popular mainly for catching black bass. The Clanwilliam dam and other bass fishing areas are used for fishing every throughout the year but are especially busy during the flower season (August to September) and over the December-January holidays (Marthinus September, Clanwilliam Dam Resort, pers. com). The town of Clanwilliam hosts no less than three Bass “classics” and two provincial tournaments, with each event hosting at least 100 participants over a weekend, and many of these staying longer. In addition, most of the Cape Bass clubs will hold at least one club outing on the Clanwilliam Dam (S. Kulenkampff, South African Federation of Artificial Lure and Fly Fishing Association and South African Bass Anglers Association *in litt*.). These outings would result in considerable expenditure in the area. Indeed, one of the biggest obstacles to conservation and control of exotic species is the high value of the bass, carp and trout fisheries, especially bass in the Olifants/Doring, where annual expenditure is probably in the millions.

In comparison, fly-fishing for indigenous species is a relatively specialised hobby. Even though this is becoming a more popular sport among fly-fishermen (as opposed to trout-fishing elsewhere), opportunities for fishing for yellowfish and sawfin are relatively small, due to bass having virtually eliminated them from most of the catchment. Where bass exist, indigenous fish are outcompeted and only occur in very small numbers, which are too low to support recreational angling for those species. The value of indigenous fly-fishing probably only about 10 – 20% that of bass-fishing (D. Impson, Cape Nature, pers. comm.), and is probably fairly small compared with the value of flyfishing in other parts of the country (Turpie et al. 2004).

Both indigenous and alien fishes are likely to be affected by changes in flow under the different scenarios considered in this study. Indigenous fish abundance is mainly affected in the lowest reaches of the Olifants (2 and 8), and along the Doring in the most developed scenarios (4 and 5; Table 6.11). However, impacts are not felt in the areas where most indigenous freshwater fishing takes place. Moreover, the value of this fishery is so small that these changes would not make a measurable impact.

Table 6.11 Percentage change from present day in indigenous fish abundances in reaches represented by EWR Site (C. Brown, *in litt*.)

Scenario	**EWR site**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0 (Nat)	unknown							
1 (PD)	0	0	0	0	0	0	0	0
2	0	+0-20	0	0	0	0	0	+0-20
7	0	+0-20	0	0	0	0	0	+0-20
5	0	0	0	0	0	0	0	+0-20
17	0	0	0	0	-40-60	0	0	-10-20
10	0	0	0	-40-60	-60-80	0	0	-10-20

The flow changes encompassed in the scenarios would affect alien fishes in the lowest reaches to some degree (Table 6.12), with species such as bass being favoured by the highest development scenarios. However, the value of this impact was not evaluated in this study because (a) the river forms only a small proportion of the value of the bass fishery, which is mainly in the dams, and (b) there is no available information on the size or value of the bass fishery. Proper valuation of this fishery would require extensive surveys, and if carried out, would probably not be able to detect the impact of such small changes in fish stocks.

Table 6.12 Percentage change from present day in alien fish abundances in reach represented by EWR Site (C. Brown, *in litt*.)

Scenario	**EWR site**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0 (Nat)	unknown							
1 (PD)	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	-0-10
7	0	0	0	0	0	0	0	-0-10
5	0	0	0	0	0	0	0	-0-10
17	0 0	0	0	0	0	0	0	+0-20
10	0	0	0	0	0	0	0	+0-20

A modest amount of recreational angling also takes place on the Olifants estuary. The value of this activity is described in more detail in section 6.10.

6.11.3 River Rafting and Kayaking

During late winter and early spring, depending on amount of rain and snow-melt, the Doring River offers some challenging white water rafting. Four rafting companies offer white water rafting from Klawer. Mainly one or two day trips are available although shorter trips are offered, often through other companies as part of a tour which includes flower viewing and hiking. Most of the trips take place on the stretch of the Doring River above the confluence near Klawer between the end of June and September, with each company running between 15 and 20 trips over the season. Some companies offer rafting from Clanwilliam as well (The River Rafters staff pers. com.). Some of the accommodation establishments in the Olifants/Doring Catchment, such as Oudrif guest farm, offer guests use of canoes for paddling on nearby rivers, streams or dams. These activities are unlikely to be significantly affected by the scenarios considered in this study.

6.11.4 Clanwilliam Dam

Clanwilliam Dam is a major attraction to the area as it provides opportunities for boating and swimming as well as fishing activities described above. The main users are Clanwilliam Aquatic Club, Clanwilliam Municipal Dam Resort, four residential developments – one including a nature resort and one including a golf course, and a private home.

The Clanwilliam Aquatic Club is located on the eastern bank of the Clanwilliam Dam. The club has approximately 140 members and facilities consist of a clubhouse and slipway and the majority of activities at the club are linked to boating (Barbour and Van de Merwe, 2005).

The Clanwilliam Municipality Resort consists of 300-400 serviced caravan/camping stands and a number of "permanent" mobile homes. The resort is used through out the year and is also used during local events associated with the dam such as the Bass Classic fishing competition and the Clanwilliam Dam Triathlon (Barbour and Van de Merwe, 2005).

Residential developments at Caleta Cove, Nooitgedacht Nature Resort, Sederview Farm and Kransvlei Golf Estate are all in various stages of development and once completed will increase the use of Clanwilliam Dam significantly. All of these user groups will be affected in some way by any increase in the height of the Clanwilliam Dam wall (see Barbour and Van de Merwe, 2005).

6.11.5 The Olifants estuary recreational fishery

A total of 67 000 recreational anglers and 5700 cast netters are estimated to use estuaries in South Africa. On the west coast, recreational angling in estuaries is limited, primarily due to lack of suitable angling fish, with an estimated effort of up to 4400 angler days per year in total (equivalent to about 147 anglers). All the effort is currently recreational, although about 14% of these anglers admit to selling part of their catch (Lamberth 1996). Cast nets are used regularly by about 95 recreational shore anglers in west coast estuaries, almost exclusively targeting harders, with a total effort of about 2837 angler days per year.

The Olifants estuary line-fishery comprises recreational shore-angling and limited recreational boat fishing. The boats used range from small dinghies to ski-boats of 6 m in length. On the Olifants, the bulk of the effort is from shore angling and boat use is minimal. Based on angler densities on the adjacent shorelines and angler and boat counts in the Berg and Olifants estuaries, there may be up to 0.12 anglers per km of estuary or a maximum of 4

400 angler-days per year expended in west coast estuaries from the Berg River northwards (Lamberth & Turpie 2003). The gear used ranges from hand lines to fishing rods of various shapes and sizes, including fly-rods. All the effort is currently recreational although approximately 14% of these anglers admit to selling part of their catch (Lamberth 1996).

Recreational anglers catch an estimated 14 – 20 t of marine line-fish in estuaries on the west coast annually, 1 - 2 t (8 %) from the Olifants Estuary. Recreational anglers catch a further 0.1 t of harders using cast-nets as well as a small but unknown quantity of freshwater fish, mostly the introduced species such as Mozambique tilapia *Oreochromis mossambicus* and smallmouth bass *Micropterus dolomieu*. The bulk of the Olifants Estuary linefish catch is made within 500 m of the mouth and comprises silver kob, Angolan kob *Argyrosomus coronus*, white steenbras *Lithognatus lithognathus*, west coast steenbras *L. aureti* and elf. Of these, the stocks of silver kob and white steenbras are collapsed and those of elf and west coast steenbras are overexploited. Estuarine fish stocks cannot be considered as discrete and in isolation from the marine environment. The current status of estuarine stocks is largely a reflection of the nationwide decline that has occurred for most line-fish species.

The economic value of the recreational fishery was considered in terms of the expenditure on fishing by recreational fishers (= income to subsidiary industries such as accommodation and fuel). While the commercial and traditional fisheries are forms of generating cash or subsistence income, and are largely valued in terms of the market value of their catches, the value of recreational angling does not lie mainly in the market value of the fish caught. Recreational anglers value the sport and experience, and expend considerable sums on this activity, largely irrespective of their catch returns (McGrath *et al.* 1997). The value attributed to this fishery is mostly in terms of gains to subsidiary industries that benefit from angler expenditure (McGrath *et al.* 1997). Based on regional estimates of recreational value, the fishery is estimated to be worth between R561 600 and R1 259 200.

Changes in the recreational catches under different scenarios were estimated based on the methodology described for the small scale fishery and the contribution of different types of species to the catch.

Table 6.13. Contribution of estuary associated species to the recreational fishery and estimated percentage abundance of different categories of estuarine fish species under different scenarios relative to present conditions

Category of main species	**Contribution to recreational catches**	**Scenario**				
		2	7	5	17	10
IIa	0.7%	130	128	112	60	50
IIc	94%	88	88	97	81	84

Catches remain least affected under scenario 5 (about 97% of present). Under scenarios 2 and 7 catches are reduced to about 89% of present catches, while they are reduced to about 82% and 85% of present catches under scenarios 17 and 10, respectively (Table 6.4). These changes are considered to be too small to have a measurable impact on the value of the recreational fishery.

Table 6.14. Estimated estuarine fish catches (tons per year) under the different scenarios

Fishery		**Scenario**					
		Present	**2**	7	5	17	10
Olifants recreational	Lower	1	0.9	0.9	1.0	0.8	0.8
	Upper	2	1.8	1.8	1.9	1.6	1.7

6.12 MACROECONOMIC IMPACTS OF CHANGES IN ECOSYSTEM QUALITY

The overall macro-economic impacts of the changes in ecosystem goods and services described above are summarised in Table 6.15. These are compared with the value of changes in water yield in the final section.

Table 6.15 Present values and values of fisheries under different scenarios (R millions).

	Baseline	**Sc 2**	**Sc7**	**Sc5**	**Sc17**	**Sc10**
Impact on Surplus Value	2.90	-0.13	-0.06	-0.03	-0.20	-0.13
Impact on GDP	3.97	-0.17	-0.07	-0.04	-0.27	-0.17
Low Income HH	0.41	-0.019	-0.008	-0.005	-0.031	-0.019
All Income HH	0.70	-0.031	-0.013	-0.007	-0.048	-0.0301
Impact on Labour Numbers	124	-7	-4	-2	-12	-7

7 VALUE GENERATED BY WATER USE AND IMPLICATIONS OF DIFFERENT SCENARIOS

7.1 INTRODUCTION

The scenarios have an influence on the volume of water available for use, especially by the irrigators. While two of the scenarios reduce the water available for irrigation, the others are linked to the raising of Clanwilliam Dam, which will make more water available to irrigators.

This section describes the economic value generated by the use of water in irrigation agriculture in the Olifants/Doring Catchment, and the way in which economic outputs will change under the different scenarios. These impacts are determined in terms of macroeconomic performance indicators such as Gross Domestic Product (GDP), capital formation, household income and expenditure and employment creation.

7.2 APPROACH

Estimated water volumes, irrigation area and production income were used in the Water Impact Model (see chapter 5) to calculate the macroeconomic impacts. The water impact model was originally developed for DWAF as part of a project in the Letaba Basin. It is populated with a series of multipliers sourced from a relevant Social Accounting Matrix (SAM) which are used to estimate the direct, indirect and induced economic impacts.

For the purposes of this project, permission was obtained from the Western Cape Department of Agriculture to use their regional SAM to calculate the multipliers and populate the Water Impact Model.

7.3 ASSUMPTIONS

The following assumptions regarding agricultural water use and economic characteristics were applied.

7.3.1 Irrigation Area

The area analysed was the Lower Olifants sub-catchment and although the irrigation area is not available with a high degree of confidence it was accepted that no major changes in cropping pattern has taken place in the last few years. The wine and grape areas appear to be reasonably correct according to sources in the KWV.

The available sources differed considerably in terms of estimates of the total area under irrigation and a figure of 11680 hectares was used as a compromise between the conflicting total area and the individual crop areas cultivated.

7.3.2 Irrigation Water Use

As irrigation uses more than 90% of the water in the lower Olifants region it was decided to assume that the water provision to the other users will not be effected. Any change in economic impact can only be measured against the present situation. It was therefore necessary to estimate the present situation as best as possible. Available information on irrigation water is summarised in Table 7.1.

Table 7.1 Use of irrigation water in the lower Olifants region

Crop	Hectares Irrigated	Volume per Hectare m^3/ha
Deciduous Fruit	200	9 400
Wine Grapes	5 586	8 000
Vegetables	840	7 000
Pastures	440	13 000
Table Grapes	4 614	10 000
Total	**11 680**	

Estimates of water allocation per hectare for the different crops namely, deciduous fruit, wine grapes and table grapes, were obtained from DWAF. As no data are available on the precise breakdown of vegetables produced an average volume of 7000m^3 was used. The volume applied to the pastures is a deduced volume to bring the total water usage and cultivated area into equilibrium. It is important to note that agriculture is dynamic and that areas would change on an annual basis.

All though these volumes only give a present day use of 140.6 Mm^3 it was accepted that the rest is used by other sectors.

7.3.3 Water Changes

It was assumed that if any volume restrictions were to take place the producers would react similarly in that they would first restrict the less high value crops and then the high value crops. In a choice between vegetables and orchard crops they would firstly cut back on the vegetables because of the high costs involved to establish orchards.

If more water was to become available it was assumed that the additional irrigation area would be available and that the farmers would rather opt for the high value crops than the lower valued ones like pastures and lucerne production.

It was also assumed that no upgrading to more efficient irrigation systems would take place if water was restricted.

7.3.4 Economic Structure

The Department of Agriculture Commodity Budgets (COMBUD) was used to develop a structure for each crop to be used in the impact model. Data on the turnover and labour inputs of typical farms in the Olifants/Doring Catchment (Table 7.2) were used together with published cost indices to upgrade the Combud costs to 2005 prices.

Table 7.2 Turnover and employment for typical farms in the irrigation-farming sector (J. Laubscher, agricultural economist – Clanwilliam Dam raising impact study, *in litt*.).

Type of crop	Location	Typical farm size (ha)	Turnover R/ha	Employment		
				Manage-ment	Permanent labour	Seasonal labour
Citrus	Citrusdal & Clanwilliam	70	R60 000	2	11	70 for 5 months
Wine grapes (plus vegetables)	Melkboom, Klawer, Vredendal, Lutzville	75	R40 000	2	12	40 for 3 months
Table grapes	Melkboom, Klawer, Vredendal	25	R160 000	2	16	60 for 4 months

7.4 LIMITATIONS

As the study was performed at a desktop level it must be accepted that major limitations are present in the calculations. A number of them are discussed in the following paragraphs.

7.4.1 Crops Cultivated

The data on which the crop analysis is based are old and no new data are available. Agriculture has undergone major restructuring since 2000 and a proper surveyed set of data would have improved the quality of the results.

In the scenarios that could lead to more water being available for irrigation it was accepted that the mix of crops produced at present would be the ones considered for the additional irrigation area becoming available. It does not, however, take into consideration any differences in soils or the long term prospects of any crop.

7.4.2 Irrigation Equipment

The availability of data on the type of irrigation equipment used at present would also improve the results as different systems have different labour requirements and water use efficiencies.

7.4.3 Production Cost Data

The production cost used in the analysis was based on old data upgraded by the use of different indices as published by the National Department of Agriculture. These indices are based on national figures that might not be applicable for this area.

7.4.4 Pollution externalities

It should be noted that in the Olifants/Doring catchment, agricultural pollutants may exceed the absorption capacity of the system, having a negative impact on downstream water users. The increase of irrigation area under some scenarios may thus carry additional external costs on downstream users, which means that the outputs may not be as high as predicted. This effect could not be quantified.

7.5 RESULTS

In the table below the present day baseline with the incremental change is presented.

Table 7.3 Present-day values and values of irrigation under different scenarios (R millions)

	Present	Sc 2	Sc7	Sc5	Sc17	Sc10
Impact on Surplus Value	R364.84	R-66.02	R-10.66	R+359.80	R+437.17	+R647.55
Impact on GDP	R1299.38	R-270.74	R-36.42	R+1231.78	R+1538.73	R+2265.91
Impact on Capital	R2796 .31	R-584.35	R-71.58	R+2637.56	R+3314.84	R+4870.75
Low Income HH	R199.60	R-36.84	R-5.01	R+192.73	R+237.77	R+350.04
All Income HH	R452.49	R-87.22	R-11.22	R+435.28	R+538.23	R+790.61
Impact on Labour Numbers	13 253	-4788	-756	+ 9976	+14 078	+20 274
Hectares	11 640	6 122	11 240	20 554	25 960	33 212

The results suggest that scenario 2 will have a very negative influence and scenario 7 a somewhat negative influence on the Lower Olifants economy. As far as employment is concerned a total of 4788 jobs will be lost under scenario 2, of which 2537 (53%) would be directly employment in agriculture. It would also have a very negative impact on low income households with a 18.5% decrease in income to the poorer section of the community. Scenario 7 will also have a negative influence but to a much lesser degree and in this case it is the impact on direct employment (385) which is probably of greatest concern.

The other scenarios will all have varying degrees of positive influences on the macro economic indicators of the Lower Olifants Valley.

8 IMPACT OF SCENARIOS ON SOCIAL WELL-BEING

8.1 INTRODUCTION

This Section provides a discussion of the socio-economic impacts of the different scenarios, based on the results generated in the previous Sections.

8.2 IMPACTS OF CHANGES IN THE GILL-NET FISHERY

The well being of the Ebenhaesar community will be affected both by changes in the estuarine fish resources and changes in water allocation for irrigation under the different scenarios.

The scenarios affect income flows amongst the 45 - 75 fisher households who are dependant on fishing for their livelihoods. Because 80% of households in the Ebenhaesar community along the estuary have been classified as poor, a change in yield will make a difference but because income generation from fish is so low – and is often a negative return according to January's report (EEU 2004) once costs for broken nets and so forth have been accounted for, the effects of diminished returns in the case of scenarios 2, 7, 10 and 17 are not going to make much difference. For the same reason, changed yields as per scenario 5 will not have much effect on financial flows.

Of households who rely on fishing, 60% get 25 – 50% of their summer income from fishing and the remaining 40% of fishing households obtain 75% of household income from fishing. The latter households would be particularly badly affected under scenarios 10 and 17.

There may also be impacts on household nutrition and health for the community as a whole because the nutrition value of fish is high. Some 64% of households in the Ebenhaeser community eat fish at every meal time (January 2004). The nutritional value of harders that are consumed cannot be underestimated because it not only reduces outgoing income flows because less protein needs to be purchased, but it impacts positively on nutritional intake of protein and other minerals that are of high value in fish. Under scenario 2, 7, 17 or 10, households who reportedly eat fish daily will be deprived of the nutritional value of this high protein food. The impact would be negligible in the case of scenario 5.

8.3 IMPACT OF CHANGES IN IRRIGATION ON LIVELIHOODS

In a survey of the Ebenhaesar community, the most common answer given for alternative livelihoods for households who were reportedly 'extremely poor' was agriculture (January 2004). Thus improved access to water for irrigation will make a difference to livelihood strategies of the poorest of the poor. Because individuals want to grow crops, improved access will be favourable. However, without capital investment it is unlikely that improved access to water alone will take poor households out of their cycles of poverty endemic or chronic poverty. Equity initiatives such as water-wise community organic food garden or irrigation water use plans (DWAF ISP 2005b) are also building blocks for improved agricultural activities in particular areas, such as Ebenhaesar. This is where the linkages between social cohesion and income become critical. It is likely that in areas where there is good co-operation between those with skills – and resources – transfers will take place. In these cases, improved access to water is likely to improve livelihoods and scenario 5 will make a difference to income flows and improve levels of well being.

The DANIDA/DWAF activities in the Olifants/Doring Catchment are likely to impact more positively on changes in allocation of water because focussed efforts have been made to improve awareness about water issues and to build capacity in the area. Scenario 2 will have a negative effect on labour - -5 770 people – and this means an immediate reduction in income flows in and out of households. Losing 5 770 jobs is going to make more households more vulnerable and this scenario will affect all zones. It will have the most effect amongst the rural poor who are working as agricultural labourers but it will affect income generation amongst the poor in the towns. As the majority of households in the WMA are classified as poor, scenario two will make at least 5 770 households more vulnerable.

On the other hand, scenario 5, 7, 17 and 10 can only have positive impacts on household income flows with the most impact made in adopting scenario 10 because as many as 23 018 individuals will gain employment and this means that households where all economically active adults are unemployed will be better off if one of their household members is working but it also means that households where there is already a wage worker, incomes will be improved by having two earners. An estimated additional R873.53 will be gained in wages. Scenario 17 also has considerable impact on earning capacity because as many as 15 185 additional people will be earning a wage and household incomes will be increased overall by an estimated R581.19 rand.

Changes in scenario have slightly different impacts within the context of each socio-economic zone. For instance in the Lower Olifants Irrigation there are 22% who work in fishery or agricultural related activities. Amongst these, there are 31% who earn only between R401 and R800 a month. Increased opportunities for labour will give more people an opportunity for work – but if it is at the meagre wage rate noted here, this is unlikely to improve living conditions amongst the poorest of the poor. On the other hand, if increases in yields result in improved wages, at least those 22% who work in fishery or agricultural related activities would make financial gains. The most impact would be made if scenario 10 were adopted, followed by scenario 17 and then 5. Scenario two will disadvantage all wage workers in the agricultural and fishery section but will not affect those who are working in Vredendal on manufacturing or in the vicinity of Vredendal and VanRhynsdorp on Namakwa Sands mining operations. DWAF (2002) notes that some of the manufacturing activity in Vredendal is linked to the regions agricultural activities and these activities could also be affected negatively in the case of Scenario 2 and positively in the case of Scenarios 5, 17 and 10.

In the Upper Olifants Irrigation Farming area, more households are poor and any changes in agricultural activity would be likely to affect these households. In other words, because there are more households who are poorer in this socio-economic zone than in the Lower Olifants, they are likely to feel any external stressors more acutely. Poverty is most felt in the rural parts of the Upper Olifants but in the towns of Citrusdal and Ceres most households are also poor. However, the changes are most likely to be felt in the lower catchment.

In the Koue Bokkeveld the value added crops, such as dried fruit, wine, citrus and rooibos only bring gains to very few people and most of the individuals who work in agriculture, fishery or related industries as labourers are earning extremely low wages. Here again, as is the case in the Lower Olifants, improved wages would improve living conditions but supplying more jobs for more people at the same wage rates – averaging between R401 and R800 per month will not reduce endemic poverty in this region. In any case, the scenarios are unlikely to impact on this zone.

9 SUMMARY OF RESULTS

This study has considered five scenarios (Table 9.1) for development of water resources in the Olifants/Doring Catchment in terms of its socio-economic impacts, both through changes in water available for use and changes in the supply of ecosystem goods and services.

Table 9.1 Scenarios considered in the socio-economic study, and the Mean annual runoff (MAR in Mm^3/a) at the estuary associated with each scenario.

Scenario	Description	MAR	Yield to schemes
1	Present day conditions, i.e. with no Reserve releases	715.0	148
2	Present Day level of development and meeting the Reserves for the REC (recommended ecological category) at each of eight EWR sites along the river	800.3	84.6
7	Raising Clanwilliam wall (15 m) and meeting the Reserves for the REC (recommended ecological category) at each of eight EWR sites along the river	741.5	135
5	Raising Clanwilliam Dam by 15 m and meeting the Reserves for the REC at 5 of the 8 EWR sites along the river, excluding sites 2, 7 and 8	605.7	258
17	Raising Clanwilliam Dam by 15 m, plus an abstraction weir at Melkbosrug (Brandewyn option) in the Doring catchment and meeting the flow requirements of the Reserve at 4 of the 8 EWR sites, excluding sites 2, 5, 7 and 8.	529.3	317
10	Raising Clanwilliam Dam by 15 m, plus an abstraction weir at Melkbosrug (Brandewyn option) in the Doring catchment, but with no River EWR releases. This development would maximise the yield from the Olifants / Doring River system.	423.5	408

A range of ecosystem goods and services provided by aquatic ecosystems were considered. Their importance in the Olifants Doring was assessed (Table 9.2), and those for which there was both significant value and this value was likely to be affected by the scenarios were considered in more detail.

Freshwater recreational fisheries are likely to be impacted under some of the scenarios, but this impact was considered to be negligible.

The estuarine gill-net fishery at Ebenhaesar is likely to be impacted to some extent, with losses of up to 20% in the most developed scenario (Table 9.3). These impacts do not translate into a high economic value, but have an important livelihood impact, both in terms of reduction in income and nutrition.

The recreational estuarine fishery is similarly impacted, but the changes in fish abundance area unlikely to have a measurable impact on utility and hence recreational expenditure (Table 9.3).

Table 9.2 Summary of aquatic ecosystem values.

	Ecosystem Goods, Services & Attributes	Description	Value
Goods	**Water**	Negligible use for basic human needs	Not valued
	Food, medicines and grazing	Subsistence estuarine fishery at Ebenhaesar	R0.5 – 0.6 million / annum
	Raw materials	Sand mining near Klawer	R35 000 / annum
Services	**Gas regulation**	Carbon sequestration assumed to be negligible	Unlikely to affected by scenarios, not valued
	Disturbance regulation	Flood attenuation possibly important but unknown	Unlikely to affected by scenarios, not valued
	Water regulation	Timing of flows probably regulated by upper catchment aquatic systems, but not been studied,	Unlikely to affected by scenarios, not valued
	Erosion control and sediment retention	Downstream erosion likely if Doring system dammed, effect unquantified	Not valued, losses could be >R100 000 per ha
	Waste treatment	Several sources of pollution benefit from the carrying capacity of the system; load capacity and actual loads unknown	Not valued, estimation of impacts under different scenarios would require further study
	Nursery areas	Olifants estuary provides important nursery area for West Coast fisheries	Value R3.45 million in contribution to commercial and recreational fisheries
\Attributes	**Genetic resources**	There are some unique biological materials and products that may have future potential value	Unlikely to affected by scenarios, cannot be valued
	Structure and composition of biological communities	There is extensive recreational and tourism use of the Catchment, with several activities being water based, though generally on a fairly small scale	Estuary fisheries R0.6 – 1.3 million per annum, and likely to be impacted by scenarios. Freshwater fishery values unknown but probably significant. Effect of scenarios very slight. Other recreational activities unlikely to be affected by scenarios.

The nursery value of the estuary is most important from an economic perspective, contributing some R3.45 m to the value of West Coast fisheries. Losses of up to R0.76 m per year are incurred in the most developed scenario

The overall economic impact of the changes in ecosystem quality (in terms of GGP) are estimated to range from R40 000 under scenario 5 to R270 000 under scenario 17. These are effectively negligible losses.

Table 9.3. Estimated value of estuarine fisheries under the different scenarios (R millions per annum).

Fishery		Scenario					
		Present	**2**	7	5	17	10
Olifants gill-net	Lower	0.491	0.436	0.436	0.478	0.403	0.417
	Upper	0.630	0.559	0.559	0.612	0.517	0.534
Olifants recreational	Lower	0.562	0.562	0.562	0.562	0.562	0.562
	Upper	1.259	1.259	1.259	1.259	1.259	1.259
TOTAL	**Lower**	**1.053**	**0.998**	**0.998**	**1.039**	**0.965**	**0.979**
	Upper	**1.889**	**1.818**	**1.818**	**1.871**	**1.776**	**1.793**

Table 9.4 Estimated change in value of the West Coast recreational and commercial fisheries under different flow scenarios (R millions).

	Scenario					
	Present	**2**	**7**	**5**	**17**	**10**
Recreational fisheries*	341.7	341.5	341.5	341.7	341.2	341.5
Commercial fisheries	305.0	304.9	304.9	305.0	304.7	304.9
Total fisheries value (lower bound)	646.7	646.6	646.6	646.7	646.4	646.6
**Total fisheries value (upper bound) ** **	646.7	646.4	646.4	646.6	645.9	646.4
Change from present (lower bound)		- 0.07	- 0.08	- 0.01	- 0.28	- 0.07
Change from present (upper bound)		- 0.25	- 0.26	- 0.05	- 0.76	- 0.25
Nursery value (lower bound)	3.45	3.38	3.37	3.44	3.17	3.38
**Nursery value (upper bound) ** **	3.45	3.20	3.19	3.40	2.69	3.20

*estimated maximum change assuming anglers respond to changes in catch rates
** upper bound estimates assume no change in recreational value

Table 9.5 Present values and values of fisheries under different scenarios (R millions).

	Baseline	**Sc 2**	**Sc7**	**Sc5**	**Sc17**	**Sc10**
Impact on Surplus Value	2.90	-0.13	-0.06	-0.03	-0.20	-0.13
Impact on GDP	3.97	-0.17	-0.07	-0.04	-0.27	-0.17
Low Income HH	0.41	-0.019	-0.008	-0.005	-0.031	-0.019
All Income HH	0.70	-0.031	-0.013	-0.007	-0.048	-0.0301
Impact on Labour Numbers	124	-7	-4	-2	-12	-7

In comparison, the economic losses and gains under the different scenarios due to changes in water use are orders of magnitude higher. GDP losses under scenarios 2 and 7 are in the order of R14 to R300 million, and gains range from R1 – 2.5 billion under scenarios 5, 17 and 10 (Table 9.6). There are also considerable social benefits in the form of increases in employment.

Table 9.6 Present values and values of irrigation under different scenarios (R millions).

	Baseline	**Sc 2**	**Sc7**	**Sc5**	**Sc17**	**Sc10**
Impact on Surplus Value	R364.84	R-66.02	R-10.66	R+359.80	R+437.17	+R647.55
Impact on GDP	R1299.38	R-270.74	R-36.42	R+1231.78	R+1538.73	R+2265.91
Impact on Capital	R2796 .31	R-584.35	R-71.58	R+2637.56	R+3314.84	R+4870.75
Low Income HH	R199.60	R-36.84	R-5.01	R+192.73	R+237.77	R+350.04
All Income HH	R452.49	R-87.22	R-11.22	R+435.28	R+538.23	R+790.61
Impact on Labour Numbers	13 253	-4788	-756	+ 9976	+14 078	+20 274
Hectares	11 640	6 122	11 240	20 554	25 960	33 212

The value of developing water resources generally appears to far outweigh the environmental costs, with overall changes in value being increasing positive for scenarios 2, 7, 5, 17 and 10 (in that order). Environmental costs are dominated by estuary fishery values and are lowest for Scenario 5, followed by Scenario 2 and Scenario 7. The range of error in estimation of environmental costs is also likely to be relatively greater than that for agricultural output.

It is important to note that while the environmental costs are low in economic terms they may be considerable in terms of some people's livelihoods. None of the scenarios meets the Pareto criterion that a development should not make anyone worse off, but Scenario 5 is closest to this in that it has the smallest impact on the value of ecosystem goods and services. Under scenario 5, the impacts on estuarine fisheries and nursery value are lowest, and thus so are the impacts on the livelihoods of small-scale fishers of Ebenhaeser, many of whom do not benefit from agriculture. This is a critical issue, since these households are very poor and thus extremely vulnerable. However, it is also very important to remember that MCM is planning to eventually phase out the Ebenhaesar fishing licences, using an alternative livelihoods approach. In this respect, the provision of irrigation water to this community would provide a development opportunity.

It should also be noted that the environmental costs and benefits of the different scenarios were only partially estimated, in that they not include non-use values such as option and existence value. For example, if the area around the Olifants estuary becomes developed, the quality of the estuary could have a very measurable impact on tourism expenditure and real estate value. Option and existence value of genetic diversity and rare species such as the endemic fish species found in the catchment was not included in the study. The estimates also do not include external costs such as impacts of reduced water quality which could have a significant impact on agricultural output. The choice of scenario should thus be driven by consideration of biodiversity impacts as well as the measurable economics impacts.

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