CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE OLIFANTS WATER MANAGEMENT AREA: (WMA 4) - WP 10383

Report On Socio-Economic Evaluation Framework and the Decision Analysis Framework
Analysis Scoring System

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Preamble

This document is a progress report to the Department of Water Affairs (DWA) on implementation of the Water Resource Classification System (WRCS) in the Olifants Water Management Area (WMA). This report deals specifically with the socio-economic components of Steps 1 and 2 of the WRCS. It thus follows the guidelines as set out in the "DWA Regulations for the Establishment of a WRCS" gazetted on 17 September 2010[1], and the of DWA technical guidelines on implementation of the WRCS (DWA 2007).

This document thus provides the economic rationale for delineation of Integrated Unit of Analysis (IUAs), and thereafter summarises available economic data describing the communities and economies of Olifants WMA, by IUA.

The document further analyses the work done to date (DWA 2010a) on the state of aquatic ecosystem services in the Olifants WMA, and use this work as a basis for determining the relationships between economic value, social well-being and ecosystem characteristics.

The key output of this document is a proposed decision-analysis framework for the analyses of scenarios in the latter steps of this project, and thus links the socio-economic and ecological value and condition of the relevant water resources.

The water resources of the Olifants WMA are natural assets that produce raw water and other aquatic ecosystem services. The raw water is used as an input in economic production, whilst the other aquatic ecosystem services are mostly directly used by households. Various economic sectors produce a variety of goods and services, many of them consumed as intermediate goods and services, but ultimately consumed by households. Households provide labour to the economic production process. Finally, the economic production process also produces a variety of effluents, which end up back in the aquatic environment as pollutants.

Total economic production of goods and services, measured as Value Added (VAD)[2], was approximately R135 billion in 2010. In contrast, the value of aquatic ecosystem services in that year was only R1, 350 million (DWA 2010a), thus contributing only 1% of the value added to the Olifants WMA economy. However, this aquatic ecosystems valuation excludes a number of important transactions relating to water resources. Firstly, two key ecosystem services were inadequately captured in the analyses: water regulating services and health services. Secondly, the damaging effects of emissions in the form of water pollutants and sedimentation emitted into aquatic ecosystems (i.e. water resources) are key environmental externalities, and have thus far not been addressed. Another externality not dealt with is the conservation cost of aquatic ecosystem stewardship function.

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[1] "DWA Regulations for the Establishment of a WRCS". No. R. 8107 Government Gazette (SA), 17 September 2010 No. 33S41

[2] Akin to Gross Domestic Product (GDP), and is formally defined as the sum of labour, company profits, taxes paid and interest earned.

In order to internalise the environmental costs and benefits into the production economy (and thus link the socio-economic and ecological value and condition of the relevant water resources), the relevant transactions can be modelled using four economic modelling techniques. These techniques, together, form the decision-analysis framework:

- Social Accounting Matrixes (SAMs), obtained from the Development Bank of Southern Africa (DBSA), model the transactions between economic production sectors and household consumption.
- Environmental Economic Accounts for Water (Water EEAs) model the transactions between economic production and water resources (and expands the Water sector component of the SAM).
- Environmental and Resource Economics (ERE) modelling, based on the Millennium Ecosystem Assessment framework, models the production of aquatic ecosystem services.
- The effects of water pollutants on water resources and households can be modelled in various ways, however in this case; we will simulate the economic effects of implementing a Waste Discharge Charge System (WDCS).

This decision-analysis framework lends itself to a cost-benefit analysis (CBA) for evaluating scenarios.

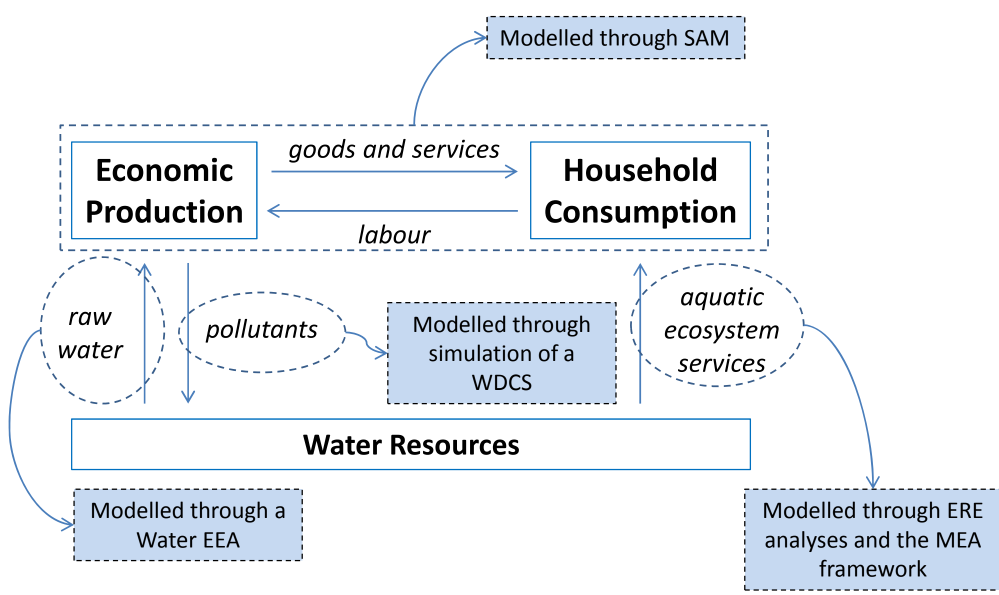

Figure 1. Schematic representation of the economic modelling techniques required to address the transactions of the Olifants WMA water economy.

List of Abbreviations and Acronyms

BIC	Bushveld Igneous Complex
COD	Chemical Oxygen Demand
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DBSA	Development Bank of Southern Africa
DMR	Department of Mineral Resources
DWA	Department of Water Affairs
EEA	Environmental Economic Account
ERE	Environmental Economic Accounts
GDP	Gross Domestic Product
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
K2C	Kruger To Canyons
KNP	Kruger National Park
MC	Management Class
Mt	Million tons
MEA	Millennium Ecosystem Assessment
NWA	National Water Act
PSP	Professional Service Provider (to DWA)
PGM	Platinum Group Metals
ROM	Run of Mine
SAM	Social Accounting Matrix
SEEAW	System of Environmental-Economic Accounting for Water
SEZ	Socio Economic Zone
SNA	System of National Accounts
VAD	Value Added
WHO	World Health Organisation
WMA	Water Management Area
WRCS	Water Resources Classification System
WTW	Water Treatment Works

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1 Background

1.1 Report objectives

The objectives of this report are to:

- Complete step 1 of Classification guidelines
  - Step 1(a) A description of the present-day socio-economic status of the Olifants WMA
  - Step 1(b) Key socio-economic zones and IUAs
  - Step 1(e) Communities and their wellbeing
  - Step 1(f) Describe and value the use of water
  - Step 1(g) Describe and value the use of aquatic ecosystems
  - Step 1(h) Define Integrated Units of Analysis (IUAs)
  - Step 1(i) Develop and/or adjust the socio-economic framework and the decision-analysis framework
  - Step 1(j) Describe the present-day community wellbeing within each IUA
- Complete step 2 of Classification guidelines
  - Select the ecosystem values to be considered based on ecological and economic data
  - Describe the relationships that determine how economic value and social wellbeing are influenced by the ecosystem characteristics and the sectoral use of water
  - Define the scoring system for evaluating scenarios

1.2 Data and data sources

The data sources for the socio-economic component of the Olifants WRCS study were both numerous and varied. The aim of this section is to give some insight on the data sources used and the assumptions that were made.

For population, number of households, employment, and access to piped water, the Statistics SA Census of 2001 was used. Although ten years old, the data still provides the most insight into the above-mentioned characteristics at a ward level. If time is available, the socio-economic characteristics will be updated with the results from the Census 2011.

For the agricultural component of the study several data sources were utilised. Land use and broad agricultural categories were determined by using land cover estimates derived from high-resolution satellite imagery published by the South African National Land Cover Project (CSIR, 2003). The crop types data was analysed from the Department of Agriculture, Forestry and Fisheries (DAFF) database (DAFF 2008). While the data is extremely detailed, it only covers Mpumalanga Province and no data is available for either Gauteng or Limpopo Provinces. While discrepancies in values for agriculture values (especially the area under irrigation) do exist, effort has been made to report on these discrepancies in this and in future reports.

For the mining component of the study several data sources were utilised. Annual production figures of minerals by Province were received from the Department of Mineral Resources (DMR). Information for individual mines was collected from annual reports.

1.3 Methodology: WRCS 7 Step Process

The Water Resources Classification System (WRCS), which is required by the National Water Act (Act 36 of 1998), is a set of guidelines and procedures for determining the desired characteristics of a water resource, and is represented by a management class (MC). The MC outlines those attributes that the Department and society require of different water resources. The WRCS prescribes a consultative process to classify water resources (Classification Process) to help facilitate a balance between protection and use of the nation's water resources. The outcome of the Classification Process will be the approval of the MC by the Minister or her delegated authority for every significant water resource (river, estuary, wetland and aquifer) which will be binding on all authorities or institutions when exercising any power, or performing any duty under the NWA (DWA 2011).

Steps 1 and 2 of the 7 step process proposed by the WRCS (DWA 2007a) are described in Figure 2 below. This component of the study is only concerned with certain steps within steps 1 and 2.

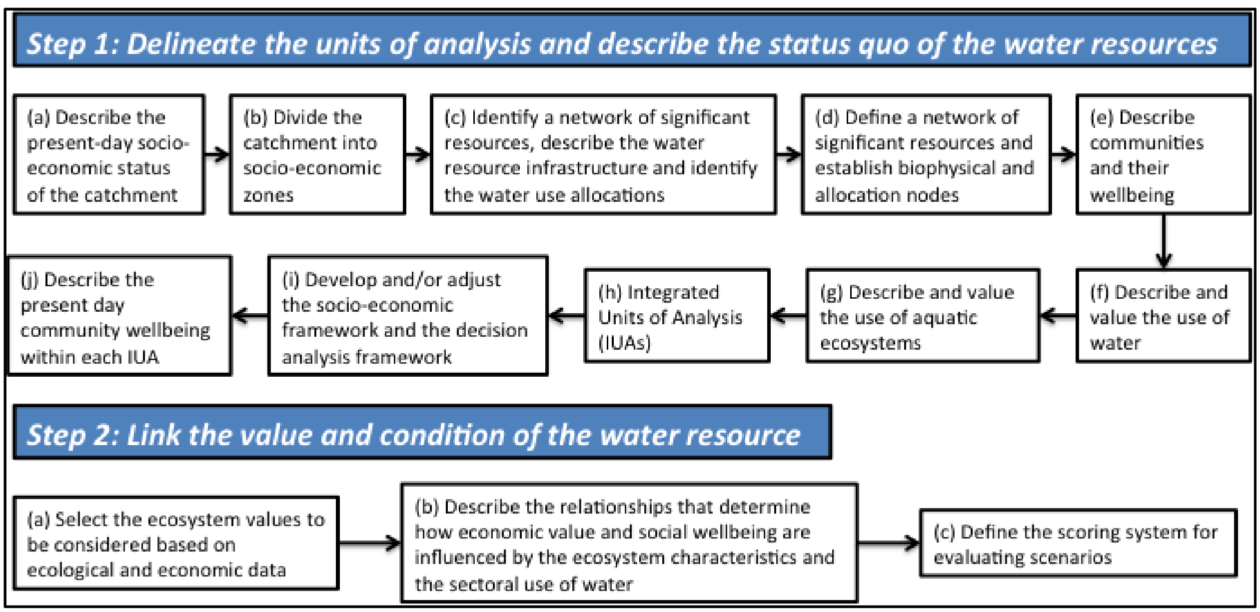

Figure 2. Steps 1 and 2 of the Water Resources Classification Study (WRCS) Guidelines

2 Step 1(a): Present Day Socio-Economic Status

2.1 Overview

The Olifants Water Management Area (WMA) is commonly divided into four sub-areas or zones; the Upper Olifants, Middle Olifants, Lower Olifants and Steelpoort sub-areas (Figure 3):

- Upper Olifants Catchment constitutes the catchment of the Olifants River down to Loskop Dam.
- Middle Olifants Catchment comprises the catchment of the Olifants River downstream from the Loskop Dam to the confluence with the Steelpoort River.
- Steelpoort Catchment corresponds to drainage region of the Steelpoort River.
- Lower Olifants Catchment represents the catchment of the Olifants River between the Steelpoort confluence and the Mozambique border.

The Olifants River is one of the major water resources in the area and it originates near Bethal in the Highveld of Mpumalanga. The river initially flows northwards before curving in an easterly direction through the Kruger National Park and into Mozambique where it joins the Limpopo River before discharging into the Indian Ocean.

The main tributaries are the Wilge, Elands and Ga-Selati Rivers on the left bank and the Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank. The Olifants River is shared by South Africa, Botswana, Zimbabwe and Mozambique (DWA 2011).

The Olifants WMA is one of the most economically important WMA's in South Africa. Economic activity in the WMA is highly diverse and is characterised by mining, metallurgic activities, commercial agriculture, dry land and subsistence agriculture and eco-tourism. The economy of the WMA is largely driven by the mining sector, with large coal deposits found in the Emalahleni and Middelburg areas and large platinum group metal (PGM) deposits found in the Steelpoort and Phalaborwa areas. The WMA is home to several large thermal power stations, which provide energy to large portions of the country. Extensive agriculture can be found in the Loskop Dam area, the lower catchment near the confluence of the Blyde and Oilfants Rivers as well as the in the Steelpoort Valley and the upper Selati catchment.

According to the DWA (2004), the Olifants WMA generates approximately 5% of South Africa's gross domestic product (GDP). The key economic drivers in the area are:

- Agriculture,
- Mining,
- Electricity,
- Tourism, and
- The value chains associated with the above sectors.

Figure 3. The Olifants Water Management Area and the four sub-areas

2.2 Land Use

Land use in the Olifants WMA is extremely diverse and consists of irrigated and dryland cultivation, improved and unimproved grazing, mining, industry, forestry and urban and rural settlements. A breakdown of land use and land cover is given in Table 3. Figure 4 is a map of land-use within the catchment based on land cover estimates derived from high-resolution satellite imagery published by the South African National Land Cover Project (CSIR, 2003).

Table 1. Land use and land cover in the Olifants Water Management Area (Source: CSIR 2003)

Land Use	Area (ha)
Natural vegetation	3 474 159
Grazing	1 689
Plantations	64 347
Wetlands & Water	56 422
Degraded	552 267
Permanent commercial cultivation	18 126
Temporary commercial cultivation	828 495
Subsistence cultivation	244 989
Urban (formal residential)	110 820
Urban (informal residential)	47 509
Urban (smallholdings)	6 841
Urban (commercial)	1 524
Urban (industrial)	5 247
Subsurface mining	26
Surface mining	36 618
Mine tailings	5 693
Total	**5 454 772**

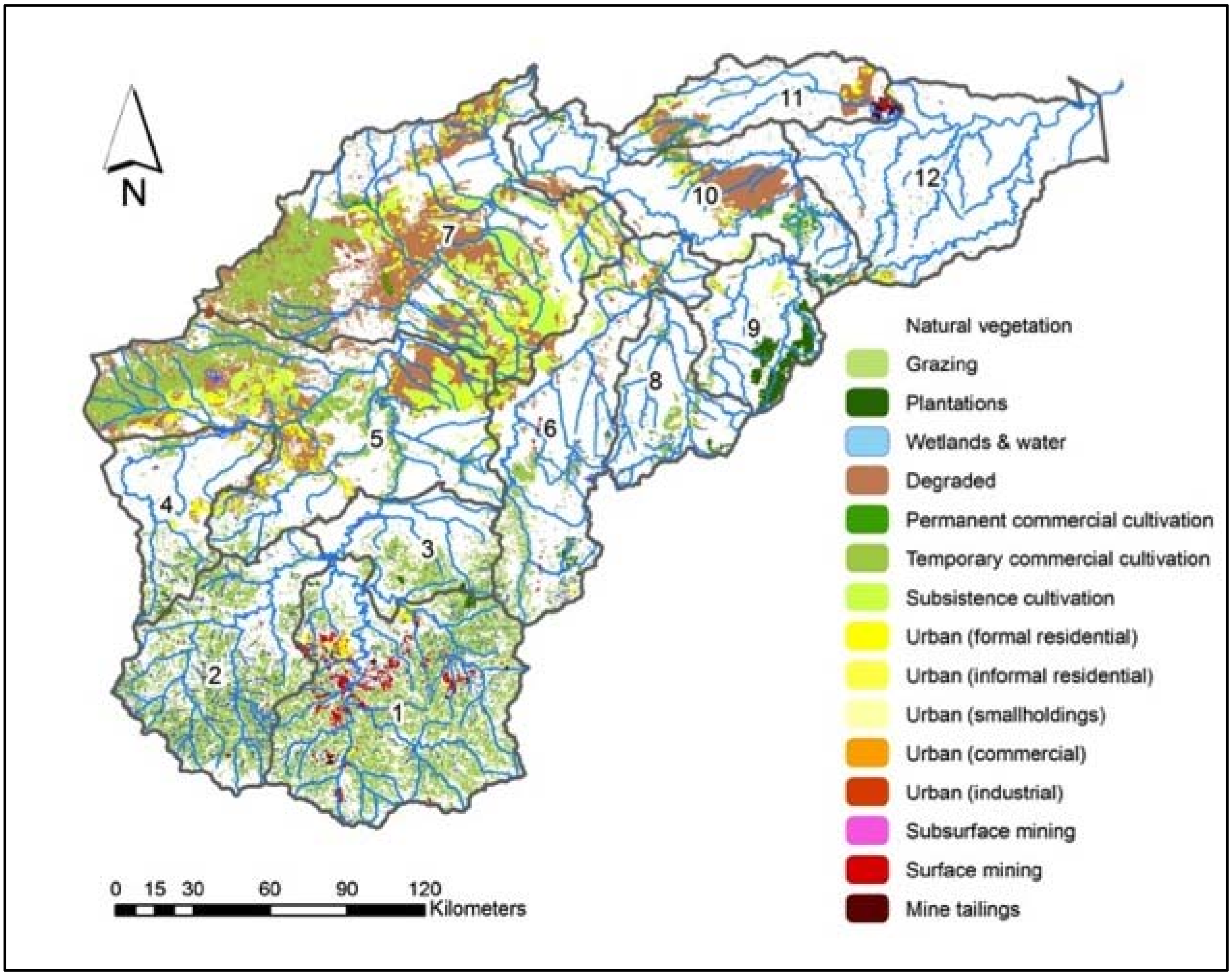

Figure 4. Land use map of the Olifants WMA (all land classes) (source: South African National Land-Cover database, CSIR, 2003)

2.3 Agriculture

Agriculture in the Olifants WMA can be broadly divided into three farming types: subsistence/semi commercial farming (typically dry land), commercial dry land (typically large-scale and highly mechanized), and commercial irrigated farming (often export-oriented, highly mechanized) (IWRM 2008) (Figure 5). Commercial dryland accounts for approximately 13% of the total Olifants WMA while irrigated farming and subsistence farming account for 2 and 4% respectively of the total land area (Table 4) (CSIR 2003).

Table 2. Distribution of dryland, irrigated and subsistence farming in the Olifants Water Management Area

	Total hectares	% of Olifants WMA
Dryland	732 149	13%
Irrigated	114 788	2%
Subsistence	245 575	4%

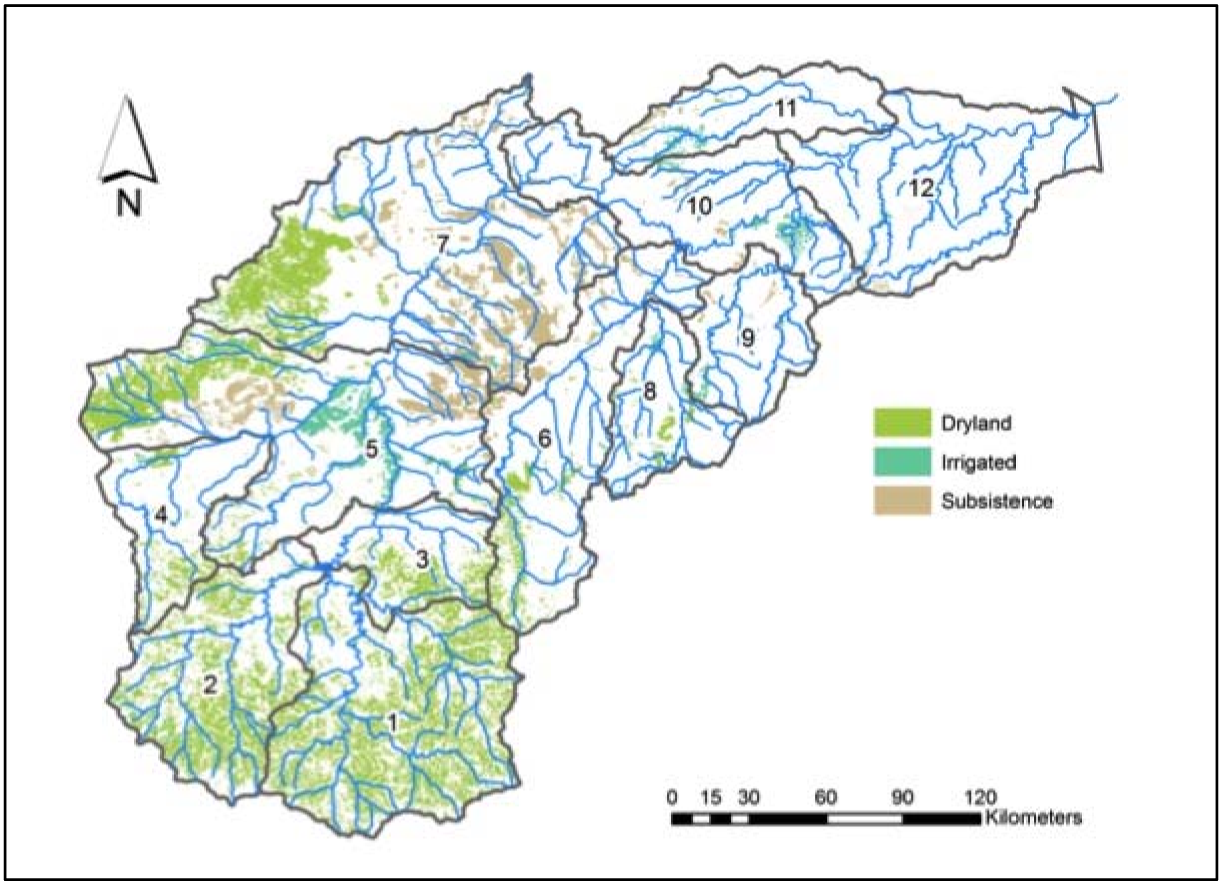

Figure 5 Distribution of agriculture within the Olifants Water Management Area

Maize is the dominant dryland crop grown throughout the catchment while commercial irrigated farming is highly diversified with wheat, maize and cotton comprising the bulk of the irrigated crop. A large portion of high value crops for export, such as citrus and grapes, are grown in the catchment especially around the Groblersdal and Marble Hall areas (IWRM 2008).

2.4 Mining

The rich mineral deposits present in the Olifants River Catchment, is a key economic driver in the area. Various mining activities span the Olifants River Basin. Three major concentrations of mining activities are of importance:

- Coal mining on the Mpumalanga Highveld;
- Platinum Group Metals (PGM) in the Middle Olifants and Steelpoort Valley; and
- Various mining activities around the Phalaborwa Industrial Complex and Gravelotte.

Mining within the Upper Olifants sub-catchment consists almost entirely of coal mining. The coal mining activities supply coal to the various power stations in the WMA.

Platinum mining dominates mining activities in the Middle Olifants zone. The Bushveld Igneous Complex BIC is the world's largest and most valuable layered intrusion. It holds over half the world's platinum, chromium, vanadium and refractory minerals and has ore reserves that could last for hundreds of years. These also include significant reserves of tin, fluorite and copper. Platinum group metals (as well as vanadium, chrome and iron) have been initiated in the Steelpoort/Mogoto and Mokopane areas, will not be able to be implemented unless additional water resources are made available.

Intensive copper and phosphate mining operations exist around Palaborwa. The mineral rich Phalaborwa complex was intruded at the same time as the Bushveld Complex. The PhalaborwaMining Company is South Africa's largest copper producer and in addition also produces titaniferous magnetite, nickel, uranium, gold, silver, rare-earth elements, phosphates, vermiculite and PGM's. Foskor is a very large producer of phosphate and zirconium as well as small quantities of copper, PGMs and other minerals. To the west of Phalaborwa, rocks of the Gravelotte Group and Rooiwater Complex outcrop in the vicinity of the town of Gravelotte. Quartzite, schists, basic lava and granitic rocks dominate the Gravelotte Group lithology. These formations contain important deposits of antimony and gold, with minor deposits of mercury and zinc. An extensive deposit of heavy mineral sands (illmenite, rutile and zirconium) is located near the town of Gravelotte.

2.5 Electricity

Eskom has 11 coal-fired power stations in South Africa and eight of these stations are found in the Olifants WMA. These eight stations produce approximately 70% of South Africa’s electricity. The Olifants WMA thus plays a key strategic role in the national economy of South Africa.

2.6 Tourism Economy

The Olifants WMA contains important natural heritage, especially in its lower reaches. These areas are water-dependent and play an important role in the tourism economy of the region. Some of these areas are closely associated with cultural heritage. Key areas include:

- The Kruger National Park and adjoining protected areas (Klaserie, Timbavati, Olifants Conservancy, Umbaba)
- The Wolkberg Wilderness Area on the northern rim of the Olifants catchment;
- The Legalametse Nature Reserve south east of the Wolkberg; and
- The Loskop Dam Nature Reserve.

Dullstroom and Lydenburg and up to the Steelpoort River and Burgersfort in the north is another important tourism area, with natural beauty and as well as being a premier fly-fishing destination.

The Kruger to Canyons Biosphere Reserve (K2C) is an internationally recognised development initiative that complies with and is accredited to UNESCO’s Man and the Biosphere programme. In such areas widely accepted principle of planning around a core-protected area, surrounded by areas where varying forms of conservation/utilisation take place, are applied. Also in the Olifants WMA is an area that abuts onto the western boundary of the KNP. It lies between Acornhoek and Phalaborwa and is the largest area of privately owned conservation land in the world. The inclusion of the Timbavati, Balule, Klaserie, Umbabat and other private nature and game reserves has effectively added in excess of 250,000 ha (more than 10%) to the conservation area of the KNP (DWA 2005).

3 Step 1(b): Socio-economic zones

The purpose of the socio-economic zones is to determine and report the implications of different catchment scenarios on social wellbeing, economic prosperity and ecosystem health at an appropriate social scale. Figure 6 and Table 5 show and describe the broad socio-economic zones.

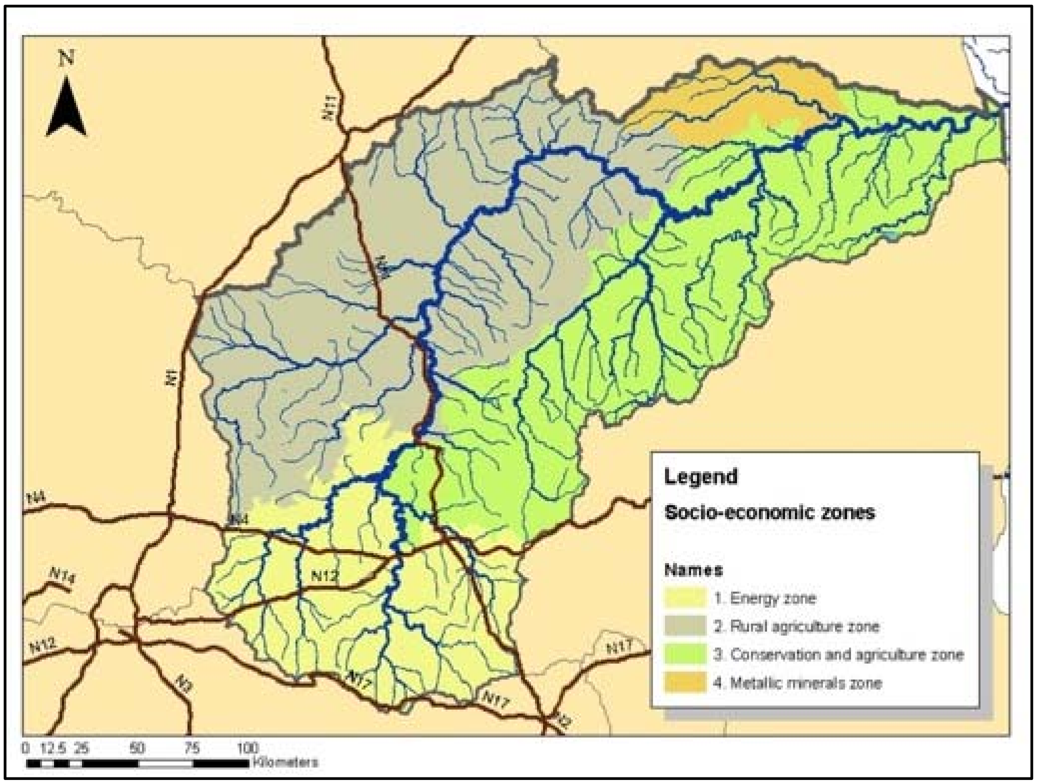

Figure 6. Socio-economic zones (SEZ) determined by the Project Team for the Olifants Water Management Area

Table 3. Description of the socio-economic zones (SEZ) for the Olifants Water Management Area

Descriptor	Primary economic characteristics and drivers	Secondary economic characteristics	IUAs
Energy Zone	Coal fields, coal mining, power generation, heavy manufacturing, N4 corridor	Annual crops grown (maize), general economic infrastructure associated with coal, energy and manufacturing	1 and 2 highly similar
Rural Agriculture Zone	Commercial agriculture (isolated irrigation), dense rural settlements, subsistence agriculture	Scattered tourism / protected areas, poverty, isolated mining activities (sand?), some influence from Polokwane economy to the north	3, 4, 5, 7 (possibly separate commercial agriculture from rural/subsistence zones)
Conservation	Protected areas and tourism,	Supporting infrastructure for primary	6 – Platinum zone

and Agriculture Zone	platinum reserves, commercial agriculture and forestry	economies	8 – Agriculture/tourism 9 – Agriculture/tourism 10 - Agriculture/protected areas 12 – Protected area/tourism
Metallic Mineral Zone	Metals mining and manufacturing	Supporting infrastructure for primary economies	11

4 Step 1(e): Describe communities and their wellbeing

The objective of this section is to provide a brief overview of the communities in the Olifants WMA, with the purpose of supporting the delineation of IUAs. A more comprehensive description of communities and their well-being follows in Step 1(j) below.

The estimated population size of the Olifants WMA is 3.13 million people in 2010. The total population of the WMA represents about 7% of the national population, which closely corresponds to the proportionate contribution to the GDP from the Olifants WMA. However, distribution of wealth is highly skewed between the urban and rural areas, and large differences in the standard of living prevail (DWA 2004).

Approximately 60% of the population reside in the former homelands areas of Lebowa, KwaNdbele, and parts of Gazankulu, which constitute 26% of the area in the basin (IWMI 2008).

The WMA has a predominantly rural character and 67% of the population reside in rural areas. Most of these people live in the Middle-, Lower and Steelpoort zones. The Middle Olifants is also the most densely populated, with nearly 60% of the population. Key towns in the Middle Olifants zone are Lebowagomo, Polokwane, Mokopane, Burgersfort, Lydenburg and Belfast. Also in this zone, in the Sekukhune, are settlements at Makhuduthamang, Leeufontein, Fetagoma, Lebelolo North and Olifantspoort South. Two significant towns in the Lower Olifants River zone are Phalaborwaand Hoedspruit while there are villages in the Selati River catchment. Rural residences are, to a large extent, in scattered informal villages with limited services and commerce.

The Upper Olifants has a predominantly urban population. The major towns here are Emalahleni, Middelburg, Bronkhorstspruit, Marble Hall, Groblersdal, Cullinan and Delmas. In the Upper Olifants, rural settlements occur in the Western Highveld, formerly Kwandabele.

Table 4. Urban and rural population (year 2010) (Adapted DWAF 2004)#

Zone	Urban population	Rural population	Total	Distribution
Upper Olifants	673,357	140,922	814,279	26.0%
Middle Olifants	260,415	1,524,051	1,784,467	56.9%
Steelpoort	31,931	207,844	239,775	7.6%
Lower Olifants	61,595	234,341	295,936	9.4%
Total	**1,027,299**	**2,107,157**	**3,134,457**	
Distribution	32.8%	67.2%		

The 2007 community Survey of Stats SA showed that there has been an improvement in the housing conditions of households in Mpumalanga and Limpopo between 2001 and 2007:

- The proportion of households living in formal dwellings has increased (77% in Mpumalanga and 83% in Limpopo now live in formal dwellings).
- The proportion of households that had access to piped water increased (91% in Mpumalanga and 84% in Limpopo had access to piped water in 2007).
- All municipalities recorded an improvement with regard to refuse removal with more households receiving services from the municipality.
- Since 2001, the proportion of households owning various household goods increased, and significant increases in cellphone, radio, computer, refrigerator and television ownership occurred.

However, in spite of these positive trends, economic characteristics of poor rural areas prevail.

Unemployment is high (24.8% in Mpumalanga and 27.8% in Limpopo). In addition, a large proportion (>50 %) of the people potentially able to enter labour force (age category 15 to 65 years) are not economically active, meaning that they are either full-time scholars and students, full-time homemakers, retired, or are unable (disabled) or unwilling to work. This results in low household income levels in the rural areas. Many poor rural households are vulnerable and rely on support from family and friends and/or state subsidies.

A striking observation is the large disparity between household income groups, with nearly 85% of households in the Very Poor and poor Categories (Table 1). More in depth information is given in the proceeding sections.

Table 5. Annual household income categories in the Olifants WMA (Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	261 827
Poor (R9601-R38 400)	133 456
Tolerable (38 401-R76 800)	35 036
Comfortable (R76 801-R153 600)	20 790
Wealthy (R153 601 & above)	13 286
Total	**464 395**

Table 6. Employment by sector in the Olifants WMA (Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	25 959
Mining and quarrying	33 858
Manufacturing	30 415
Electricity; gas and water supply	7 668
Construction	20 309
Wholesale and retail trade; repairs, hotels and restaurants	40 693
Transport, storage and communication	11 752
Financial intermediation; insurance; real estate and business services	16 711
Community; social and personal services	57 393
Private households	35 212
Extraterritorial organisations	11
Representatives of foreign governments	16
Undetermined	21 924
Total	**301 920**

In healthcare, the area has very few medical specialists and dental practitioners (Stats SA reports that there were no dental specialists in Mpumalanga in 2004). The percentage of the population who consulted a health worker in the month prior to the day of the interview for the General Household Survey (GHS) 2002 and 2004 was only 7.5% (compared to 23.5% in Gauteng). Medical aid coverage is extremely low (7% -13%). The areas' functional literacy rate is approximately 60%.

The major formal employment opportunities in the WMA arise from Agriculture, Mining and associated downstream economic sectors. (Please see Table below.) Tourism is an important economic activity in the Lower Olifants and contributes to employment created in the Trade, Accommodation and Transport sectors.

Statistics SA estimates that the informal sector employs approximately 30 - 33% of the labour force. A large proportion of this is likely in subsistence agriculture, craft manufacturing, trade and harvesting of natural products.

Please see Step 1(j) below for a more detailed discussion of the community well-being, by IUA.

Table 7. Distribution of employment by race and by sector.

Economic Sectors		Africans	Coloureds	Asians/Indians	Whites
Agriculture	Cereal and Crop Farming	0.16%	0.10%	0.00%	0.11%
	Citrus Farming	0.07%	0.04%	0.00%	0.05%
	Sub-Tropical Farming	0.16%	0.03%	0.01%	0.09%
	Vegetable Farming	0.07%	0.03%	0.00%	0.04%
	Livestock Farming	0.13%	0.04%	0.01%	0.13%
	Forestry	0.48%	0.06%	0.02%	0.23%
	Other Agriculture	0.17%	0.06%	0.01%	0.10%
Mining	Coal & Lignite Mining	8.79%	0.18%	0.20%	5.24%
	Platinum Mining	0.36%	0.01%	0.00%	0.15%
	Other Mining and Quarrying Products	1.38%	0.12%	0.03%	0.73%
Industrial		4.39%	1.16%	1.37%	12.96%
Electricity		1.26%	0.32%	0.22%	1.55%
Water		0.30%	0.05%	0.05%	0.29%
Building and Construction		1.22%	0.29%	0.08%	0.84%
Trade		4.20%	1.17%	0.88%	3.67%
Accommodation		0.41%	0.06%	0.04%	0.24%
Transport		1.75%	0.33%	0.31%	1.54%
Communication		0.93%	0.28%	0.19%	1.45%
Insurance		1.08%	0.37%	0.29%	2.15%
Real Estate		0.83%	0.25%	0.21%	1.86%
Business Services		0.81%	0.18%	0.19%	1.05%
Community, Social and Personal Services		3.41%	0.71%	0.40%	2.87%
National Government		6.19%	0.96%	0.42%	2.92%
Provincial Government - Education		1.88%	0.55%	0.16%	2.39%
Provincial Government - Health		0.52%	0.26%	0.31%	0.59%
Provincial Government - Social		0.06%	0.01%	0.01%	0.05%
Provincial Government - Other		0.29%	0.01%	0.01%	0.43%
Local Government		0.87%	0.05%	0.11%	0.93%

Table 8. Skills distribution in employment

Skills distribution	Africans	Asians/Indians	Coloureds	Whites	Grand Total
Clerks	3.0%	0.6%	1.1%	4.3%	9.0%
Craft and related traders workers	5.7%	0.4%	1.2%	3.9%	11.2%
Domestic workers	1.9%	0.2%	0.4%	1.1%	3.7%
Elementary occupations	4.5%	0.2%	1.0%	3.4%	9.0%
Legislators, senior officials and managers	3.8%	0.9%	1.0%	9.6%	15.3%
Plant and machine operators & assemblers	5.5%	0.5%	0.8%	2.9%	9.6%
Professionals	7.1%	1.1%	1.5%	10.0%	19.7%
Service workers, shop & market sales workers	5.6%	0.5%	1.1%	3.8%	11.0%
Skilled agric. and fishery workers	0.7%	0.0%	0.1%	0.4%	1.2%
Technical & associate professionals	2.6%	0.6%	0.9%	6.2%	10.3%
Grand Total	40.3%	5.1%	9.1%	45.5%	100.0%

5 Step 1(f) Describe and value the use of water

5.1 Objective

This objective of this sub-step is to describe the way in which water is used currently in the Olifants WUA, and to estimate the value generated by that use.

5.2 Water use in the Olifants WMA[3]

5.2.1 Overview

The draft Reconciliation Strategy for the Olifants River Water Supply System (DWA 2011) contains the most up to date description of the water use in the WMA.

Diverse economic activities drive in increasing demand for water in the Olifants WMA. These activities include power generation, mining, urban development, improved service delivery to rural communities, and irrigation. The Olifants WMA supplies water to Polokwane (Levuvu-Letaba WMA) for urban consumption and will likely in future also supply Mokopane (Levuvu-Letaba WMA) from the Flag Boshielo Dam, for mining consumption.

The water balance for the Olifants River catchment as a whole indicates a small surplus in 2010, but a deficit from about 2015. The future demand for water by mining and rural communities precipitated the De Hoop Dam development, due for commissioning in 2012. However, the draft Reconciliation Strategy states that even the additional yield provided by the De Hoop Dam and the raised Flag Boshielo Dam, may not be sufficient to supply future demand.

However, this balance only partly internalises the Ecological Reserve requirements. The Draft Reconciliation study conducted a preliminary estimate of the Reserve requirements, which indicated a reduction in system yield of about 200 million m^3/year. The yield of the De Hoop Dam is 66 million m^3/year, after allowing for the Reserve while the current ecological release of 18.6 million m^3/year from Flag Boshielo Dam is also part of the Reserve. The yield available at the PhalaborwaBarrage assumes a minimum flow of 0.5 m^3/s at the Mamba weir, which is the interim arrangement of the ecological flow requirements.

Overall, Irrigation is the largest consumer of water within WMA. Mining activities are dominated by coal mining, particularly in the Highveld, but also include copper, gold, tin, platinum, phosphate and diamonds in the Lowveld. The mines use water for the processing of ores. The number of active mines in the catchment was estimated to be 93 (South African Council of Geoscience cited in DWAF 2003b). Rural water demand encompasses all domestic water requirements outside of urban areas and includes stock watering and subsistence irrigation on small rural garden plots. Urban water demand encompasses industrial, commercial, institutional and municipal use. Strategic water requirements are those reserved for Eskom for power generation.

[3] DWA 2011

The Reconciliation Strategy delineates the Olifants into three socio-economic zones: Upper-, Middle- and Lower Olifants. The sections below discuss the water use in each of these zones, by sector.

Table 9. Summary of water requirements (units: million m^3/year)

Sub-catchment	Strategic	Industrial	Urban	Rural	Mining	Irrigation	Total
Upper	228	8	58	36	23	249	602
Middle	0	0	21	5	21	81	128
Lower	0	0	28	1	31	153	213
Total	**228**	**8**	**107**	**42**	**75**	**483**	**943**

5.2.2 Strategic Water Requirements

Power stations in the Upper Olifants zone uses 228 million m^3/a for cooling purposes, from the upper Komati or the Vaal Systems. The new Kusile power station near Emalahleni will use a dry cooling process, which is more water efficient, and thus water strategic demand is expected to reduce by 2014.

5.2.3 Irrigation Water Requirements

The total irrigated area in the Upper Olifants River catchment is 69,500 ha. Of this, 24,800 ha form part of irrigation schemes, while the remainder are defined as diffuse source irrigation.

Table 10. Irrigation within irrigation schemes: Upper Olifants zone

Irrigation Board	Schedule area (ha)	Actual area (DWAF, 2010)	Application rate (mm/year)	Current estimated demand (million m^3/year)
Bloempoort	684	551	6200	3.4
Hereford	4 466	3 426	6200	21.2
Loskop	20 952	16 059	7700	123.6
Olifants River	1 732	1 706	7600	13.0
Selons	777	189	6200	1.2
TransElands	716	1 372	7700	10.6
Rust de Winter	1200	200	7000	1.4
Total	**30 527**	**23 503**		**174.4**

Table 11. Diffuse irrigation requirements and use: Upper Olifants zone

Sub area	Irrigated area (ha)	Water requirement (million m^3/year)	Actual water use (million m^3/year)
Witbank Dam	4 300	20.5	17.4
Middelburg dam	3 890	16.9	13.9
Bronkhorstspruit/Wilge Dam	5 717	25.7	20.2
Loskop Dam	3 900	18.2	15.9
Elands River	4 641	36.1	14.7
D/s of Loskop Dam	6 961	36.9	15.1
Total	**29 409**	**154.3**	**97.2**

Table 12. Summary of irrigation demands: Upper Olifants zone (Units: million m^3/year)

Sub area	Controlled irrigation requirement		Diffuse irrigation requirement	Total irrigation requirement
	Average	1 in 50		
Witbank Dam	0		17.4	17.4
Middelburg dam	0		13.9	13.9
Bronkhorstspruit/Wilge Dam	0		20.2	20.2
Loskop Dam	0		15.9	15.9
Elands River	37.8	32.9	14.7	47.6
D/s of Loskop Dam	136.6	118.8	15.1	133.9
Total	**174.4**	**151.7**	**97.2**	**248.9**

Although irrigation schemes are not as abundant or as active in the Middle Olifants sub-catchment as the Upper Olifants sub-catchment, irrigation remains a significant water using sector. The tables below summarises its water use.

Table 13. Irrigation from Irrigation Boards: Middle Olifants zone

Irrigation Board	Schedule area (ha)	Actual area (DWAF, 2010)	Application rate (mm/year)	Current estimated demand (million m^3/year)
Groot Dwars	786	606	7 156	4.3
Watervals	2 436	917	7 000	18.5
Spekboom	-	535	10 392	5.6
Laer Spekboom	2 643	1 573	5 000	7.9
Central Steelpoort	549	288	7 164	2.0
Central Olifants	2 338	-	7 700	18.0
Total	**8 752**			**56.3**

Table 14. Diffuse irrigation requirements and use: Middle Olifants zone

Sub area	Irrigated area (ha)	Water requirement	Actual water use
U/s of De Hoop Dam	2 278	15.1	14.7
D/s of De Hoop Dam	247	2.0	1.9
Spekboom (B42)	876	6.9	4.1
Olifants (B51)	3 100	9.2	6.9
Olifants (B52)	325	1.0	0.6
Olifants (B71)	2 313	33.5	3.2
Total	**9 139**	**67.7**	**31.4**

Table 15. Summary of irrigation demands: Middle Olifants zone (Units: million m^3/year)

Sub area	Controlled irrigation requirement		Diffuse irrigation requirement	Total irrigation requirement
	Average	1 in 50		
U/s of De Hoop Dam	0	0	14.7	14.7
D/s of De Hoop Dam	6.3	5.5	1.9	7.4
Spekboom (B42)	32.0	28.2	4.1	32.5
Olifants (B51)	0	0	6.9	6.9
Olifants (B52)	18.0	15.8	0.6	16.4
Olifants (B71)	0	0	3.2	3.2
Total	**56.3**	**49.5**	**31.4**	**81.1**

Irrigation in the Lower Olifants is extensive with nearly 12,000 ha within irrigation schemes and another approximately 8,500 ha uncontrolled irrigation within the Selati River catchment. Please see tables below.

Table 16: **Irrigation from Irrigation Boards: Lower Olifants sub-catchment**

Irrigation Board	Schedule area (ha)	Actual area (DWA, 2010)	Application rate (mm/year)	Current estimated demand (million m^3/year)
Origstad (B60)	1 857	2 675	7 000	25.8
Blyde River (B60)	8 604	7 863	9 900	89.9
Klaseri (B73)	786	200	9 900	2.0
Selati (B72)	722	1 218	9 900	1.3
Total	**11 969**	**11 956**		**119.0**

Table 17. Diffuse irrigation requirements and use: Lower Olifants sub-catchment

Sub area	Irrigated area (ha)	Water requirement	Actual water use
Olifants/Selati (B72)	5 549	51.1	35.3
Blyde River (B60)	2 934	23.7	6.3
Olifants (B73)	50	0.4	0.3
Total	**8 533**	**75.2**	**41.9**

Table 18. Summary of irrigation demands: Lower Olifants zone (Units: million m3/year)

Sub area	Controlled irrigation requirement		Diffuse irrigation (use)	Total irrigation requirement
	Average	1 in 50		
Olifants/Selati (B72)	1.3	1.2	35.3	36.5
Blyde River (B60)	115.7	106.4	6.3	112.7
Olifants (B73)	2.0	1.8	0.3	2.1
Total	**118.0**	**108.8**	**41.9**	**151.3**

5.2.4 Urban and Industrial Water Requirements

In the Upper Olifants, the major towns within the Upper Olifants sub-catchment are Emalahleni, Middelburg, Bronkhorstspruit, Marble Hall, Groblersdal, Cullinan and Delmas.

Emalahleni currently has a consumptive water use of 43.8 million m^3/year and is supplied from the Witbank Dam and from recycled mine water decant. Of this, the Urban requirement is 35.8 million m^3/year, while Highveld Steel uses another 8 million m^3/year. Marble Hall and Groblersdal have use 0.85 and 2.0 million m^3/year respectively, from the Loskop canal. The Bronkhorstspruit Dam supplies 3.2 million m^3/year to Bronkhorstspruit. Middelburg uses 12,6 million m^3/year from the Middelburg Dam with small contributions from the Pienaars and Kruger dams. Cullinan lies on the watershed of the Olifants and Crocodile West WMA and receives water from the Wilge River Dam. The water treatment works (WTW) at Cullinan produces 4 million m^3/year of which 2 m^3/year is supplied to the town of Cullinan and the remainder to the Cullinan Mine. Delmas receives 1.8 million m^3/year from Rand Water (transferred from the Vaal System) and the remainder of its requirements from groundwater while the towns of Hendrina and Kriel form part of the water supply to the power stations which receive their water from the Komati and Vaal system. Please see the table below.

Table 19. Summary of Urban demands (Upper Olifants)

Town	Water Demand (million m³/year)	
	2005	**2010**
Emalahleni	28.8	35.8
Middelburg	10.3	12.6
Groblersdal/Marble Hall	2.0	2.0
Bronkhorstspruit	3.2	3.4
Cullinan	2.0	2.0
Delmas	1.8	1.8
Total	**46.3**	**55.8**

Table 20. Industrial demands in the Upper Olifants zone

Industry	Water requirement (million m³/year)
Highveld Steel	8.0
Gouda/Festival Farms	0.4
Total	**8.4**

Lebowagomo, Polokwane, Mokopane, Burgersfort, Lydenburg and Belfast represents the urban water requirements of the Middle Olifants zone.

Table 21. Summary of Urban demands (Middle Olifants zone)

Town	Water Demand (million m³/year)	
	2005	**2010**
Polokwane	5.5	7.0
Lebowogoma	6.8	8.3
Burgersfort	1.2	1.5
Lydenburg	2.2	3.2
Belfast	0.8	0.9
Total	**16.3**	**20.9**

There two significant towns in the Lower Olifants River zone are Phalaborwaand Hoedspruit and source their water from the PhalaborwaBarrage but can be supplemented by releases from the Blyderivierpoort Dam.

Table 22. Summary of Urban demands (Lower Olifants zone)

Town	Water Demand (million m³/year)	
	2005	**2010**
Palaborwa	18.0	24.5
Hoedspruit	2.3	2.4
Total	**21.3**	**27.9**

5.2.5 Rural Water Requirements

In the Upper Olifants, the Western Highveld, formerly Kwandabele, consists of numerous villages and towns with a large water requirement. The Weltevreden weir located on the Elands River, supplies the northern part of this area, including the town of Siyabuswa. The Mkombo Dam and the Loskop Dam supplements this supply. The total current abstraction for the northern Western Highveld is 22 million m^3/year. The Bronkhorstspruit Dam supplies the southern Western Highveld via the Rand Water pipeline from Mamelodi. The current abstraction from the Bronkhorstspruit Dam is 13.4 million m^3/year to the Western Highveld. Other rural water use within the Upper Olifants sub-catchment is limited and supplied mostly from local sources, i.e., boreholes and farm dams.

Table 23. Summary of the water requirements within the Western Highveld

Location	2010 water demand
Northern WH	22.0
Southern WH	13.6
Total	**35.6**

In the Middle Olifants, in Sekukhune, most villages obtain their water from groundwater or local source but level of service is inadequate. One of the aims of the Olifants Water Resources Development Project, which includes the construction of the De Hoop Dam, is to supply many of these villages with water from the new dam. In addition, four rural water supply schemes exist: Makhuduthamang, Leeufontein, Fetagoma, Lebelolo North, and Olifantspoort South. The Makhuduthamang settlements, located East of the Olifants River, obtain water from the Flag Boshielo Dam and have a current demand of approximately 1,4 million m^3/year. The Leeufontein settlements, located West of the Olifants River, also obtain their water from the Flag Boshielo Dam and have a current demand of 3,4 million m^3/year. The Olifantspoort South settlements obtain their water from the Olifants River, abstracted at Olifantspoort. The current demands of this settlements is 2,3 million m^3/year and significant growth to 3,8 million m^3/year is expected by 2030 (DWA, 2010). The Fetagoma and Lebelolo North settlements currently obtain their water from groundwater but could be supplied from the De Hoop Dam in future.

Table 24: **Summary of rural water demands (Middle Olifants zone)**

Settlement	Water Demand (million m^3/year)
	2010
Makhuduthamang	1.4
Leeufontein	1.0
Olifantspoort South	**2.3**
Total	**4.7**

In the Lower Olifants, approximately 1 million m^3/a is supplied from the Thabina Dam in the neighbouring Groot Letaba catchment to villages in the Selati River catchment. All other rural water requirements are supplied from groundwater.

5.2.6 Mining Water Requirements

Coal mines source the bulk of their water from their underground operations and from own dams.

Platinum mining water use within the Middle Olifants is estimated at about 20 million m^3/year.

The Phalaborwa Barrage on the Olifants River, supplemented from the Blyderivierpoort Dam and the Groot Letaba River, supply the water requirements to mining activities around Phalaborwa.

Table 25. Mining water requirements in the Upper Olifants zone

Sub-area	Water requirement (million m^3/year)
Witbank Dam	13.7
Middelburg Dam	3.7
Bronkhorstspruit/Wilge Dam	0.0
Loskop Dam	4.6
Elands River	0.5
Total	**22.5**

Table 26. Mining water requirements in the Lower Olifants River zone

Mine	Water requirement
PhalaborwaMining	10
Foskor	19
Murchison Mine	2
Total	**31**

5.3 The economic value of water use in the Olifants WMA

5.3.1 The water sector of the Olifants WMA

The water sector in the Olifants WMA comprises the supply of raw and bulk water, potable water and wastewater treatment by the relevant water authorities. The total output produced by this sector was between R2.5 - R3 billion in 2010. Of this, between R580 million R940 million in 2010 contributed to GDP in the WMA. However, not included in this analysis is the own supply of water, by mining activities and of farm dams.

The total output of the water sector is also equivalent to an economic price of between R2.65/m^3 and R3.18/m^3.

5.3.2 Water as an input into the economy

Economic production activities use water as an input into their production processes. Production outputs are the gross income or turnover of each user activity.

The GDP of the WMA is estimated by the DWA ISP (2004) to be approximately 5% of the South African GDP. This was about R135 billion in 2010. Of this, approximately 41% or R55.8 billion were salaries and wages paid to employment.

This economy is characterised primarily by:

- The coal, platinum and other mining economies of northern Mpumalanga;
- The rural settlements of southern Limpopo;
- Irrigation, dryland and subsistence agriculture; and
- The tourism economy in the lower catchment areas.

The Development Bank of South Africa (DBSA) provides production data for water-using sectors in their provincial Social Accounting Matrixes, and this provides some insight into the size, employment creation and water use of these economies. The border between Mpumalanga and Limpopo bisects the Olifants WMA. The WMA also includes a small part of rural Gauteng, although these areas share economic similarities with that of the southern Limpopo regions. Thus, the tables below are for Mpumalanga and Limpopo respectively, and summarise the economic output of the above key economic sectors, as well as their levels of job creation, value added (VAD[4]) generation per water use, and economic multiplier effects[5].

The Agriculture, Coal Mining, Electricity, Industrial and Commercial sectors are all significant value adding sectors, with significant multiplier effects into the rest of the economy. The VAD of the Accommodation sector is an indicator of the size of the tourism economy and is relatively small in relation to other sectors. This corresponds to analyses done by the Mpumalanga Tourism and Parks Agency (MTPA), who estimated the size of the tourism economy in Mpumalanga to be approximately 0.6% of GDP (DWA 2004).

[4] Value added is an indicator of GDP

[5] The multiplier effect is an indicators of the indirect effects of economic activity in a particular sector.

The VAD/Water use ratios of the various economic sectors vary and demonstrate the intensity of water use of the various economic sectors. Agriculture, Mining, Construction, Accommodation, Real Estate and Personal Services are relatively "wet" industries with VAD/Water use ratios of less than R200VAD/R1 water used. An apparent exception in this data is the Coal Mining sector. The Coal Mining VAD/Water use ratios is in reality likely an order of magnitude smaller when the own supply of water by this sector is not factored into the analysis (the DBSA Water sector data does not include own water supply).

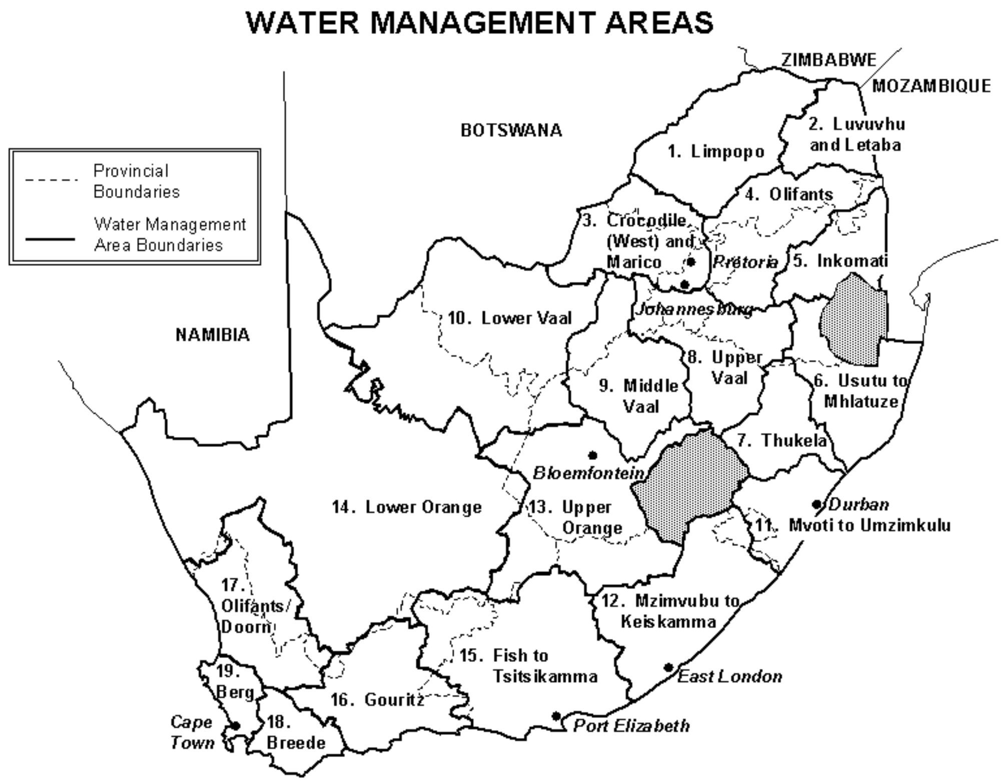

Figure 7. This map shows the WMA and provincial boundaries in South Africa. The border between Mpumalanga and Limpopo bisects the Olifants WMA. The WMA also includes a small part of rural Gauteng.

Table 27. The sectoral Value Added, Job creation, VAD/Water use and multiplier effects in Mpumalanga.

		Value added	Job creation	VAD/Water use	Multiplier effect
		R'million	R'million	R VAD/R Water	R/R
Agriculture	Cereal and Crop Farming	805	229	56	3.3
	Citrus Farming	360	102	53	2.9
	Sub-Tropical Farming	611	174	116	3.1
	Vegetable Farming	322	91	112	3.0
	Livestock Farming	660	188	127	3.4
	Forestry	1,679	477	165	3.5
	Other Agriculture	719	204	140	3.7
Mining	Coal & Lignite Mining	24,131	8,746	1,691	3.1
	Platinum Mining	885	321	233	3.6
	Other Mining and Quarrying	1,891	685	180	3.5
Industrial		26,276	12,072	547	3.7
Electricity		5,630	2,040	215	3.7

Building and Construction	2,528	1,477	235	3.9
Trade	12,343	6,017	388	3.6
Accommodation	929	453	18	4.1
Transport	6,303	2,382	136	3.7
Communication	4,564	1,725	261	3.4
Insurance	6,628	2,361	630	3.5
Real Estate	5,366	1,911	21	3.9
Business Services	3,787	1,349	13,617	3.4
Community, Social and Personal Services	8,557	4,488	205	3.1
Total	**114,975**	**47,494**		

Table 28. The sectoral Value Added, Job creation, VAD/Water use and multiplier effects in Mpumalanga.

		Value added	Job creation	VAD/Water use	Multiplier effect
		R'million	R'million	R VAD/R Water	R/R
Agriculture	Citrus Fruit Farming	681	194	83	3.1
	Subtropical Fruit Farming	446	127	173	3.5
	Vegetable Farming	1,102	313	116	3.2
	Livestock Farming	688	196	91	3.4
	Game Farming	13	4	105	3.4
	Forestry	315	89	186	3.5
	Other Agriculture	999	284	67	3.2
Mining	Coal and Lignite Mining	5,515	1,999	1,177	3.5
	Platinum Mining	20,228	7,332	241	3.4
	Other Mining and Quarrying	8,247	2,989	129	3.9
Industrial		5,003	2,299	579	3.1
Electricity		3,543	1,284	439	4.0
Building and Construction		2,506	1,464	185	3.5
Trade		16,498	8,043	404	3.8
Accommodation		1,242	605	15	3.8
Transport		6,952	2,627	128	3.4
Communication		5,034	1,903	258	3.4
Insurance		10,919	3,889	715	3.8
Real Estate		8,839	3,149	23	4.0
Business Services		6,240	2,222	12,845	3.5
Community, Social and Personal Services		8,813	4,622	179	3.5
Total		**113,869**	**45,703**		

6 Step 1(g) Describe and value the use of aquatic ecosystems

This section provides an overview of the value of ecosystem services produced by rivers and wetlands in The Olifants WMA. The DWA study (DWA 2010) analysed the extent of ecosystem services in the WMA, according to the Millennium Ecosystems Assessment Framework of ecosystem services, in four zones: the Upper Olifants, Middle Olifants, Steelpoort and Lower Olifants subcatchments.

The study identified and valued the following provisioning services:

- river water for domestic use
- livestock watering and grazing
- sand and clay harvesting and use

- use of plant resources
- harvesting and use of wild food and medicinal products
- hunting resources
- fishing resources

The study identified and valued the following regulating services:

- value of flood attenuation
- value of base flow maintenance
- value of water purification
- carbon sequestration values

The study identified and valued the following cultural services:

- value of river based adventure tourism
- value of recreational angling
- ecotourism value
- property values
- scientific and educational value.

The combined ecosystem services produced by rivers were valued at R907 million per year in 2009. The combined ecosystem services produced by wetlands were valued at R383 million per year in 2009. The combined value of river and wetland ecosystem services of R1,290 million in 2009 adjusts to R1,350 in 2010. These ecosystem services are of direct benefit to households and are therefore directly comparable to GDP and VAD. With the exception of the tourism and recreation services, these ecosystem services are external to the economy. The value of ecosystem services as externalities is thus estimated as approximately R970 million in 2010.

Although the DWA (2010) valuation provides valuable additional information on the state of aquatic ecosystem services in the WMA, it must nevertheless not be used as a proxy for the value of the ecological Reserve. This is because the analysis reported on here does not include the value of water regulation, the opportunity cost of health and the potential damaging effects of poor water quality. These are dealt with in Step 1(i) below.

Table 29. Summary of the ecosystem service values reported by DWA (2010).

	Upper Olifants	Middle Olifants	Steelpoort	Lower Olifants	Total
River length (km)	1697	3007	1106	1890	7700
Domestic water use	16.5	232.1	85	54.5	388.1
Livestock watering	0	45.1	10.1	10.7	65.9
Harvested products	11	28.2	10.2	17.5	66.9
Total	**27.5**	**305.4**	**105.3**	**82.7**	**520.9**
Water regulation	4.5	3.1	1.4	3.8	12.8
Carbon Sequestration	0.1	1	0.2	1.4	2.7
Total	**4.6**	**4.1**	**1.6**	**5.2**	**15.5**
Tourism	37.4	38.4	38.8	249.6	364.2
Aesthetic value	0	0	0	5.7	5.7
Education	0.1	0.2	0.1	0.1	0.5
Total	**37.5**	**38.6**	**38.9**	**255.4**	**370.4**
Sub-Total	**69.6**	**348.1**	**145.8**	**343.3**	**906.8**
Wetland area (ha)	5595	9867	3183	4037	22682
Livestock watering	39	151	1	37	228
Harvested products	16	43	15	26	100
Total	**55**	**194**	**16**	**63**	**328**
Flood attenuation	9.2	1	0.4	0.4	11
Groundwater recharge	7.4	1.2	0.3	0.3	9.2
Water purification	11.8	4.1	1.1	1.7	18.7
Carbon Sequestration	2.6	0.5	0.1	0.2	3.4
Total	**31**	**6.8**	**1.9**	**2.6**	**42.3**
Angling	3.3	0.5	0	0	3.8
Tourism	4.3	1.6	0.3	2.3	8.5
Total	**7.6**	**2.1**	**0.3**	**2.3**	**12.3**
Sub-Total	**93.6**	**202.9**	**18.2**	**67.9**	**382.6**
Grand Total	**163.2**	**551**	**164**	**411.2**	**1289.4**

7 Step 1(h): Integrated units of analysis (IUAs) and Step 1(j): Describe the present-day community well-being within each IUA

The determination of an IUA is a combination of socio-economic zones and the watershed boundaries, within which ecological information is provided at a finer scale. For the study, 12 IUAs were determined by the Project Team (Figure 8). For purposes of brevity, Steps 1(h) and (j) of the Classification Procedure were combined. A brief description of the main demographic indicators, major mining activities, major manufacturing activities, and agricultural activities are given for teach of the 12 IUAs in the proceeding sections.

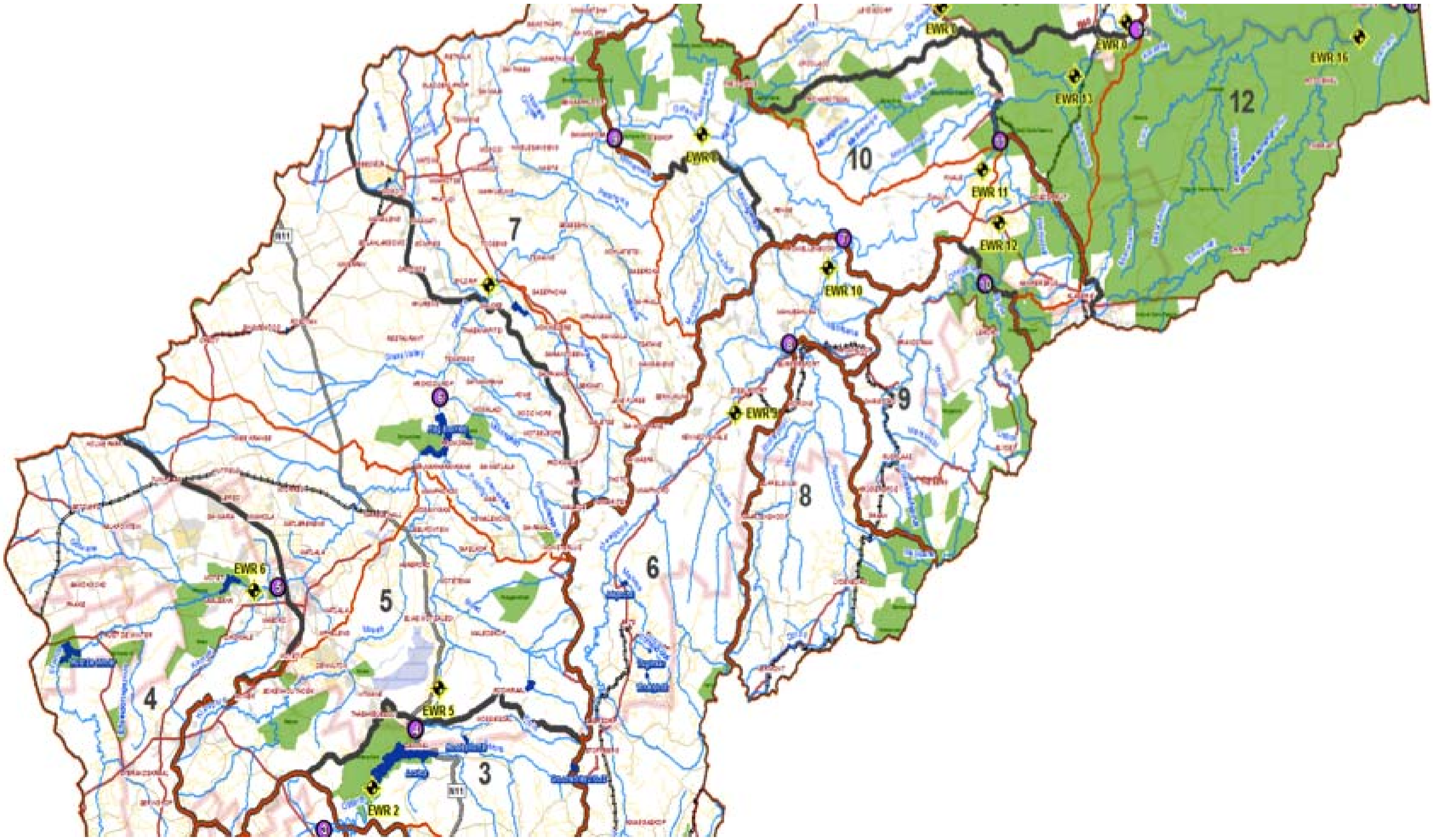

Figure 8. Physical map of the Olifants Water Management Area indicating the twelve selected integrated units of analysis (IUA)

7.1.1 IUA 1

This IUA principally includes the local economy of eMalahleni (Witbank) and includes the towns of Middelburg, Hendrina, Douglas, Kriel and Kinross (Figure 9). The southern border of the IUA is located just north of Evander, Secunda and Bethal. The IUA includes the upper Olifants River and the Klein Olifants, Witbank Dam and the Klip River. The IUA is characterized by intensive coal mining and associated energy and manufacturing economy. The IUA is highly used and impacted. The IUA Includes a large number of coalmines, steel industry, urban areas and return flows. Secondary economic activities include dryland agriculture and a wide variety of industrial and commercial sectors.

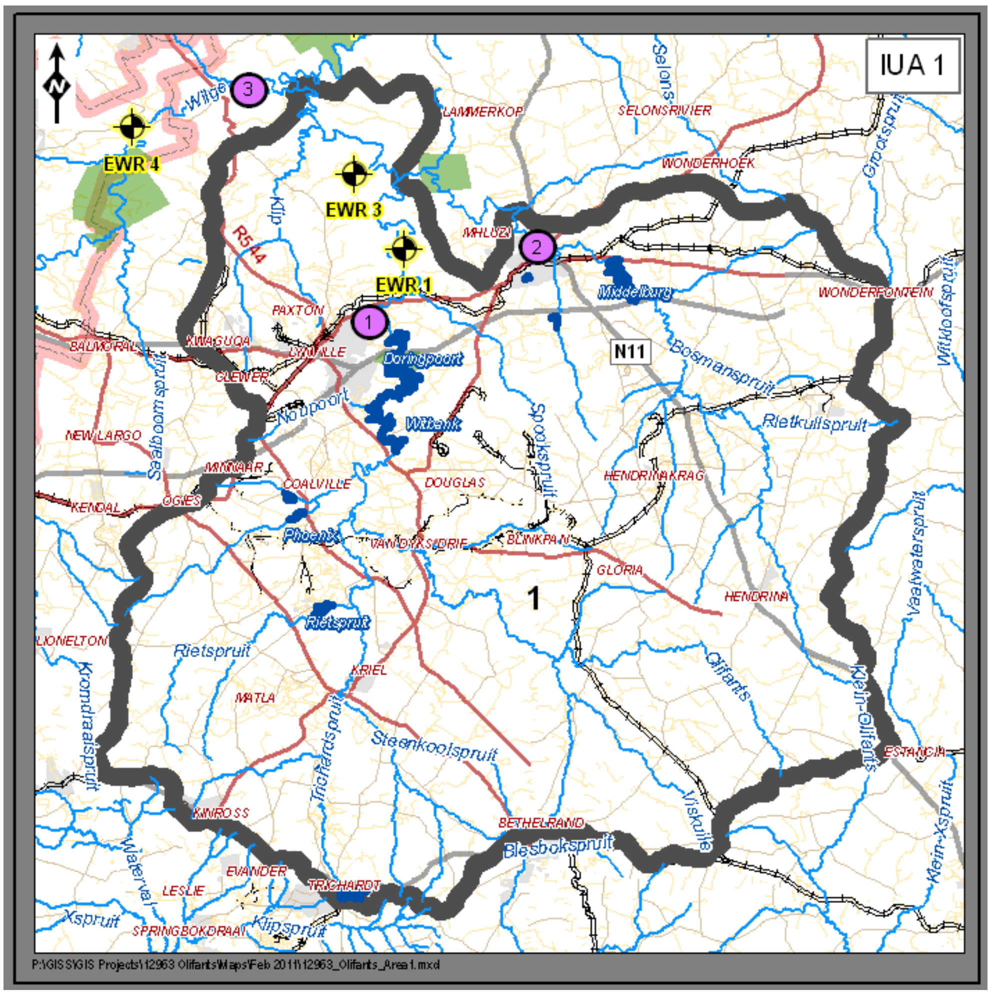

Figure 9. Physical map of IUA1

7.1.1.1 Demographic profile and basic services

The population of IUA 1 is approximately 369 808 (Census 2001). The IUA has approximately 104 648 households of which the large majority falls within the very poor and poor income categories (Table 30). Of the 104 648 households approximately 5 829 (6%) have no access to piped water (Census 2001).

Table 30. Household income categories for IUA 1 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	36 958
Poor (R9601-R38 400)	35 840
Tolerable (38 401-R76 800)	13 564
Comfortable (R76 801-R153 600)	10 706
Wealthy (R153 601 & above)	7 579
Total	**104 648**

Of the total number of people interviewed in IUA 1 approximately 23% were unemployed (Table 31). The mining and quarrying sector supplied the largest amount of jobs in IUA 1 (Table 32).

Table 31. Employment categories for IUA 1 (Source: Census 2001)

Employment categories	Number
Unemployed	58 787
Employed	106 901
Not economically active	88 586
Total Interviewed	**254 273**

Table 32. Employment by sector in IUA 1 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	6 712
Mining and quarrying	20 865
Manufacturing	11 893
Electricity; gas and water supply	5 784
Construction	5 810
Wholesale and retail trade; repairs, hotels and restaurants	14 242
Transport, storage and communication	3 637
Financial intermediation; insurance; real estate and business services	7 067
Community; social and personal services	15 005
Private households	8 825
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	7 060
Total	**106 901**

7.1.1.2 Mining

Coal mining is the predominate sector in this IUA. Much of the IUA falls within the Witbank Coalfield, where most of South Africa's coal is mined. Of the 71 operating collieries in South Africa at the end of 2001, 39 (55%) of these were located in the Witbank Coalfield. In 2001, the coalfield accounted for 155.132 million tons (Mt) (about 52.49%) of the total 295.546 Mt run of mine (ROM[6]) production in SA (Jeffrey, 2005).

Within the IUA, there are five major coal companies (BHP Billiton, Anglo Coal, Exstrata, Exxaro and Optimum Coal) that produce the bulk of coal in South Africa (Table 33). In addition there are a host of other smaller coal companies that produce coal in the IUA, but available information is limited. The above-mentioned companies produced approximately 143,9 Mt of coal in 2010, which was approximately 57% of the total coal produced in SA for 2010.

Table 33. Coal production (Mt ROM) in IUA 1 for the five major coal-producing companies in IUA1 for 2010

Company	Name	Location	Annual Production Capacity (Mt) (2010)
BHP Billiton	Douglas/Middelburg	Douglas/Middelburg	14,7
	Khutala	Near Witbank	10,8
	Klipspruit	Near Ogies	4,8
AngloCoal	Goedehoop Colliery	40km east of Witbank	7,5
	Greenside Colliery	15km south-west of Witbank	4,4
	Kleinkopje Colliery	8km south of Witbank.	4,5
	Zibulo Colliery	25km south-east of Ogies	7
	Landau Colliery	Witbank	4,2
	Mafuba Colliery	37km east of Middelburg	4,2
	Kriel Colliery	45km south of Witbank near Bethal	10
	Isibonelo Colliery	120km east of Johannesburg	5
Xstrata	iMpunzi Mining Complex	27km south of Witbank	4
	Tweefontein Division	Close to Ogies	9
	Goedgevonden Colliery	7km south of Ogies	1,2
	Southstock Division		11
Exxaro	Arnot	43 km from Middelburg	5
	Leeuwpan	Near Delmas	3
	Matla	20km west of Kriel	14
	New Clydesdale	Near Witbank	1,4
	North Block Complex	East of Witbank	3,3
Optimum Coal	Optimum Collieries		13,9
	Koornfontein		1
		Total Produced	**143,9**

[6] The coal delivered from the mine that reports to the coal preparation plant is called run-of-mine, or ROM, coal. This is the raw material for the coal preparation plant (CPP), and consists of coal, rocks, middlings, minerals and contamination. Contamination is usually introduced by the mining process and may include machine parts, used consumables and parts of ground engaging tools. ROM coal can have a large variability of moisture and maximum particle size.

7.1.1.3 Energy

IUA 1 is home to a large number of thermal power plants, which provide a large proportion of SA's energy requirements. The six thermal power plants (Table 34) provide 34% of Eskom's total installed capacity.

Table 34. Installed capacity of thermal power stations in IUA 1

Power Station	Installed Capacity (MW)
Arnot	2 100
Duvha	3 600
Hendrina	2 000
Kriel	3 000
Komati	1 000
Matla	3 600
Total	**15 300**

7.1.1.4 Manufacturing

Although there are several manufacturing operations within IUA 1, Evraz Highveld Steel is one of the largest operations within the IUA. The Steelworks, which is close to eMalahleni comprises the Iron Plant, the Steel Plant, the Flat Products and Structural Products Mills and operational support infrastructure. The Mapochs Mine in Roossenekal (IUA 6) supplies iron ore for the various operations. The production figures for the various operating divisions in the steelworks for 2010 and 2009 are given in Table 35.

Table 35. Production (tons) of steel products at Evraz Highveld Steel for 2009/2010

Production ('000 tons)	2010	2009
Liquid Iron	771	661
Blooms	281	231
Slabs	457	457
Billets	36	-
Structural sections	210	174
Plates	121	162
Coils	132	140

Samancor Chrome operates two chrome-smelting operations within IUA 1 being, Ferrometals (FMT) near Emalahleni and Middelburg Ferrochrome (MFC) near Middelburg.

7.1.1.5 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 1 is given in Table 36 below (CSIR 2003).

Table 36 Area (ha) of dryland, irrigated and subsistence agriculture for IUA 1

Farming Type	Area (Ha)
Dryland	251 613
Irrigated	5 050
Subsistence	-
Total	**256 663**

Maize (107 106 ha) is the most common crop planted in IUA 1, followed by pasture (65 529 ha) (Table 37).

Table 37. Crop types grown in IUA 1 (Source: DAFF 2008)

Crop	Area (ha)
Drybeans	3 353
Fallow	6 730
Maize	107 106
Vegetables	5 532
Pasture	65 529
Sorghum	3 207
Soya	17 346
Sunflower	7 530
Weeds	8 427
Undetermined	92
Total	**224 852**

7.1.2 IUA 2

This IUA principally includes the towns of Bronkhorstspruit and Delmas as well as the Ezemvelo Game Reserve to the north (Figure 10). The town of Ogies is located on the border of the IUA and IUA 1. The town of Cullinan is located on the border of the IUA 2 and IUA 4. The IUA includes the Wilge River and tributaries. The economy of IUA 2 is dominated by mixed coal mining and dryland agricultural activities, supported by local economies around the key towns.

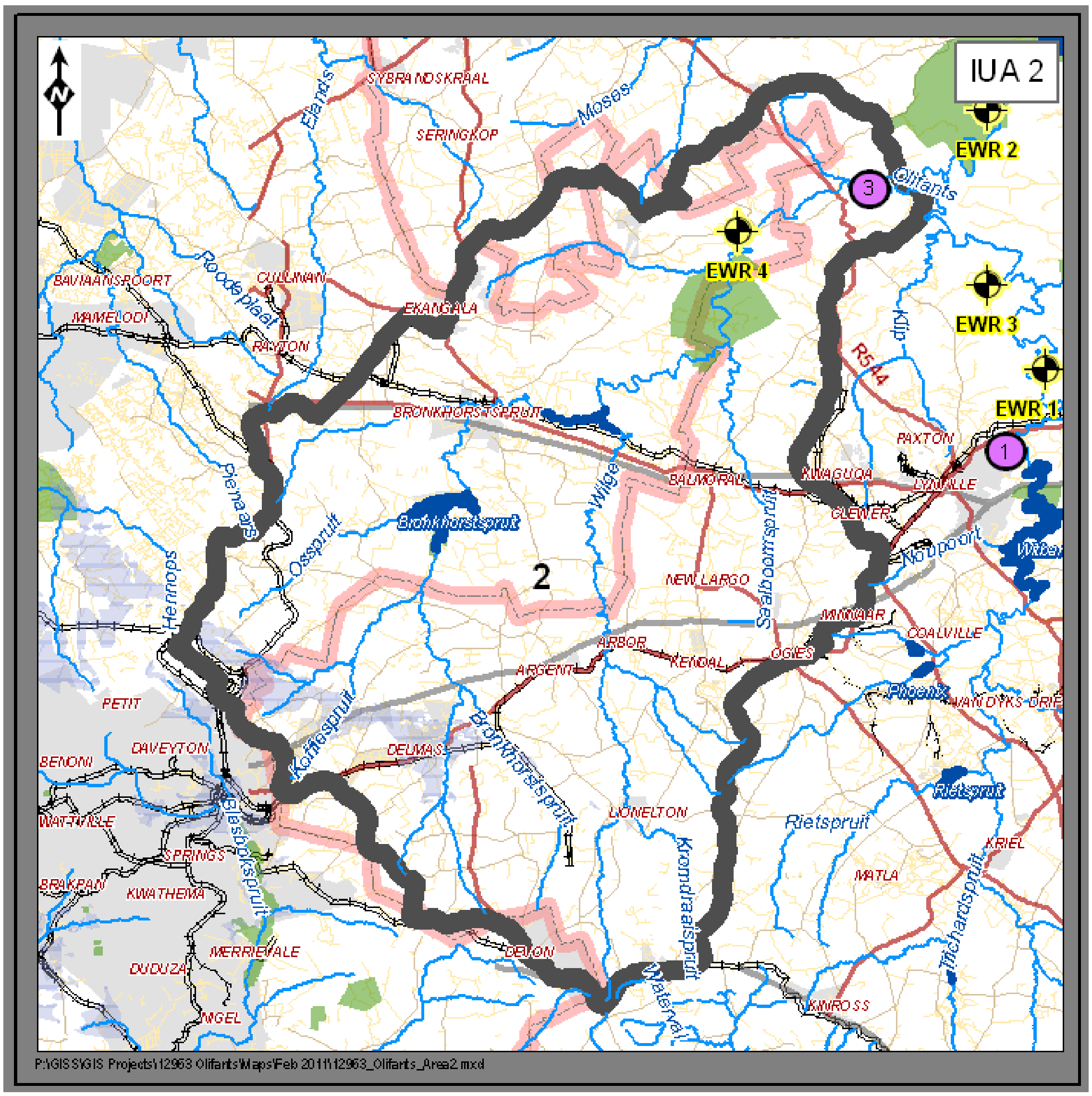

Figure 10. Physical map of IUA 2

7.1.2.1 Demographic profile and basic services

The population of IUA 2 is approximately 146 647 (Census 2001). The IUA has approximately 38 227 households of which the large majority falls within the very poor and poor income categories (Table 38). Of the 38 227 households approximately 2 333 (6%) have no access to piped water (Census 2001).

Table 38. Household income categories for IUA 2 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	19 197
Poor (R9601-R38 400)	14 080
Tolerable (38 401-R76 800)	2 819
Comfortable (R76 801-R153 600)	1 207
Wealthy (R153 601 & above)	925
Total	**38 227**

Of the total number of people interviewed in IUA 2 approximately 31% were unemployed (Table39). The manufacturing sector supplied the largest amount of jobs in IUA 2 (Table 40). The mining and quarrying sector is also an important sector in terms of employment in IUA 2.

Table 39. Employment categories for IUA 2 (Source: Census 2001)

Employment categories	Number
Unemployed	29 291
Employed	31 318
Not economically active	35 319
Total Interviewed	**95 928**

Table 40. Employment by sector in IUA 2 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	3 824
Mining and quarrying	3 910
Manufacturing	4 139
Electricity; gas and water supply	540
Construction	1 645
Wholesale and retail trade; repairs, hotels and restaurants	3 990
Transport, storage and communication	1 575
Financial intermediation; insurance; real estate and business services	1 510
Community; social and personal services	3 582
Private households	4 075
Extraterritorial organisations	4
Representatives of foreign governments	0
Undetermined	2 526
Total	**31 318**

7.1.2.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 2 is given in Table 41 below (CSIR 2003).

Table 41 Area (ha) of dryland, irrigated and subsistence agriculture for IUA 2

Farming Type	Area (Ha)
Dryland	141 323
Irrigated	8 430
Subsistence	-
Total	**149 752**

Maize (66 483 ha) is the most common crop grown in IUA 2 followed by pasture (26 644 ha) (Table 42).

Table 42.Crop types grown in IUA 2 (Source: DAFF 2008)

Crop	Area (ha)
Drybeans	285
Fallow	11 132
Maize	66 483
Vegetables	8 737
Pasture	26 644
Sorghum	1 038
Soya	15 338
Sunflower	5 579
Weeds	6 196
Undetermined	4 236
Total	**145 669**

7.1.2.3 Energy

While not as prevalent in number in IUA 1, there are two significant thermal power plants found in IUA2, one of which is the proposed Kusile Power Station (Figure 43). The Kusile Power Station is one of two (the other is Medupi Power Station in Limpopo Province) new build thermal power stations currently being built by Eskom. The new power station will have an installed capacity of 4 800 MW, making it one of the largest thermal power stations in the world.

Table 43. Installed capacity of thermal power plants in IUA2

Power Station	Installed Capacity (MW)
Kendal	4 116
Kusile (Under construction)	4 800
Total	**8 916**

7.1.3 IUA 3

IUA 3 includes the Loskop Dam and its surrounding protected area (Figure 11). The IUA starts at the confluence of the Klein Olifants and the Wilge Rivers and also includes the Selons River and The Kruis River. The IUA includes a section of the Klein Olifants between Mhluzi and the Doornkop protected area. The IUA has a largely natural and rural character and the agriculture sector is an important source of employment.

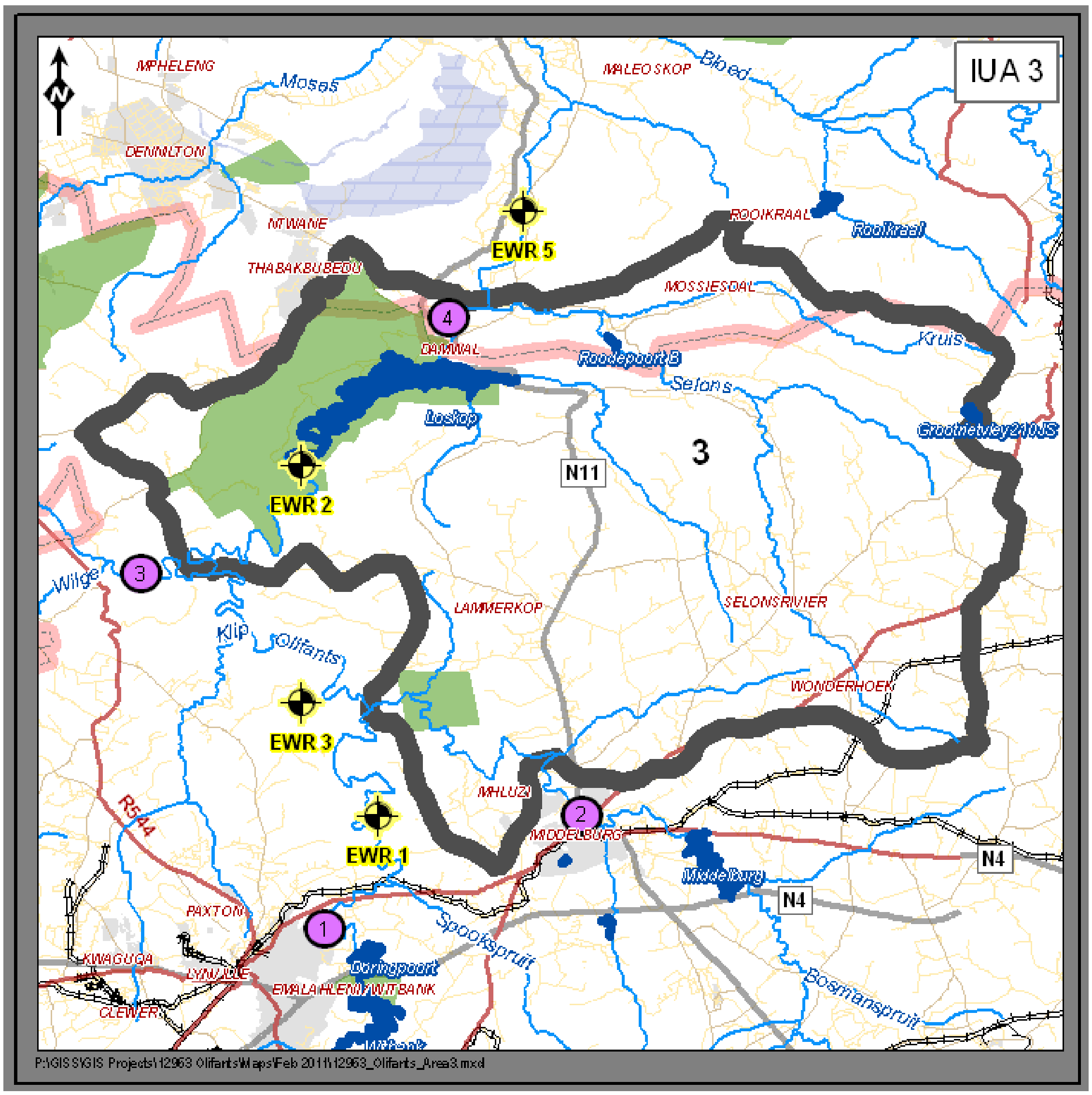

Figure 11. Physical map of IUA 3

7.1.3.1 Demographic profile and basic services

The population of IUA 3 is approximately 42 682 (Census 2001). The IUA has approximately 11 347 households of which the large majority falls within the very poor and poor income categories (Table 44). Of the 11 347 households approximately 807 (7%) have no access to piped water (Census 2001).

Table 44. Household income categories for IUA 3 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	5 127
Poor (R9601-R38 400)	4 518
Tolerable (38 401-R76 800)	895
Comfortable (R76 801-R153 600)	501
Wealthy (R153 601 & above)	306
Total	**11 347**

Of the total number of people interviewed in IUA 3 approximately 27% were unemployed (Table 45). The private households sector supplied the largest amount of jobs in IUA 3 (Table 46). The wholesale and retail trade; repairs, hotels and restaurants sector is also an important sector in terms of employment in IUA 3.

Table 45. Employment categories for IUA 3 (Source: Census 2001)

Employment categories	Number
Unemployed	7 393
Employed	11 299
Not economically active	9 149
Total Interviewed	**27 841**

Table 46. Employment by sector in IUA 3 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	1 147
Mining and quarrying	714
Manufacturing	1 418
Electricity; gas and water supply	103
Construction	914
Wholesale and retail trade; repairs, hotels and restaurants	1 857
Transport, storage and communication	322
Financial intermediation; insurance; real estate and business services	637
Community; social and personal services	1 266
Private households	2 046
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	875
Total	**11 299**

7.1.3.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 3 is given in Table 47 below (CSIR 2003).

Table 47. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 3

Farming Type	Area (Ha)
Dryland	41 587
Irrigated	1 591
Subsistence	0
Total	**43 178**

Maize (14 678 ha) is the most common crop grown in IUA 3 followed by pasture (10 101 ha) (Table 48).

Table 48.Crop types grown in IUA 3 (Source: DAFF 2008)

Crop	Area (ha)
Fallow	3 534
Maize	14 678
Vegetables	1 546
Pasture	10 101
Sorghum	345
Soya	2 947
Sunflower	187
Weeds	17
Undetermined	105
Total	33 459

7.1.4 IUA 4

IUA 4 includes the town of Cullinan in the South, Kwamahlanga, the Rust De Winter Dam, and the rural settlements (Siyabuswa) around the Mkhombo Dam. Bela Bela (Warmbaths falls outside of the IUA on the western boundary) (Figure 12). The IUA includes the Elands, Kameel and Mkhombo Rivers. The IUA includes the Dinokeng protected area and Mdala Nature Reserve.

The economy has a rural characteristic with a large amount of smallholdings upon which a variety of economic activities take place (agriculture, grazing, light manufacturing, associated commercial activities and some tourism). The Elands River is mainly rural in the upper reaches with impacts from agriculture, dams and settlements in the lower reaches of the catchment.

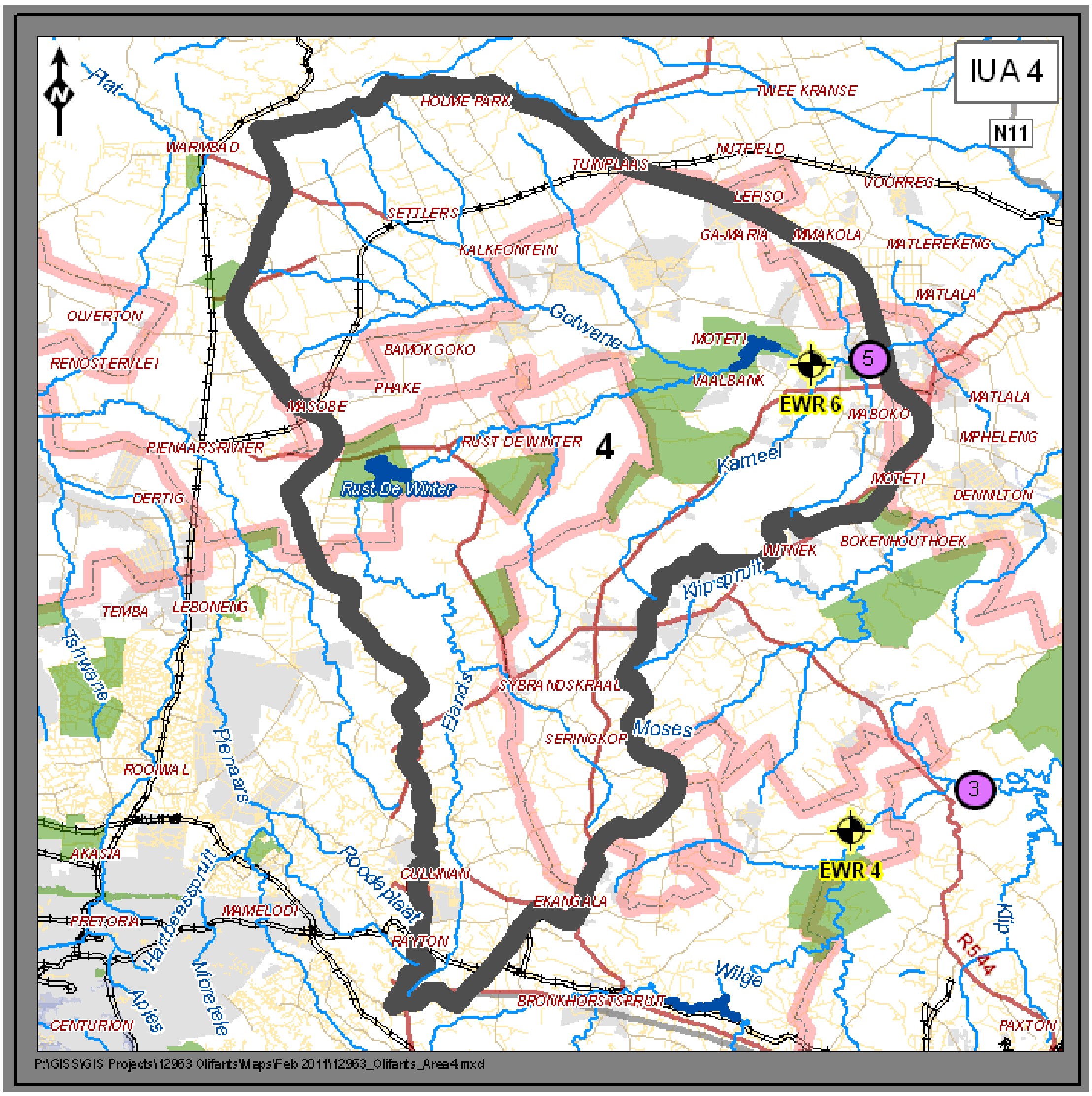

Figure 12. Physical map of IUA 4

7.1.4.1 *Demographic profile and basic services*

The population of IUA 4 is approximately 164 250 (Census 2001). The IUA has approximately 38 772 households of which the large majority falls within the very poor and poor income categories (Table 49). Of the 38 227 households approximately 4 647 (12%) have no access to piped water (Census 2001).

Table 49. Household income categories for IUA 4 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	23 063
Poor (R9601-R38 400)	11 603
Tolerable (38 401-R76 800)	2 345
Comfortable (R76 801-R153 600)	1 128
Wealthy (R153 601 & above)	634
Total	**38 772**

Of the total number of people interviewed in IUA 4 approximately 23% were unemployed (Table 50). The community, social and personal services sector supplied the largest amount of jobs in IUA 4 (Table 51). The private households sector is also an important sector in terms of employment in IUA 4.

Table 50. Employment categories for IUA 4 (Source: Census 2001)

Employment categories	Number
Unemployed	22 140
Employed	23 923
Not economically active	50 890
Total Interviewed	**96 953**

Table 51. Employment by sector in IUA 4 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	1 047
Mining and quarrying	551
Manufacturing	1 744
Electricity; gas and water supply	175
Construction	2 681
Wholesale and retail trade; repairs, hotels and restaurants	3 311
Transport, storage and communication	1 248
Financial intermediation; insurance; real estate and business services	1 344
Community; social and personal services	5 140
Private households	4 560
Extraterritorial organisations	0
Representatives of foreign governments	6
Undetermined	2 115
Total	**23 923**

7.1.4.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 4 is given in Table 52 below (CSIR 2003).

Table 52. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 4

Farming Type	Area (Ha)
Dryland	26 338
Irrigated	1 556
Subsistence	58
Total	**27 953**

Vegetables (4 113 ha) is the most common crop grown in IUA 4 followed by maize (2 800 ha) (Table 53).

Table 53. Crop types grown in IUA 4 (Source: DAFF 2008)

Crop	Area (ha)
Fallow	2 742
Maize	2 800
Vegetables	4 113
Pasture	1 678
Sorghum	17
Soya	750
Sunflower	136
Weeds	458
Undetermined	2 251
Total	14 945

7.1.5 IUA 5

The IUA includes the towns of Marble Hall, Groblersdal and Roedtan (Figure 13). The IUA contains the Flag Boshielo Dam, the Bloed, Klipspruit and Grass Valley Rivers. Several protected areas occur within the IUA and include, Mbusa, Moutse, Kwaggavoetpad and Schuinsdraii Nature Reserves. The economy of the IUA is characterised by intensive irrigation agriculture (specifically around Marble Hall and Groblersdal), commercial dryland agriculture (in the Springbok Flats region), some subsistence agriculture and some platinum mining.

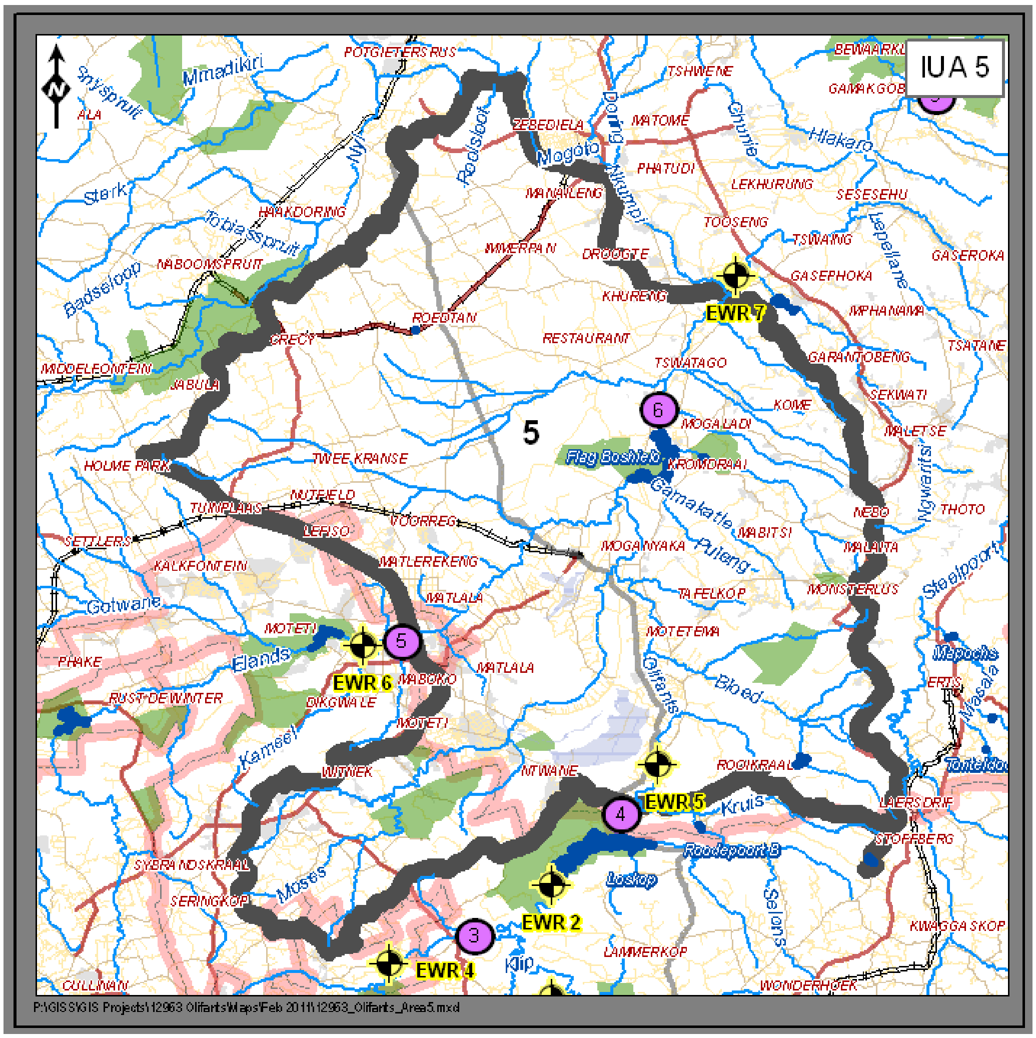

Figure 13 Physical map of IUA 5

7.1.5.1 Demographic profile and basic services

The population of IUA 5 is approximately is 366 051 (Census 2001). The IUA has approximately 81 474 households of which the large majority falls within the very poor and poor income categories (Table 54). Of the 81 474 households approximately 16 041 (20%) have no access to piped water (Census 2001).

Table 54. Household income categories for IUA 5 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	52 336
Poor (R9601-R38 400)	22 342
Tolerable (38 401-R76 800)	4 266
Comfortable (R76 801-R153 600)	1 748
Wealthy (R153 601 & above)	783
Total	**81 474**

Of the total number of people interviewed in IUA 5 approximately 25% were unemployed (Table 55). The community, social and personal services sector supplied the largest amount of jobs in IUA 5 (Table 56). The private households sector is also an important sector in terms of employment in IUA 5.

Table 55. Employment categories for IUA 5 (Source: Census 2001)

Employment categories	Number
Unemployed	51 724
Employed	38 771
Not economically active	118 447
Total Interviewed	208 942

Table 56. Employment by sector in IUA 5 (Source Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	2 128
Mining and quarrying	236
Manufacturing	2 811
Electricity; gas and water supply	279
Construction	4 448
Wholesale and retail trade; repairs, hotels and restaurants	5 492
Transport, storage and communication	2 181
Financial intermediation; insurance; real estate and business services	1 977
Community; social and personal services	9 336
Private households	6 744
Extraterritorial organisations	0
Representatives of foreign governments	8
Undetermined	3 131
Total	**38 771**

7.1.5.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 5 is given in Table 57 below (CSIR 2003).

Table 57. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 5

Farming Type	Area (Ha)
Dryland	114 394
Irrigated	49 821
Subsistence	65 499
Total	**229 713**

Pasture (10 876 ha) is the most common crop type in IUA 5 followed by maize (5 080 ha) (Table 58). The IUA is highly reliant on the agricultural sector and several farms in the IUA grow high value crops such as citrus and grapes, which have not been captured in Table 58 below.

Table 58. Crop types grown in IUA 5 (Source: DAFF 2008)

Crop	Area (ha)
Cotton	3 100
Drybeans	122
Fallow	15 328
Maize	5 080
Vegetables	3 629
Pasture	10 876
Sorghum	7
Soya	4 263
Sunflower	493
Weeds	947
Undetermined	1 192
Total	**45 037**

7.1.5.3 Mining

While the majority of platinum mining in the Olifants WMA is situated in IUA 6, mining does occur in this IUA. The Blue Ridge Platinum Mine (operated by Aquarius) is situated 15km from Groblersdal and produces 35 000 oz. of platinum annually.

7.1.6 IUA 6

IUA 6 follows the Steelpoort River valley, starting from the Grootspruit River in the south; up to it's confluence in the north with the Olifants River mainstem (Figure 14). It includes the towns of Belfast in the south, Steelpoort in the north and Roossenekal. The IUA includes a section of the Verloren Vallei Nature Reserve near Dullstroom. The economy of the IUA is characterized by mining, manufacturing, some irrigation for agriculture and tourism.

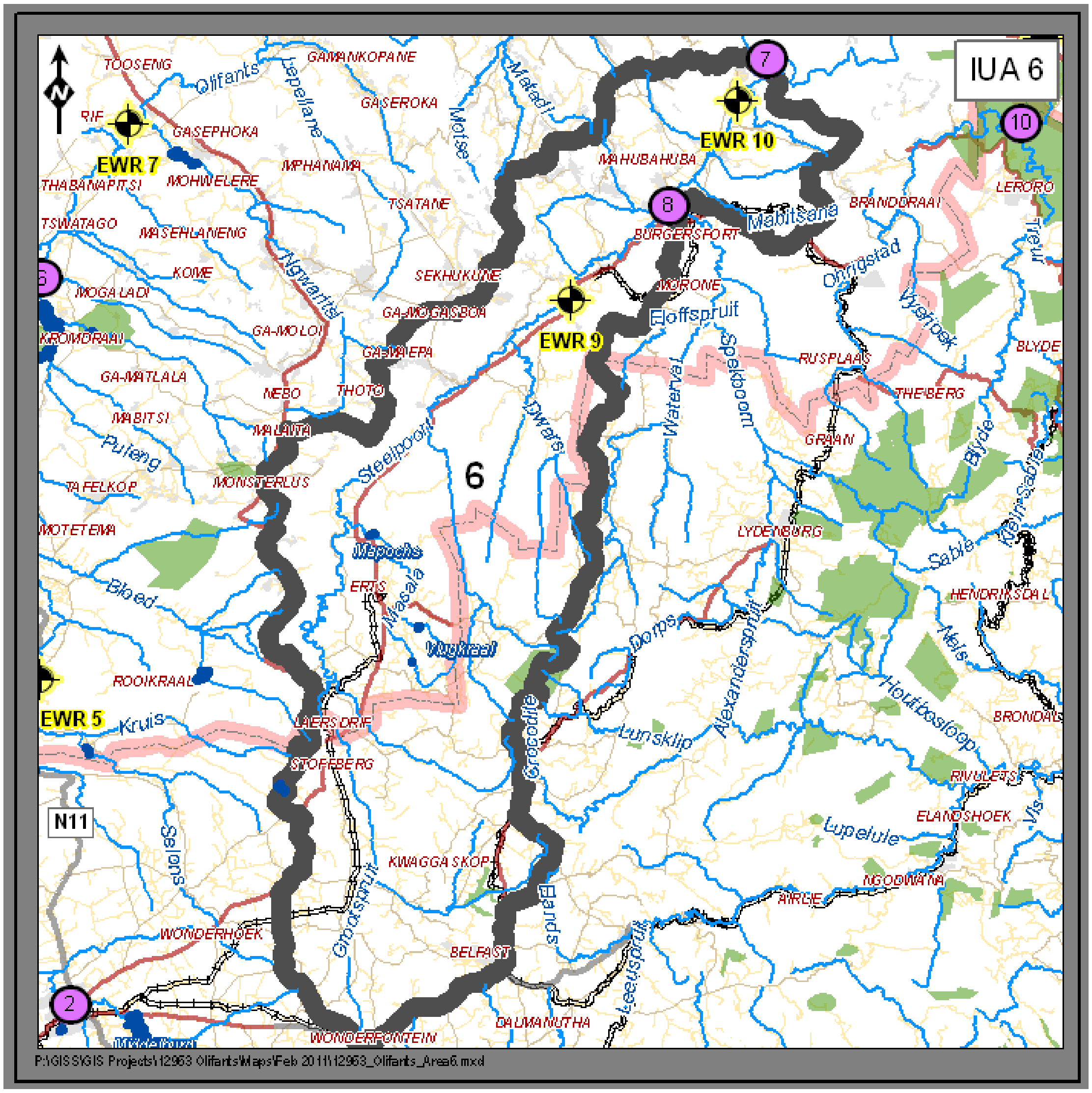

Figure 14. Physical map of IUA 6

7.1.6.1 Demographic profile and basic services

The population of IUA 6 is approximately 37 958 (Census 2001). The IUA has approximately 8 489 households of which the large majority falls within the very poor and poor income categories (Table 59). Of the 8 489 households approximately 2 859 (34%) have no access to piped water (Census 2001).

Table 59. Household income categories for IUA 6 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	5 043
Poor (R9601-R38 400)	2 561
Tolerable (38 401-R76 800)	536
Comfortable (R76 801-R153 600)	227
Wealthy (R153 601 & above)	122
Total	**8 489**

Of the total number of people interviewed in IUA 6 approximately 23% were unemployed (Table 60). The agriculture, hunting, forestry and fishing sector supplied the largest amount of jobs in IUA 6 (Table 61). The community, social and personal services sector is also an important sector in terms of employment in IUA 6.

Table 60. Employment categories for IUA 6 (Source: Census 2001)

Employment categories	Number
Unemployed	5 131
Employed	5 689
Not economically active	11 089
Total Interviewed	21 910

Table 61. Employment by sector in IUA 6 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	1 176
Mining and quarrying	274
Manufacturing	367
Electricity; gas and water supply	20
Construction	317
Wholesale and retail trade; repairs, hotels and restaurants	841
Transport, storage and communication	216
Financial intermediation; insurance; real estate and business services	262
Community; social and personal services	996
Private households	799
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	420
Total	**5 689**

7.1.6.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 6 is given in Table 62 below (CSIR 2003).

Table 62. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 6

Farming Type	Area (Ha)
Dryland	36 311
Irrigated	3 662
Subsistence	17 499
Total	**57 472**

Maize (15 286 ha) is the most common crop grown in IUA 6 followed by pasture (5 030 ha) (Table 63).

Table 63.Crop types grown in IUA 5 (Source: DAFF 2008)

Crop	Area (ha)
Drybeans	35
Fallow	1 312
Maize	15 286
Vegetables	1 276
Pasture	5 030
Sorghum	55
Soya	1 865
Sunflower	375
Weeds	4 477
Undetermined	19
Total	**29 730**

7.1.6.3 Mining

Platinum mining is a major contributor to GDP in the Olifants WMA. The bulk of platinum mining falls within IUA 6 with some mining occurring in IUA 5 near Groblersdal. IUA 6 falls within the eastern limb of the Bushveld Complex, which contains the largest platinum deposits in the world (Figure 15).

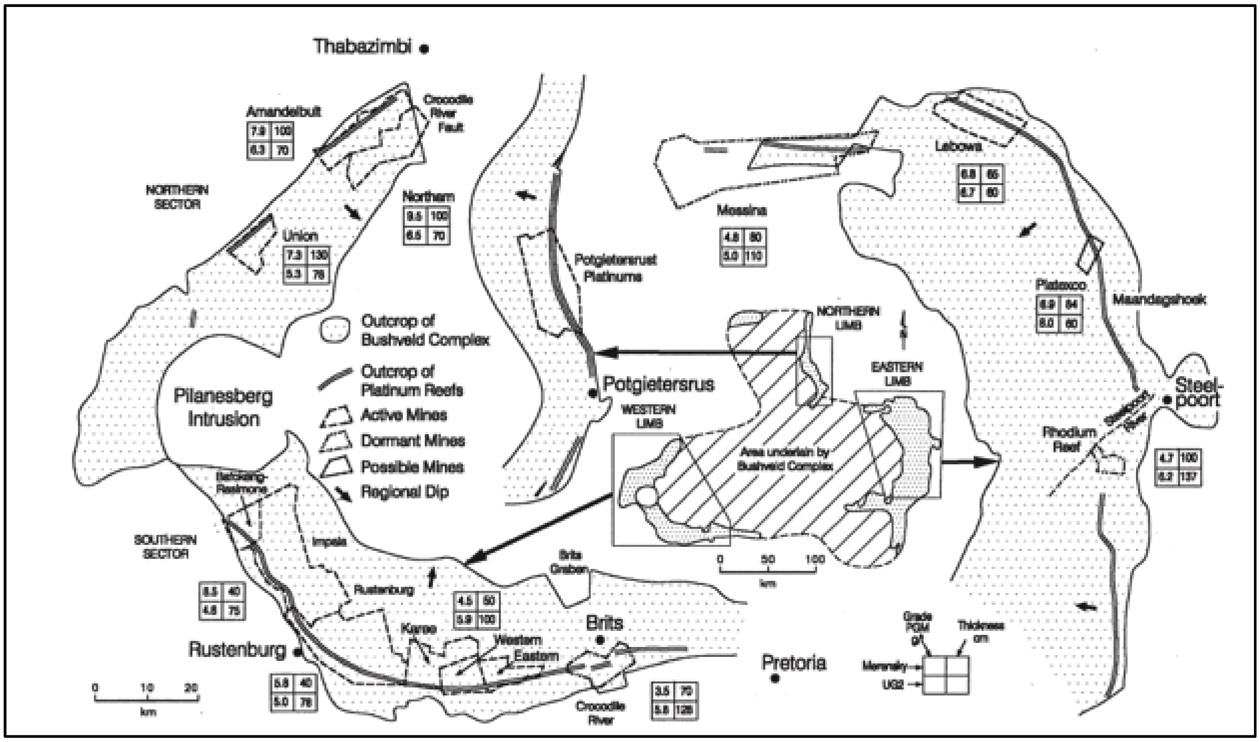

Figure 15. General map of the Bushveld Complex. The eastern limb is shown to the left of the map, which underlay IUAs 5and 6. (Taken from Cawthorn 1999).

There are three major platinum mining operators present (Amplats, Impala Platinum and Aquarius) in IUA 6, while other, smaller mining companies are present, information regarding their operation is however limited. The IUAs were responsible for producing approximately 552 000 oz. of platinum in 2010 (Table 64).

Table 64 .Platinum production (oz.) for IUAs 5 and 6 for 2010

Operator	Name	Location	Production 2010 (000 oz) Platinum (in concentrate production)	IUA
Amplats	Modikwa Platinum Mine	The mine is on the border of the Mpumalanga and Limpopo provinces of South Africa, approximately 25 kilometres west of the town of Burgersfort.	130	6
	Mototolo Platinum Mine	Limpopo Province, approximately 30 kilometres west of the town of Burgersfort	108	6
	Bokoni Platinum Mine	Limpopo Province of South Africa, approximately 80 kilometres southeast of the town of Polokwane	63	6
Impala Platinum	Marula Platinum Mine	Limpopo Province north-east of Burgersfort	70	6
	Two Rivers Platinum Mine	Eastern limb of the Bushveld Complex, near Mashishing, in Mpumalanga.	141	6
Aquarius	Everest Platinum Mine	Eastern limb of the Bushveld Complex, near Mashishing, in Mpumalanga.	5	6
	Blue Ridge Platinum Mine	South-western extension of the Bushveld Complex in the Sekhukune District, 15km from Groblersdal	35	5
Total			**552**	

Samancor operates the Eastern Chrome Mine (ECM) situated close to Steelpoort. The mine consists of three underground mines, two opencast mines, four surface beneficiation plants and two tailings re-treatment plants, typically producing around 2.0 Mt of saleable product per annum.

Xstrata Alloys operate both the Thornecliffe and Helena Chrome Mines near Steelpoort. The mines annual production capacity is 1 440 and 600kt respectively.

Evraz Highveld Steel operates the Mapochs Mine near Roossenekal. The mine is an open-cast mining operation which produces lump iron ore and ore fines. Table 65 below summarise the Mine's production for 2009 and 2010.

Table 65. Lump ore production at the Mapochs Mine in IUA 6 for 2009 and 2010

Production ('000 tons)	2010	2009
Run of Mine	2 283	2 176
Lump Ore	1 717	1 357
Fines	608	490

7.1.6.4 Manufacturing

Samancor operates the Tubatse Ferrochrome Plant (TFC) situated in Steelpoort, Mpumalanga that is in close proximity to the ECM. The core business of the operation is the production of charge. The expected useful life of the facility is at least 25 years.

Xstrata Alloys' Lion Ferrochrome Operation is located near Steelpoort. The annual production capacity of the plant is approximately 360kt.

7.1.7 IUA 7

The IUA consists primarily of dryland agriculture and rural subsistence farmers (Figure 16). It encompasses the Local Municipalities of Polokwane, Lepele-Nkumpi, Fetakgomo Makhuduthamaga. Some platinum mining occurs within the IUA.

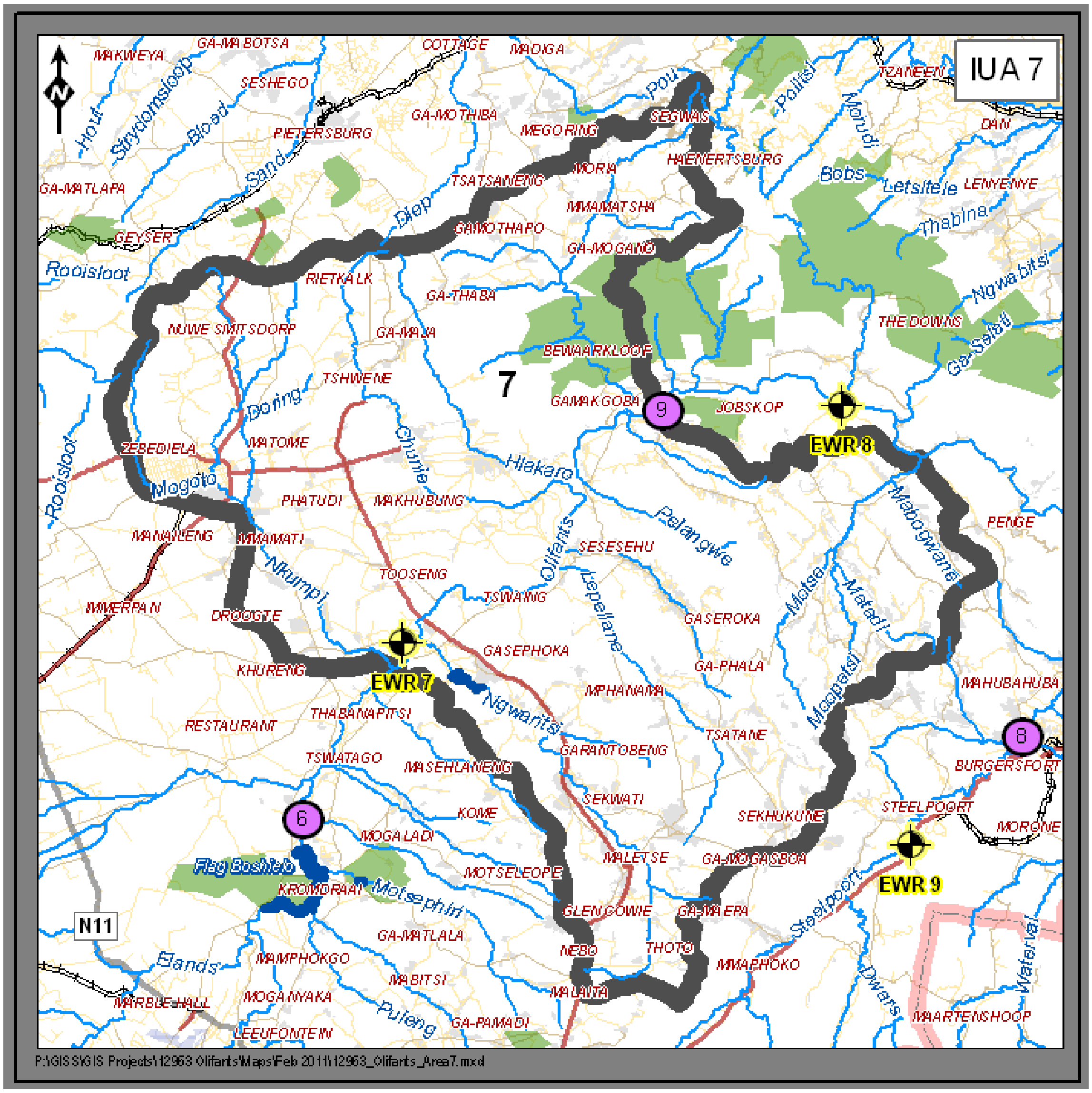

Figure 16. Physical map of IUA 7

7.1.7.1 Demographic profile and basic services

The population of IUA 7 is approximately 550 871 (Census 2001). The IUA has approximately 123 234 households of which the large majority falls within the very poor and poor income categories (Table 66). Of the 52 990 households approximately 16 041 (43%) have no access to piped water (Census 2001).

Table 66. Household income categories for IUA 7 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	87 711
Poor (R9601-R38 400)	25 306
Tolerable (38 401-R76 800)	6 255
Comfortable (R76 801-R153 600)	2 717
Wealthy (R153 601 & above)	1 245
Total	**123 234**

Of the total number of people interviewed in IUA 7 approximately 23% were unemployed (Table 67). The community, social and personal services sector supplied the largest amount of jobs in IUA 7 (Table 68). The wholesale and retail trade, repairs, hotels and restaurants sector is also an important sector in terms of employment in IUA 7.

Table 67. Employment categories for IUA 7 (Source: Census 2001)

Employment categories	Number
Unemployed	67 152
Employed	38 807
Not economically active	185 263
Total Interviewed	291 222

Table 68. Employment by sector in IUA 7

Sector	Employment
Agriculture; hunting, forestry and fishing	4 093
Mining and quarrying	1 119
Manufacturing	1 981
Electricity; gas and water supply	413
Construction	2 131
Wholesale and retail trade; repairs, hotels and restaurants	4 738
Transport, storage and communication	1 470
Financial intermediation; insurance; real estate and business services	1 701
Community; social and personal services	14 079
Private households	4 299
Extraterritorial organisations	6
Representatives of foreign governments	0
Undetermined	2 777
Total	**38 807**

7.1.7.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 7 is given in Table 69 below (CSIR 2003). It is important to note that subsistence agriculture makes up a large proportion of agriculture in this IUA.

Table 69. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 7

Farming Type	Area (Ha)
Dryland	109 197
Irrigated	5 587
Subsistence	144 482
Total	259 267

7.1.7.3 Mining

While the majority of platinum mining in the Olifants WMA is situated in IUA 8, limited mining does occur in this IUA. The Marula Platinum Mine (operated by Impala Platinum) is situated north east of Burgersfort and produces 70 000 oz. of platinum annually. Platinum mining is discussed in more detail in the proceeding section.

7.1.8 IUA 8

The IUA is situated within the Spekboom Catchment (Figure 17). The IUA includes the town of Mashishing (Lydenburg) in the south and Burgersfort in the north. Several protected areas occur within the IUA and include the Sterkspruit and Gustav Klingbiel Nature Reserves. The economy of the IUA is characterized by platinum mining, tourism, dryland and irrigated agriculture.

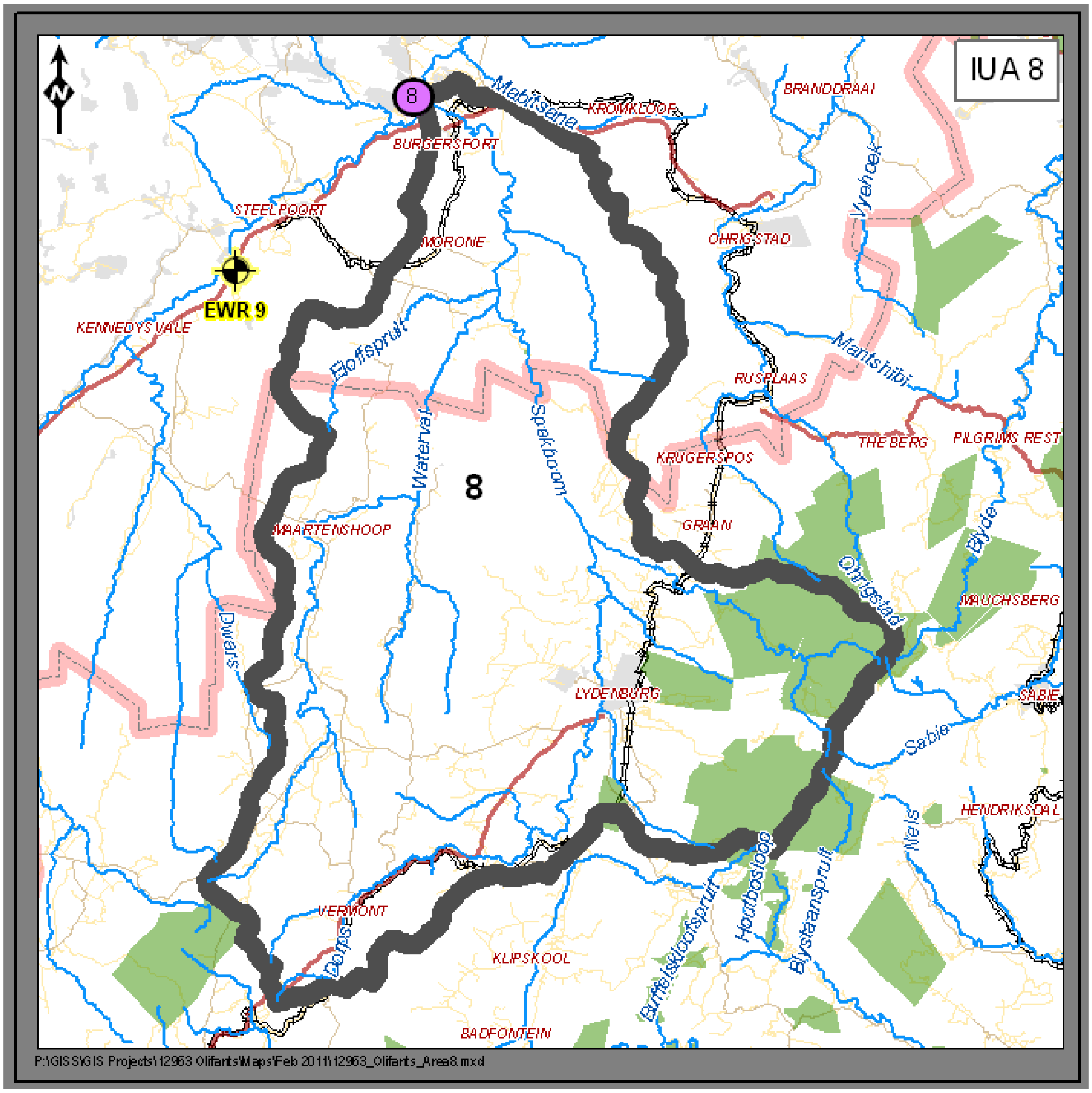

Figure 17. Physical map for IUA 8

7.1.8.1 Demographic profile and basic services

The population of IUA 8 is approximately 30 026 (Census 2001). The IUA has approximately 9 029 households of which the large majority falls within the very poor and poor income categories (Table 70). Of the 9 029 households approximately 234 (3%) have no access to piped water (Census 2001).

Table 70. Household income categories for IUA 8 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	3 777
Poor (R9601-R38 400)	3 292
Tolerable (38 401-R76 800)	943
Comfortable (R76 801-R153 600)	650
Wealthy (R153 601 & above)	367
Total	**9 029**

Of the total number of people interviewed in IUA 8 approximately 20% were unemployed (Table 71). The wholesale and retail trade, repairs, hotels and restaurants sector supplied the largest amount of jobs in IUA 8 (Table 72). The community, social and personal services sector is also an important sector in terms of employment in IUA 8.

Table 71. Employment categories for IUA 8 (Source: Census 2001)

Employment categories	Number
Unemployed	3 947
Employed	9 369
Not economically active	6 732
Total Interviewed	20 048

Table 72. Employment by sector in IUA 8

Sector	Employment
Agriculture; hunting, forestry and fishing	1 550
Mining and quarrying	540
Manufacturing	991
Electricity; gas and water supply	37
Construction	510
Wholesale and retail trade; repairs, hotels and restaurants	1 908
Transport, storage and communication	261
Financial intermediation; insurance; real estate and business services	474
Community; social and personal services	1 588
Private households	1 089
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	419
Total	**9 369**

7.1.8.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 8 is given in Table 73 below (CSIR 2003).

Table 73. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 8

Farming Type	Area (Ha)
Dryland	9 544
Irrigated	6 550
Subsistence	168
Total	16 262

Pasture (2 720ha) is the most common crop type in IUA 8 followed by maize (1 954ha) (Table 74).

Table 74. Crop types grown in IUA 5 (Source: DAFF 2008)

Crop	Area (ha)
Fallow	773
Maize	1 954
Vegetables	345
Pasture	2 720
Soya	1 502
Weeds	249
Undetermined	25
Total	**7 568**

7.1.8.3 Manufacturing

Xstrata Alloys operates the Lydenburg Ferrochrome plant near the town of Mashishing. The Plant has the capacity to produce 396kt of Ferrochrome per annum and provides employment for 545 employees.

7.1.9 IUA 9

The IUA contains the towns of Ohrigstad and Pilgrims Rest (Figure 18). This IUA has a high conservation status, as it is contains part of the Blyde River Catchment area. The catchment is important because it forms an integral part of the proposed Kruger to Canyons biosphere reserve. Important water resources include the Blyde River upstream from the Blyderivierspoort Dam. The economy of the IUA is characterized by irrigated and dryland agriculture, ecotourism and subsistence agriculture. Some forestry occurs in the upper reaches of the Treur River.

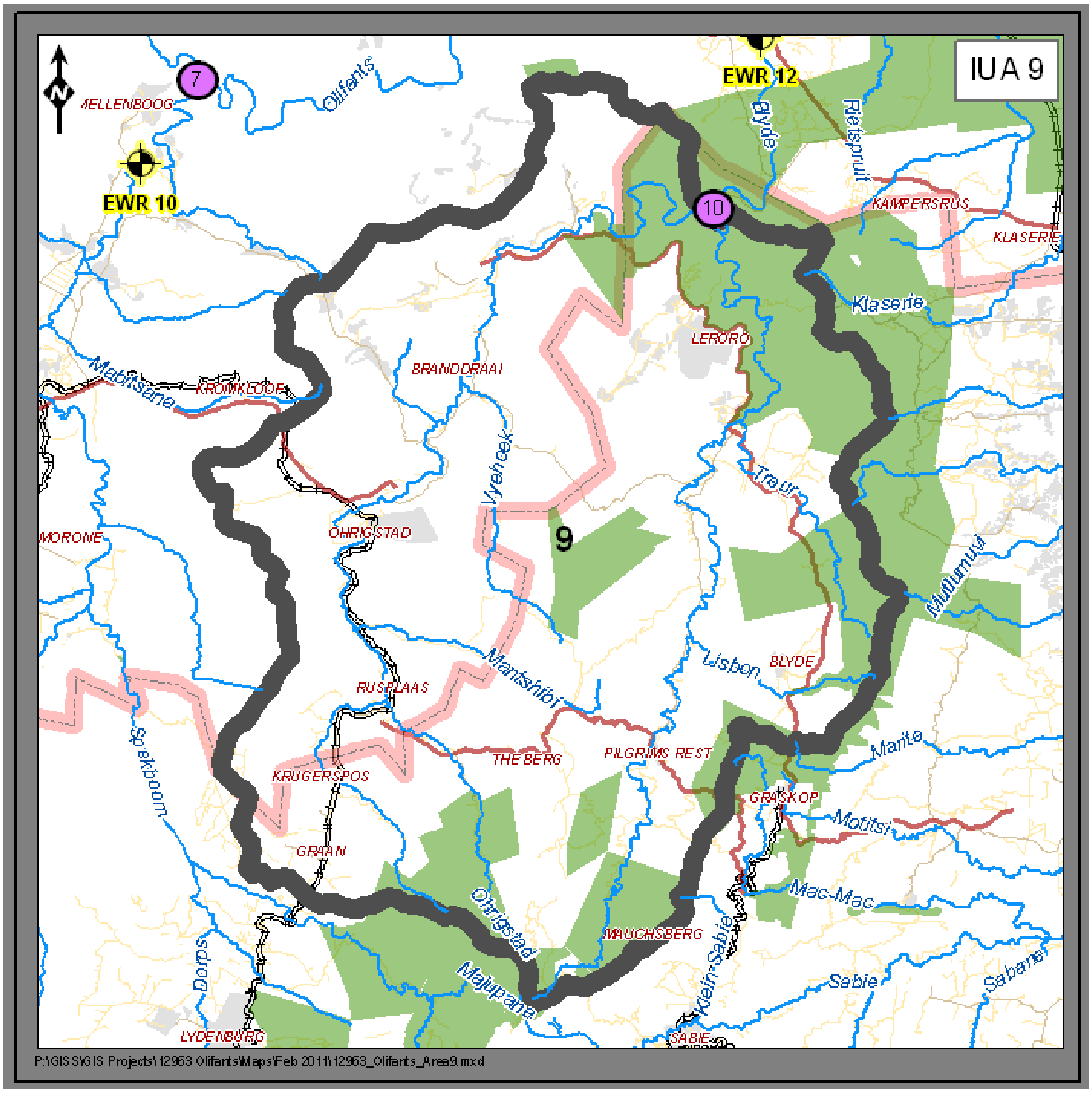

Figure 18. Physical map of IUA 9

7.1.9.1 Demographic profile and basic services

The population of IUA 9 is approximately 25 041 (Census 2001). The IUA has approximately 7 881 households of which the large majority falls within the very poor and poor income categories (Table 75). Of the 7 881 households approximately 470 (6%) have no access to piped water (Census 2001).

Table 75. Household income categories for IUA 9 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	4 683
Poor (R9601-R38 400)	2 609
Tolerable (38 401-R76 800)	317
Comfortable (R76 801-R153 600)	167
Wealthy (R153 601 & above)	106
Total	**7 881**

Of the total number of people interviewed in IUA 9 approximately 18% were unemployed (Table 76). The manufacturing sector supplied the largest amount of jobs in IUA 9 (Table 77). The agriculture, hunting, forestry and fishing sector is also an important sector in terms of employment in IUA 9.

Table 76 Employment categories for IUA 9 (Source: Census 2001)

Employment categories	Number
Unemployed	2 879
Employed	6 797
Not economically active	6 437
Total Interviewed	16 113

Table 77. Employment by sector in IUA 9

Sector	Employment
Agriculture; hunting, forestry and fishing	1 234
Mining and quarrying	158
Manufacturing	2 654
Electricity; gas and water supply	30
Construction	160
Wholesale and retail trade; repairs, hotels and restaurants	918
Transport, storage and communication	110
Financial intermediation; insurance; real estate and business services	197
Community; social and personal services	823
Private households	318
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	194
Total	**6 797**

7.1.9.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 9 is given in Table 78 below (CSIR 2003). Irrigation is a major component of the economy of IUA 9 with several irrigated crops occurring along the Orhigstad River.

Table 78. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 9

Farming Type	Area (Ha)
Dryland	543
Irrigated	8 589
Subsistence	2 237
Total	11 369

Pasture (2 069 ha) is the most common crop type in IUA 9 followed by maize (1 831 ha) (Table 79). High value crops such as citrus are not captured in Table 79 below, but are grown along the Orhigstad River.

Table 79.Crop types grown in IUA 5 (Source: DAFF 2008)

Crop	Area (ha)
Fallow	1 071
Maize	1 831
Vegetables	459
Pasture	2 069
Soya	466
Sunflower	12
Weeds	686
Undetermined	44
Total	**6 637**

7.1.10 IUA 10

The IUA contains the town of Hoedspruit (Figure 19). The IUA also contains the semi-urban areas of Hlohlokwe, Sofaya and Mahlomelong. The IUA contains several conservation areas, which include: Bewaarkloof Nature Reserve, the Wolkberg Wilderness area and a portion of the Blyde River Canyon catchment area. Important water resources include the Olifants River. The economy of the IUA is characterized by intensive agriculture (especially near Hoedspruit), rural subsistence, ecotourism and light commercial activities.

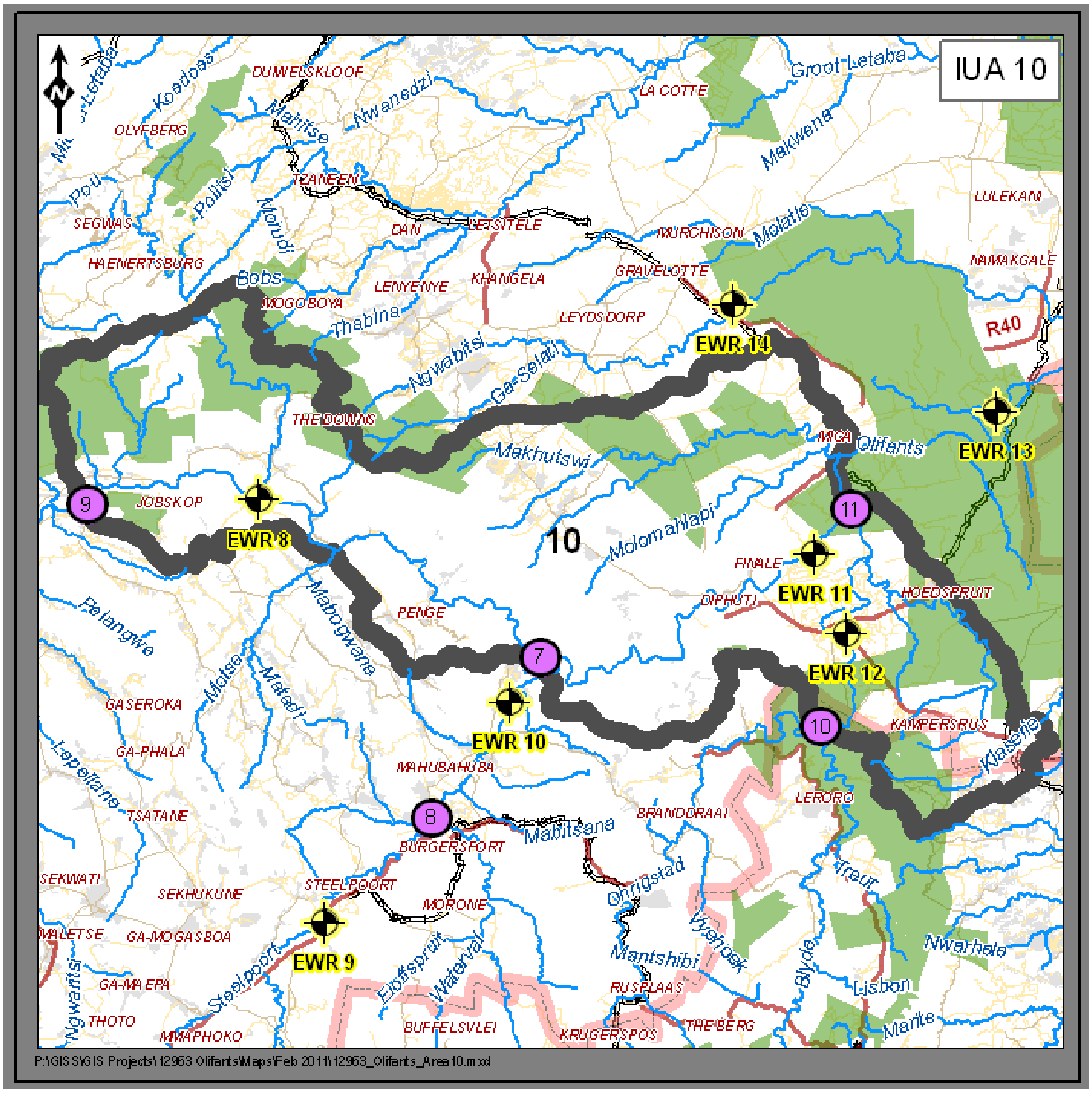

Figure 19. Physical map of IUA 10

7.1.10.1 Demographic profile and basic services

The population of IUA 10 is approximately 25 430 (Census 2001). The IUA has approximately 5 665 households of which the large majority falls within the very poor and poor income categories (Table 80). Of the 5 665 households approximately 1 217(21%) have no access to piped water (Census 2001).

Table 80. Household income categories for IUA 10 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	4 292
Poor (R9601-R38 400)	1 110
Tolerable (38 401-R76 800)	175
Comfortable (R76 801-R153 600)	54
Wealthy (R153 601 & above)	35
Total	**5 665**

Of the total number of people interviewed in IUA 10 approximately 21% were unemployed (Table 81). The agriculture, hunting, forestry and fishing sector supplied the largest amount of jobs in IUA 10 (Table 82). The community, social and personal services sector is also an important sector in terms of employment in IUA 10.

Table 81. Employment categories for IUA 10 (Source: Census 2001)

Employment categories	Number
Unemployed	2 824
Employed	1 625
Not economically active	8 823
Total Interviewed	13 272

Table 82. Employment by sector for IUA 10 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	478
Mining and quarrying	144
Manufacturing	70
Electricity; gas and water supply	11
Construction	87
Wholesale and retail trade; repairs, hotels and restaurants	177
Transport, storage and communication	28
Financial intermediation; insurance; real estate and business services	49
Community; social and personal services	342
Private households	102
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	136
Total	**1 625**

7.1.10.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 10 is given in Table 83 below (CSIR 2003). There has been a significant increase in irrigation in IUA 10 over the last few years. High value crops such as citrus are grown around the Hoedspruit area.

Table 83. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 10

Farming Type	Area (Ha)
Dryland	345
Irrigated	13 696
Subsistence	9 618
Total	23 659

7.1.11 IUA 11

This IUA contains the towns of Phalaborwa, Gravelotte and Mica (Figure 20). The IUA is bordered by the Kruger National Park to the west and other conservation areas to the east. The IUA also contains the semi-urban areas of Ga-Mashishimale and Namakgale. Important water resources include the Ga-Selati River. The economy of the IUA is characterized by intensive mining (including the Rio Tinto copper mine near Phalaborwa), ecotourism and agriculture.

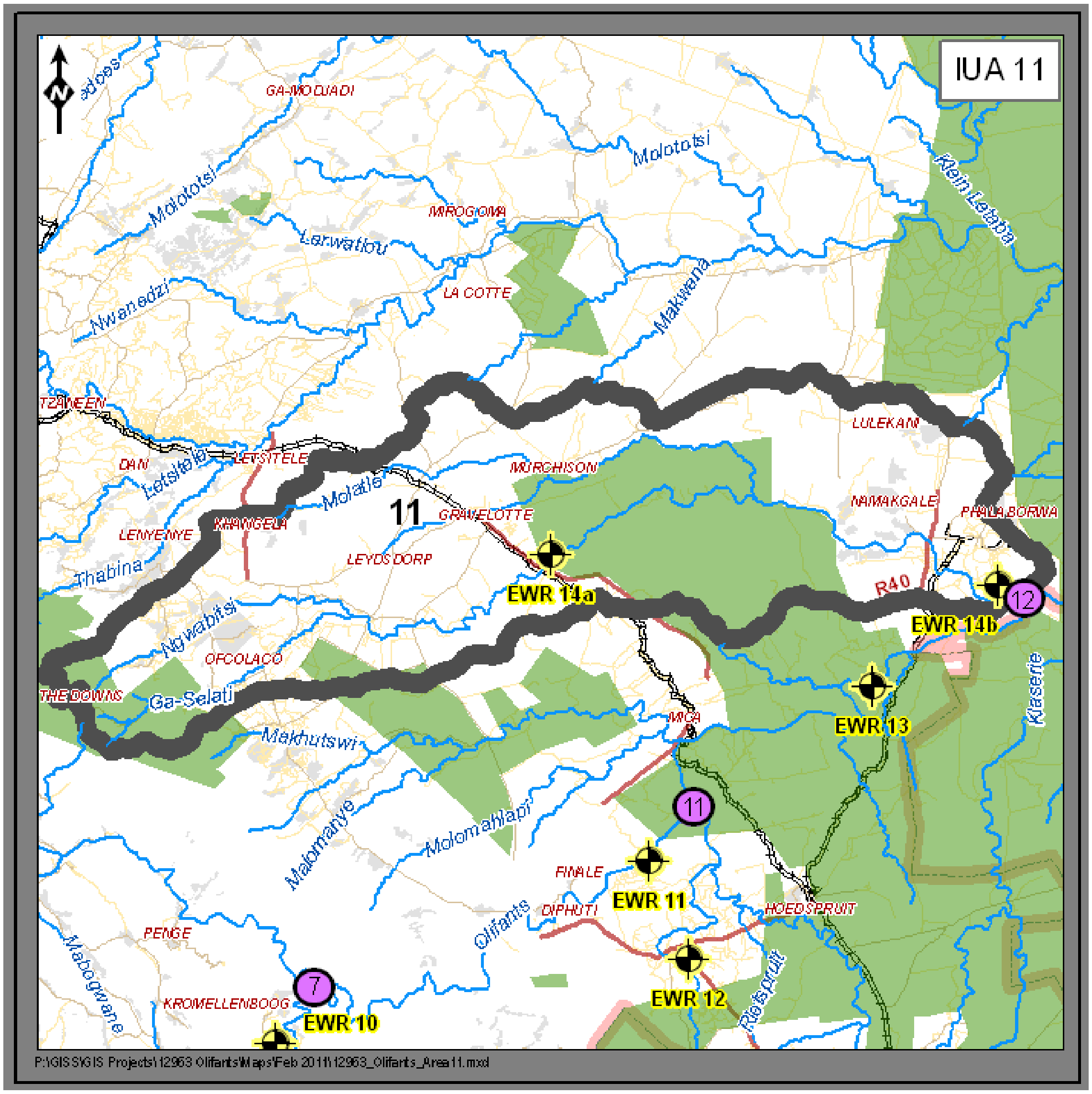

Figure 20. Physical map of IUA 11

7.1.11.1 Demographic profile and basic services

The population of IUA 11 is approximately 134 894 (Census 2001). The IUA has approximately 33 156 households of which the large majority falls within the very poor and poor income categories (Table 84). Of the 33 156 households approximately 3 642 (11%) have no access to piped water (Census 2001).

Table 84.Household income categories for IUA 11 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	18 659
Poor (R9601-R38 400)	9 283
Tolerable (38 401-R76 800)	2 706
Comfortable (R76 801-R153 600)	1 500
Wealthy (R153 601 & above)	1 008
Total	**33 156**

Of the total number of people interviewed in IUA 11 approximately 21% were unemployed (Table 85). The mining and quarrying sector supplied the largest amount of jobs in IUA 11 (Table 86). The community, social and personal services sector is also an important sector in terms of employment in IUA 11.

Table 85. Employment categories for IUA 11 (Source: Census 2001)

Employment categories	Number
Unemployed	20 536
Employed	24 794
Not economically active	36 631
Total Interviewed	81 961

Table 86. Employment by sector in IUA 11 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	2 358
Mining and quarrying	4 609
Manufacturing	2 106
Electricity; gas and water supply	252
Construction	1 450
Wholesale and retail trade; repairs, hotels and restaurants	2 933
Transport, storage and communication	661
Financial intermediation; insurance; real estate and business services	1 360
Community; social and personal services	4 806
Private households	2 147
Extraterritorial organisations	1
Representatives of foreign governments	1
Undetermined	2 108
Total	**24 794**

7.1.11.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 11 is given in Table 87 below (CSIR 2003). There has been a significant increase in irrigation in IUA 11 over the last few years.

Table 87. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 11

Farming Type	Area (Ha)
Dryland	698
Irrigated	7 933
Subsistence	3 896
Total	12 527

7.1.11.3 Mining

Several mining activities occur in the IUA with the largest being the PhalaborwaCopper Mine operated by Rio Tinto near Phalaborwa. The operation encompasses a copper mine, smelter and refinery and produces approximately 80 000 tonnes of refined copper annually.

Other operations include the Consolidated Murchison Mine, which produces antimony and gold found near Mica and the mining of mica in the greater Gravelotte and Mica areas.

7.1.12 IUA 12

The IUA encompasses the Lower Olifants catchment area and includes the Kruger National Park (KNP) (Figure 21). Most of the IUA is therefore of high conservation status and the majority is protected. The main economic activity is eco-tourism.

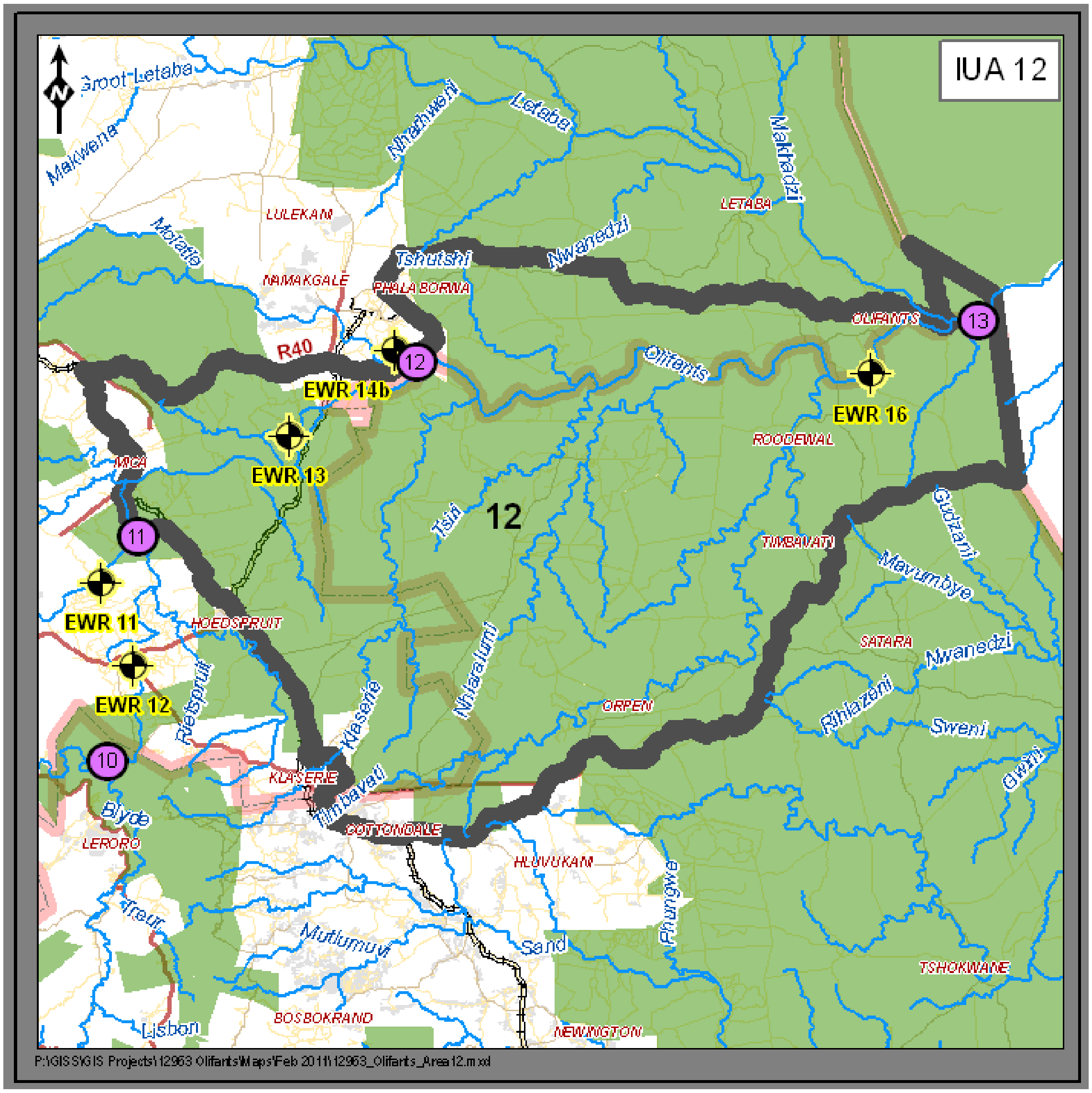

Figure 21. Physical map of IUA 12

7.1.12.1 Demographic profile and basic services

The population of IUA 12 is approximately is 7 721 (Census 2001). The IUA has approximately 2 471 households of which the large majority falls within the very poor and poor income categories (Table 88). Of the 2 471 households approximately 106 (4%) have no access to piped water (Census 2001).

Table 88.Household income categories for IUA 12 (Source: Census 2001)

Income Category	Number of Households
Very Poor (no income-R9600)	981
Poor (R9601-R38 400)	914
Tolerable (38 401-R76 800)	214
Comfortable (R76 801-R153 600)	186
Wealthy (R153 601 & above)	176
Total	**2 471**

Of the total number of people interviewed in IUA 12 approximately 19% were unemployed (Table 89). The mining and quarrying sector supplied the largest amount of jobs in IUA 12 (Table 90). The community, social and personal services sector is also an important sector in terms of employment in IUA 12.

Table 89. Employment categories for IUA 12 (Source: Census 2001)

Employment categories	Number
Unemployed	1 034
Employed	2 628
Not economically active	1 646
Total Interviewed	5 307

Table 90. Employment by sector in IUA 12 (Source: Census 2001)

Sector	Employment
Agriculture; hunting, forestry and fishing	212
Mining and quarrying	738
Manufacturing	241
Electricity; gas and water supply	23
Construction	156
Wholesale and retail trade; repairs, hotels and restaurants	285
Transport, storage and communication	42
Financial intermediation; insurance; real estate and business services	132
Community; social and personal services	429
Private households	207
Extraterritorial organisations	0
Representatives of foreign governments	0
Undetermined	162
Total	**2 628**

7.1.12.2 Agriculture

The area of dryland, irrigated and subsistence agriculture for IUA 12 is given in Table 91 below (CSIR 2003).

Table 91. Area (ha) of dryland, irrigated and subsistence agriculture for IUA 12

Farming Type	Area (Ha)
Dryland	255
Irrigated	2 320
Subsistence	2 117
Total	4 692

8 Step 1(i) Develop the socio-economic framework and the decision-analysis framework

8.1 Objective

The WRCS Guidelines describes the objective of this sub-step to be the development of a suitable socio-economic valuation framework that links changes in yield and ecosystem characteristics to socio-economic values. The framework must enable forecasting of changes in socio-economic values due to changes in water yield and ecosystem characteristics for different water resource management scenarios. The WRCS Guidelines proposes the use of an integrated ecosystem services / economic modelling framework, but advises that the decision of which framework to adopt would depend on the specific characteristics of the catchment analysed, and the preference of DWA and the PSP team.

The WRCS Guidelines distinguish between three key variables (1) utilizable water yield, (2) water quality and (3) aquatic ecosystem health. All these variables affect the socio-economy and the WRCS Guidelines proposes that these effects be measured in terms of economic impact using a Social Accounting Matrix, or a related input-output analysis tool.

This section proposes a decision-analysis framework for supporting the required analyses.

8.2 The water economy in context and a critical assessment of the available socio-economic data

The water economy of the Olifants WMA comprises several components. The water resources of the Olifants WMA are natural assets that produce raw water and other aquatic ecosystem services. The raw water is used as an input in economic production, whilst the other aquatic ecosystem services are mostly directly used by households. Various economic sectors produce a variety of goods and services, many of them consumed as intermediate goods and services, but ultimately consumed by households. Households provide labour to the economic production process. Finally, the economic production process also produces a variety of effluents, which end up back in the aquatic environment as pollutants. The figure below describes these transactions.

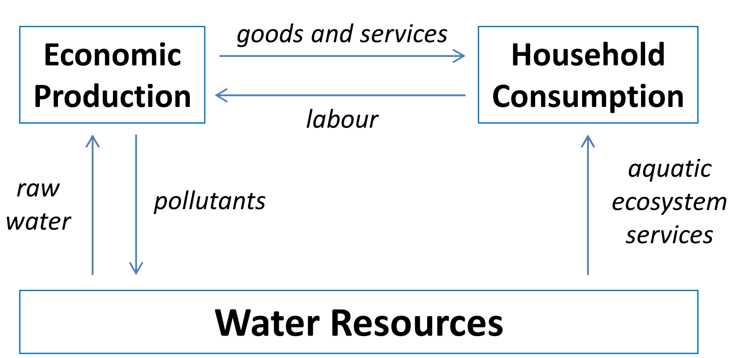

Figure 22. A schematic representation of the transactions between water resources, economic production and household consumption.

The discussions in the preceding sections have extracted from available literature, some economic values related to the water economy of the Olifants WMA.

Total economic production, measured as Value Added (VAD), according to DWA (2004) was approximately R135 billion in 2010. Value added is formally defined as the sum of labour, company profits, taxes paid and interest earned.

The value of aquatic ecosystem services (according to DWA (2010)) external to the economy of the WMA was approximately R970 million in 2010. The inclusion of these ecosystem services into the economy of the WMA adjusts GDP to approximately R136 billion in 2010. According to this analysis, the value of all aquatic ecosystem services (R1,350 million in 2010) thus contribute only 1% of the value added to the Olifants WMA economy. However, this aquatic ecosystems valuation excludes a number of important transactions relating to water resources. Firstly, the value of water regulation, which produces raw water for use in economic production, was not valued in DWA (2010).

Hassan and Farolfi (2005) conducted an excellent study in the Steelpoort basin, which estimated the economic value of raw water. The study developed an analytical framework and an empirical water sector model to evaluate current and alternative water allocation regimes in the Steelpoort sub-basin (SPSB). The analyses showed that raw water was oversupplied to offstream uses at the expense of the ecological Reserve (instream benefits). It also showed that raw water was underpriced. The study estimated the water resource rent (RR) in the Steelpoort basin to vary between R0.45/m^3 and R5.50/m^3 (R0.42/m^3 and R5.20/m^3 in 2005). This implies that almost all water resource rent accrues to various offstream users in the form of indirect subsidies.

A second important omission from the DWA (2010) study is the value of human health associated with aquatic ecosystems. The World Health Organisation (WHO) postulates that environmental hazards are responsible for as much as a quarter of the total burden of disease world-wide, and more than one-third of the burden among children. Heading that list are diarrhoea, lower respiratory infections, various forms of unintentional injuries and malaria. The disease burden is much higher in the developing world, although in the case of certain non-communicable diseases, such as cardiovascular diseases and cancers, the per capita disease burden is larger in developed countries. Health impacts of environmental hazards run across more than 80 diseases and types of injury.

The damaging effects of emissions in the form of water pollutants and sedimentation emitted into aquatic ecosystems (i.e. water resources) are an important environmental externality.

Another externality is the conservation cost of aquatic ecosystem stewardship function. These costs are defined as externalities because they are not borne by the formal economy, but instead result in degradation of the water resource asset.

These transactions can be modelled using various economic modelling techniques:

- Social Accounting Matrixes (SAMs) model the transactions between economic production sectors and household consumption.
- Environmental Economic Accounts for Water (Water EEAs) model the transactions between economic production and water resources (and expands the Water sector component of the SAM).
- Environmental and Resource Economics (ERE) modelling, based on the Millennium Ecosystem Assessment framework, models the production of aquatic ecosystem services.
- The effects of water pollutants on water resources and households can be modelled in various ways, however in this case, we will simulate the economic effects of implementing a Waste Discharge Charge System (WDCS).

The sections below provide background on each of these modelling techniques.

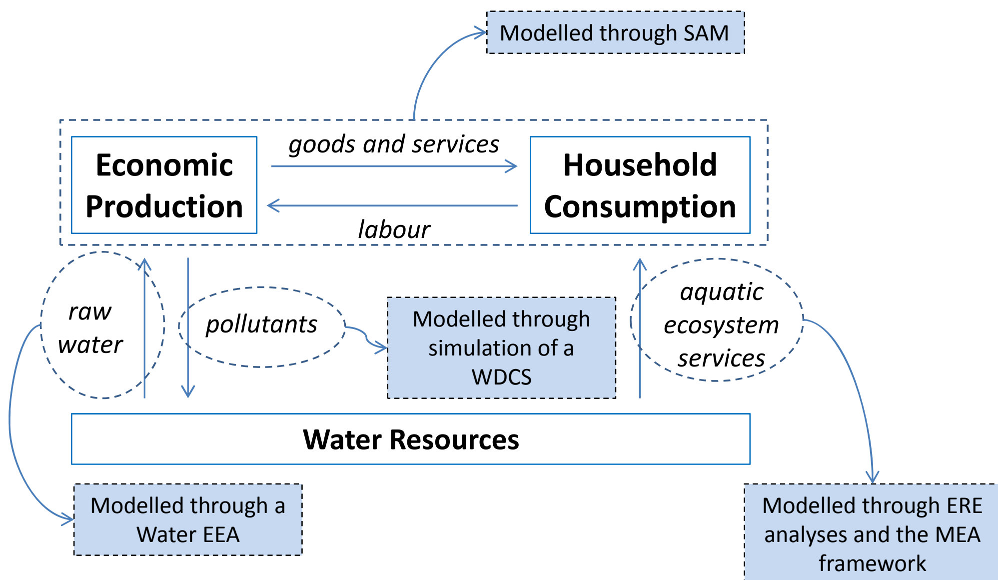

Figure 23. Schematic representation of the economic modelling techniques required to address the transactions of the Olifants WMA water economy.

8.3 Analyses of the formal and informal economies using sectoral analyses and SAMs

8.3.1 Macro-economic analyses[7]

Water resource management scenarios need to be evaluated in terms of their implications on the broader economy at a regional scale. The WRCS Guidelines proposes the use of a Social Accounting Matrix (SAM) (such as that developed by the Development Bank of Southern Africa (DBSA)) to model the macro-economic and social implications of different scenarios.

[7] DWA 2010a

A SAM is a matrix that summarises the linkages that exist between the different role players in the economy i.e. business sectors, households and government. Thus, a SAM reflects all of the inter-sectoral transactions in an economy and the activities of households. A household is a very important economic definition, as it is the basic unit where significant decisions regarding important economic variables such as expenditure and saving are taken. A SAM combines households into meaningful groups, and thus enables analysis of different household groups, and its dependence on the rest of the economy. A SAM thus enables modelling of changes in economic activity on economic growth (i.e. the impact on GDP); job creation (i.e. the impact on labour requirements); impact on capital formation; and income distribution (i.e. the impact on low-income, poor households and the total income households).

A SAM enables the simulation of changes in sector turnover (please see the table below for a definition of sectors covered by a SAM) to estimate macro-economic impacts using economic multipliers. Economic models fundamentally incorporate a number of “multipliers” that form the nucleus of the modelling system. A multiplier specifies the nature and extent of the impact of a change in a specific economic quantity (e.g. agriculture) on another economic quantity or quantities (e.g. food manufacturing or employment). Multipliers consist of direct, indirect and induced multipliers. The direct multiplier measures an economic effect occurring in a specific sector, whilst the indirect multiplier measures those effects occurring in the different economic sectors that link backwards and forwards to this sector. The induced effect measures the additional economic activity generated by the spending of additional the salaries and profits generated. Sectoral multipliers are calculated using information contained in the Sectoral SAMs and data obtained from the Reserve Bank of South Africa and Stats SA.

The DBSA has published SAMs for each of the nine Provinces of South Africa. The Olifants WMA straddles the Limpopo and Mpumalanga Provinces and thus the SAMs for these two provinces will be used in the decision framework.

Table 92. Description of the economic sectors addressed by a SAM. Source: WRCS Guidelines (DWA 2010a)

Sector	Description
Agriculture, fishing and forestry (‘Agriculture’)	Includes agriculture, hunting and related services, comprising the following activities: • growing of crops; • market gardening; • horticulture; • mixed farming; • production of organic fertiliser; • forestry; • logging and related services; • fishing; and • operation of fish hatcheries and fish farms.
Mining and quarrying	Includes, *inter alia*: • mining and quarrying of metallic minerals (coal, lignite, gold, cranium ore, iron ore etc.); • extraction of crude petroleum and natural gas; • service activities incidental to oil and gas extraction; • stone quarrying; • clay and sand pits; and • mining of diamonds and other minerals.

Sector	Description
Manufacturing	Includes, *inter alia*: • the manufacturing of food products, beverages and tobacco products; • production, processing and preserving of meat, fish, fruit, vegetables, oils, fats; • dairy products and grain mill products; • textile and clothing; • spinning and weaving; • tanning and dressing of leather; • footwear; • wood and wood products; • paper and paper products; • printing and publishing; • petroleum products; • nuclear fuel; and • manufacture of chemical substances.
Electricity, water and gas	These are utilities. This sector includes: • supply of electricity, gas and hot water; • the production, collection and distribution of electricity; • the manufacture of gas and distribution of gaseous fuels through mains; • supply of steam and hot water; and • collection, purification and distribution of water.
Construction	This sector includes: • site preparation; • building of complete constructions or parts thereof; • civil engineering; • building installation; • building completion; and • renting of construction or demolition equipment.
Wholesale and retail trade, hotels and restaurants ('Trade')	This includes: • wholesale and commission trade; • retail trade; • repair of personal household goods; • sale, maintenance and repair of motor vehicles and motor cycles; and • hotels, restaurants, bars, canteens, camping sties and other short-stay accommodation.
Transport, storage and communication ('Transport')	Includes, *inter alia*: • land transport; • railway transport; • water transport; • transport via pipelines; • air transport; • activities of travel agencies; • post and telecommunications; • courier activities; and • storage.
Finance, real estate and business services	This includes: • financial intermediation; • insurance and pension funding; • real estate activities; • renting of transport equipment; • computer and related activities; • research and development; • legal, accounting, book-keeping and auditing activities; • architectural, engineering and other technical activities; and • business activities not classified elsewhere.
Government and social services	Includes, *inter alia*: • public administration and defence;

Sector	Description
('Community services')	• social and related community services (education, medical, welfare and religious organisations); • recreational and cultural services; and • personal and household services. Other Includes, *inter alia*: • private households; • extraterritorial organisations; and • representatives of foreign governments and other activities not adequately defined.

8.3.2 Analyses of sector turnover

SAM analyses require inputs in the form of changes in sector turnover that may result from the scenarios to be modelled. SAM analyses are thus preceded by sector-specific analyses. Sector specific analyses are of a micro-economic nature.

Thus, every scenario to be modelled through a SAM has to be preceded by a sector-specific analysis.

8.4 Analyses of aquatic ecosystem services using ERE analyses and the MEA Framework

8.4.1 Background

The modelling and estimation of the value of aquatic ecosystem services is done through environmental and resource economics (ERE) modelling.

ERE studies seek to value the stream of future benefits delivered by the set of ecosystem services associated with an ecosystem. The evaluation thus usually begins with a systems analysis which treats the ecosystem akin to an asset, which delivers benefits in the form of ecosystem services. The analysis begins with a systems analysis, such as that performed during water resource eco-classification and defines the ecosystem that is subject to enquiry. It assembles all relevant and valid scientific information about the system. It defines the boundaries of the entity to be analysed, and the meta-system within which it functions. It defines the biodiversity of the ecosystem.

The term ecosystem here means a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment. The concept of biodiversity, here following Noss, is the living component of the ecosystem. Accordingly, the analysis interprets the ecosystem as a portfolio of abiotic and biotic assets that deliver a specific set of ecosystem services.

Ecosystem services are formally defined by the Millennium Ecosystems Assessment Framework and provide a scientific, logical and transparent definition of the value delivered by an ecosystem, to humans.

The evaluation proceeds to identify chains of causality that exist between ecosystem assets, drivers that impact upon them, and the ecosystem services benefits that are derived from these services. When these chains are defined and quantified through the selection and measurement of appropriate indicators, they form the bases for the development of production functions for each ecosystem service. Thereafter, the production functions are integrated into economic demand functions. A wide variety of ERE valuation techniques exist through which to estimate demand for ecosystem services. Data availability governs the selection of most appropriate valuation techniques, for each type of ecosystem service to be valued. The next step is to value the changes that would result from each development option, as the net present social values of the differences in future flows of ecosystem services.

Finally, an ERE analysis integrates the environmental economic valuation results into the SAM or directly into household benefits. The resultant model / analysis can then be run for each management scenario / project alternative, through a cost-benefit assessment (CBA).

Good ERE studies assist decision-makers to make informed and defendable decisions. The final output of a good ERE study is thus much more than some economic value: it is a transparent cause and effect analysis of management decisions, which communicates clearly.

8.4.2 The Millennium Ecosystems Assessment Framework of ecosystem services

The Millennium Ecosystems Assessment (MEA) proposes a consistent and standardised classification of environmental goods and services, which it collectively refers to as ecosystem services.

In the MA system, ecosystems are aggregate assets that yield a flow of services, all of which benefit people, much like other capital stocks. These include provisioning services (including the production of fresh water, foods, fuels, fibres and biochemical and pharmaceutical products), cultural services (including non-consumptive uses of the ecosystem for recreation, amenity, spiritual renewal, aesthetic value and education) and regulating services (including the absorption of pollutants, storm buffering, erosion control and the like). The social opportunity cost of developments that change ecosystems accordingly includes the value of the resulting change in ecosystem services. This is makes it possible to evaluate environmental impacts alongside the other costs and benefits of the development options, and so to estimate the net present social value of distinct development options *inclusive of environmental effects*[8].

The MA classification system accommodates the framework of total economic values (TEV) of the environment (i.e. use, non-use and option and bequest values as used in many other studies to date), but supersedes TEV. It provides the analytic linkage between ecosystem function and human well being.

It is important to recognize that the utilitarian values (the benefits consumed, used or enjoyed) of these services are not additive. Supporting and regulating services can be considered to be similar to intermediate consumption in the economic sense. Provisioning and cultural services are those that

[8] More than 1,360 international experts have contributed to the MA. The key outputs of the MA have been published in five technical volumes and six synthesis reports. These contain a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide (such clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems (MA, 2007).

enter final consumption. In order to avoid double accounting, only the final consumption services should be valued. The supporting and regulating services in the MA system are the ecosystem functions and processes upon which the provisioning and cultural services depend. They are therefore embedded in those services, and are not evaluated separately, but through production functions.

8.4.3 Supporting and regulating services

Table 1 lists the supporting and regulating services normally to be found in an inventory of ecosystem services. These services define the underlying ecosystem components and processes that produce the final ecosystem service units, provided through the provisioning and cultural services. Where appropriate, these underlying services are captured in the evaluation as independent variables in production functions, in algorithms that capture the environmental effects of the development as these effects determine the productivity and controls within the ecosystem.

Table 93. Millennium Ecosystems Assessment list of supporting and regulating services.

Types of services in the category	Description
Category of ecosystem service: supporting	
Soil formation	Sediment retention and the accumulation of organic matter underpin other services
Primary production	Rate of biomass produced by an ecosystem
Nutrient cycling	The process of the storage, recycling, processing and acquisition of nutrients, which underpins all other ecosystem services
Water cycling	Affects climate, chemistry and biology and is fundamental to the delivery of all ecosystem services
Category of ecosystem service: regulating	
Air quality regulation	Ecosystems both contribute and extract chemicals from the atmosphere that influence many aspects of air quality.
Climate regulation	Ecosystems influence climate both locally and globally. At a local scale, changes in land cover can affect both temperature and precipitation. At a global scale, ecosystems play an important role in the carbon cycle by either sequestering or emitting greenhouse gases.
Water regulation (hydrological flows)	The timing and magnitude of runoff and flooding can be strongly influenced by changes in land cover, including in particular alterations that change the water storage potential of the system such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.
Erosion regulation	Vegetative cover plays an important role in soil retention and the prevention of landslides.
Water purification and waste treatment	Ecosystems can be a source of impurities in freshwater but also can help to filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems
Disease regulation	Changes in ecosystems can directly change the abundance of human pathogens such as cholera and can alter the abundance of disease vectors such as mosquitoes.
Pest regulation/Biological control	Ecosystem changes affect the prevalence of crop and livestock pests and diseases.
Pollination	Ecosystems that support pollinators are important often important to the success of economies and genetic diversity. Refers to animal-assisted pollination, done by bees, rather than wind pollination
Detoxification	Biological processes are involved in the sequestration or detoxification of various chemical wastes introduced into the environment.
Natural hazard	Such as storm protection, the presence of coastal ecosystems such as mangroves and coral reefs

Types of services in the category	Description
regulation	can dramatically reduce the damage caused by hurricanes or large waves.

8.4.4 Provisioning services

Provisioning services are principally those that deliver the goods or commodities that we easily recognise and which are normally traded.

Figure 24. Millennium Ecosystems Assessment list of provisioning services.

Types of services in the category	Relevance and definition in the context of the entity
Food	Provision of food from crops, livestock, marine and freshwater capture fisheries, aquaculture or wild plant and animal food products
Fresh water	Ecosystems provide storage and retention of water for domestic, industrial, and agricultural use
Wood and fibre	Direct benefits from wood for timber and pulp, biomass energy (fuelwood and charcoal consumption) and from the production of agricultural fibres such as cotton, silk and hemp
Biochemical and pharmaceutical products	Ecosystems provide natural products that have been used for biochemicals and pharmaceuticals and other natural products (such as cosmetics, personal care, bioremediation, biomonitoring and ecological restoration).
Genetic resources	The potential in biodiversity for new products and industries, such as medicine, genes for plant pathogen resistance or ornamentals. Conserving genetic diversity maintains the potential to yield larger future benefits and ensures options for adapting to changing environments.

8.4.5 Cultural services

Cultural services underlie the largely intangible benefits of the ecosystem. These services and benefits are often the least understood and most difficult to evaluate. For this reason we deal with each separately below. It is especially difficult to compile an inventory of mutually exclusive cultural ecosystem services.

Despite these problems, cultural services may often be extremely valuable. For example, the book by Richard Louv (2005) refers to many clinical and psychological studies that reveal the benefits of ecosystem in terms of human health and psychosocial wellbeing. Hartig (2007), another example, summarises prior work as follows: “Our understanding of how the experience of nature might promote health has advanced through studies on environmental aesthetics, motivations for outdoor recreation, sources of residential satisfaction, and the affective and cognitive benefits of activities in gardens, parks, and wilderness areas”. A distinct theme in this work is the value of natural environments for psychological restoration, such as psycho-physiological stress reduction. This restorative value seems to stem from mutually reinforcing aspects of experiences of nature: distance from everyday demands, and possibilities for aesthetic appreciation and activity driven by interest.” In identifying these benefits enjoyed by humanity, Hartig also reveals the difficulties of classification and measurement.

Table 94. Cultural ecosystem services defined by the Millennium Ecosystems Assessment.

Types of services in the category	Relevance and definition in the context of the entity	Examples
Aesthetic	The quality of the aggregate viewscape as seen by residents in and visitors to the entity	Perceived quality of viewscapes
Spiritual	The degree to which the entity satisfies human needs for religious or other spiritual fulfilment	Use of opportunities for religious tourism (e.g. pilgrimages)
Inspirational	The degree to which the entity inspires creativity among residents and visitors	Activity in art, literature and music dependent on the state of the entity
Knowledge and education	The degree to scientific knowledge which arises from the study of the entity contributes to intellectual fulfilment among residents and visitors	Level of use of research and educational opportunities unique to the entity.
Recreation and ecotourism	The degree to which the entity is enjoyed for leisure activity.	
Sense of place	The degree to which people depend on the particular features of the entity for their cultural identity.	Potential culture loss in local communities (inverse measure)
Cultural heritage values	The degree to which the cultural heritage within the entity is enjoyed by residents and visitors	Use and enjoyment of cultural heritage opportunities within the entity

8.5 Analyses of water quality effects on the economy using a WDCS simulation

8.5.1 Overview

Various aspects of economic development could have detrimental effects on the water quality of water resources, which in turn could affect economic activities such as irrigation productivity, operation and maintenance cost of water infrastructure, subsistence fishing, recreation, tourism and human health.

Typical water pollution drivers include:

- Point-source pollution from wastewater treatment plants;
- Stormwater pollution from a variety of sources (engine leaks, tyre and brake wear, fertilizers and pesticides from landscaping and pest management, sediment from erosion of non-landscaped areas and areas disturbed by construction, toxic chemicals from paints, solvents and cleaning compounds, and litter from plastics, paper and cold drink cans);
- Contamination of mine water affected by acid mine drainage and heavy metal concentrations (Huizenga 2004);
- Agricultural runoff (fertilizers, salts, nutrients and pesticides);
- Animal grazing and watering (microbiological, turbidity). (DWA 2010b)

The Olifants River Water Resources Development Project (DWA 2005) describes water quality in the whole of the Olifants River to be in a crisis.

Water quality in the Olifants River is greatly affected by the wide variety of mining operations and mineral processing activities that take place all over the catchment. From the available data, it appears that those mining operations that are located within low rainfall regions of the basin (predominantly the north-eastern and eastern regions, where physical weathering processes dominate) have relatively low and/or localized impacts on the water resources. In contrast, mining operations located in the wetter regions of the basin (predominantly the southern regions, where chemical weathering processes prevail) tend to have far more extensive impacts. This seems to be due to the presence of ample moisture within the soil profile that enables continual chemical changes to take place and allows the water available to mobilize and transport the different contaminants that become available.

In the Upper Olifants water quality is threatened by the impact of more than 100 years of coal mining. The available evidence suggests that the extensive coal mining in the region has had, and will continue to have, very high impacts on water resources, particularly water quality in all streams and rivers. The primary cause of the degradation is the extensive acid mine drainage where water of low pH, with high concentrations of total dissolved salts and metals, enters local water courses. This results in a complete change in water chemistry. It is estimated that some 62 million m^3 of water decants from closed or abandoned mine workings each year. The mining industry has assumed responsibility and undertaken the task of managing these decant volumes. There are a number of treatment and irrigation management projects. Currently there is collaboration on research, monitoring and collective effort to cut down on the impacts from coal mining on the water resources of the region. However, the large volumes of acid mine drainage and the long period of time over which these discharges and seepages have taken place has resulted in the impacts still being discernable (as altered water chemistry characteristics) over two hundred kilometres downstream from the Witbank and Highveld Coalfields. These effects are also accentuated by seepages from power station ash dumps, as well as effluent discarded by different industries and the larger municipalities (DWA 2004, DWA 2005).

The water quality problems in the Middle and Steelpoort areas are salinity, eutrophication, toxicity and sediment. The salinity and eutrophication problems are due to the irrigation return flows, mining impacts and sewage treatment plant discharges. Sediment problems are related to poor agricultural practise and from overgrazing in rural areas. The production of sediment in the Middle Olifants causes operational problems far downstream at the Phalaborwa Barrage as well as in the Kruger National Park where sediment laden water causes fish kills.

In the Lower Olifants, water quality is affected by mining and industrial return flows from the Phalaborwa Mining and Industrial Complex. The mines at Phalaborwa impact on both the Olifants and the Selati Rivers. Water quality is also further impaired by agricultural return flows and other effluent discharges upstream. After the inflow of the seepage and effluent from Phalaborwa into the Selati River, the concentrations of a few constituents increases but there is no overall improvement or worsening of water quality. In contrast, the water quality in the Phalaborwa Barrage is comparatively good, but when mixed with water from the Selati River, there is a marked deterioration in water quality as shown by the results for Mamba Weir below. Some relief is obtained from very good water quality emanating from the Blyde River, which together with the good quality water from the Mohlapitse River, usually maintains the water quality in the Olifants River in the KNP at an acceptable level.

Recent work through a WRC study highlights insufficient monitoring of water quality, which prevents researchers from identifying the exact sources of pollution (Heath et al 2010). It nevertheless identifies the Klipspruit and Ga-Selati as particular problem rivers. Heavy metal and pesticide emissions into the water, from mining and agriculture activities, are other problem areas identified.

Aquatic ecosystems in the lower Olifants River and in the KNP are placed under heavy stress by the quality of water in the Olifants River. This is greatest during the dry winter months when river flows are lowest. Moreover, there have been occasions where the water is almost unfit for human consumption in the Kruger National Park. In addition, the quality of water entering the Massingir Dam in Mozambique is not suitable for irrigation of sensitive crops and may contravene the requirements of international agreements between South Africa and Mozambique (DWA 2005).

8.5.2 Analytical approach[9]

The economic effects of poor water quality are difficult to measure. Firstly, water quality is an input variable (or intermediate consumption) to final-use goods and services and does therefore not have a direct monetary effect associated with it. Secondly, water quality is often measured by a complex set of indicators or variables, which may change (positively or negatively) along the length of a river and over time. In addition, there is often a disconnect between these water quality indicators and the fitness-for-use of water. The Department of Water Affairs has consequently (and recently) adopted a water quality abatement cost approach, as envisaged in the DWA's Waste Discharge Charge System (WDCS), to management of water quality. Although the details of implementation of the WDCS are still to be finalized, the WDCS approach provides a methodology for evaluating the economic effects of poor water quality in the CWM WMA.

The WDCS is premised upon the polluter-pays principle, which intends to assign the cost of preventing such damages to polluters, and thus internalizes the cost of pollution prevention into the economy. The WDCS would reduce pollution to a level where the Resource Quality Objectives (RQOs) of the particular catchment area are met (DWA 2007b).

Water pollution abatement costs can be estimated if a marginal abatement cost curve is available. Such a curve is a multivariate mathematical-statistical function, which should ideally be developed, based on empirical data sourced from the particular catchment area within which the pollution problem is located. The marginal abatement cost curve relates a set of independent variables to the cost of water pollution abatement. The WDCS have identified five sets of water quality measures including salinity, pH, nutrient load, chemical oxygen demand (COD) and heavy metals, and these would thus form the independent variables of the abatement cost curve. In mathematical notation, the abatement cost curve is structured as follows:

[9] DWA 2010b

Cj = f(Vj,Eij,Ms,Xj)

Where:

Cj: Total abatement cost for a water treatment plant

Vj: Total annual wastewater treated

Eij: Vector of effluent/influent ratios for n pollutant measures

Ms: Vector of input prices at each water treatment plant

Wj: Vector of relevant water treatment plant characteristics

The figure below presents a simplified example of a marginal abatement cost curve.

The economic effect of reduced water quality is therefore quantified by estimating the cost of abatement required to improve the water quality category of the each IUA to its current state.

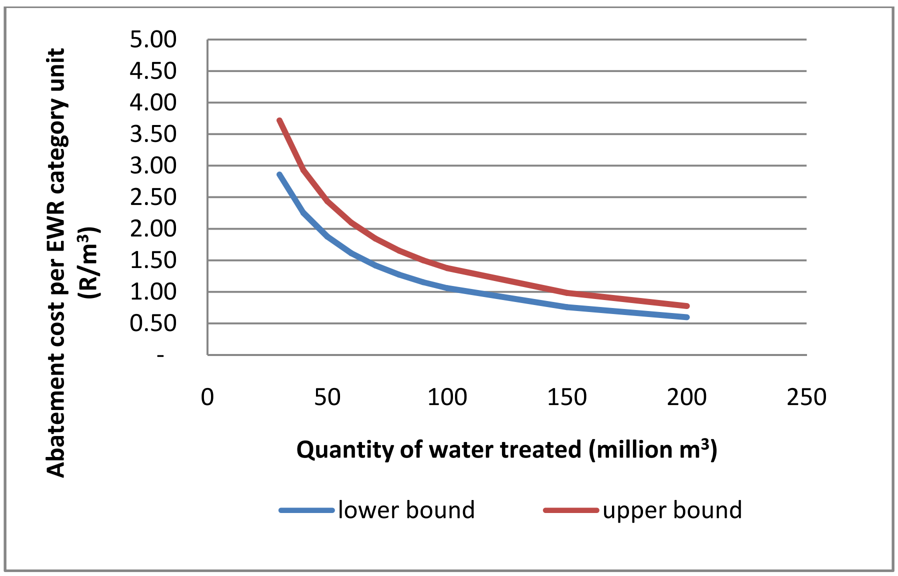

Figure 25. Schematic representation of the marginal abatement cost curve for water quality developed for this study.

8.6 Analyses of water yield effects on the economy using a Water SEEA

The economic transactions associated with water supply and use in the economy is officially captured in a format, which is referred to as Environmental Economic Accounts for Water. The United Nations sets out guidelines the System of Environmental Economic Accounting for Water (SEEAW). Statistics South Africa has developed various Water EEAs for South Africa. These accounts are compatible with SAMs.

Water EEAs provide an accounting framework that enables the integration of specialised physical resource sector data with other information on the economics of water supply and use in a structure that is consistent with the way data on economic activities are organised in the System of National Accounts (SNA). In addition to facilitating integration and sharing of a more comprehensive knowledge base, the Natural Resource Accounting (NRA) framework provides the basis for evaluating the consistency between the objectives and priorities of water resource management and broader goals of economic development planning and policy at national and local scales.

In Water EEAs, physical accounts present the physical flow of water resources (measured by volume), and monetary accounts convert the volumetric flow of water to economic values.

The physical accounts provide information on the volumetric supply and use of water. The monetary accounts provide a basket of measures that describe the economic and welfare impacts of water supply and use.

8.7 Modelling scenarios

8.7.1 Overview

The overall analysis framework thus consists of four analytical components:
- Sectoral and SAM analyses;
- ERE analyses based on the MEA Framework;
- Water quality analyses using a WDCS simulation; and
- Water yield analyses using a Water SEEA.

The analysis starts with the development of a set of plausible water resource management scenarios for all the IUAs. The risks to every economic sector, aquatic ecosystems and households are estimated, whereafter these risks are quantified through the Water SEEA, the WDCS simulation, the ERE analysis and finally the sectoral and SAM analyses.

Such analyses will enable cost-benefit assessment comparison of the different scenarios.

The analyses should enable modelling of the effects of various scenarios, such as those proposed by the DWA Reconciliation Strategy:

- Population growth
- Changes in key economic trends – such as growth in mining
- Water conservation and demand management implementation
- Water re-use and recycling
- Changing (and controlling) the assurance of supply
- Compulsory licensing
- Water trading
- System Operating rules
- Groundwater development
- Water transfers (from the East Rand of Vaal Dam)

- Removal of Invasive Alien Plants
- Raising of the Blyderivierpoort Dam
- A new dam at one of various sites on the Lower Olifants River.

9 Step 2(a): Select the ecosystem values to be considered based on ecological and economic data

The Table below sets out the ecosystem services to be evaluated in this study. The potential ecosystem services effects were rated as "unlikely", "possible", and "likely" to be affected.

This rating was done based on the outputs of the DWA (2010) study.

Table 95. Rating of the applicability of ecosystem services affected by possible water management scenarios in the Olifants WMA

Types of services in the category	Description	Applicability
Category of ecosystem service: regulating		
Air quality regulation	Ecosystems both contribute and extract chemicals from the atmosphere that influence many aspects of air quality.	Unlikely
Climate regulation	Ecosystems influence climate both locally and globally. At a local scale, changes in land cover can affect both temperature and precipitation. At a global scale, ecosystems play an important role in the carbon cycle by either sequestering or emitting greenhouse gases.	Possible
Water regulation (hydrological flows)	The timing and magnitude of runoff and flooding can be strongly influenced by changes in land cover, including in particular alterations that change the water storage potential of the system such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.	Likely
Erosion regulation	Vegetative cover plays an important role in soil retention and the prevention of landslides.	Likely
Water purification and waste treatment	Ecosystems can be a source of impurities in freshwater but also can help to filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems	Likely
Disease regulation	Changes in ecosystems can directly change the abundance of human pathogens such as cholera and can alter the abundance of disease vectors such as mosquitoes.	Likely
Pest regulation/Biological control	Ecosystem changes affect the prevalence of crop and livestock pests and diseases.	Likely
Pollination	Ecosystems that support pollinators are important often important to the success of economies and genetic diversity. Refers to animal-assisted pollination, done by bees, rather than wind pollination.	Unlikely
Detoxification	Biological processes are involved in the sequestration or detoxification of various chemical wastes introduced into the environment.	Likely
Natural hazard regulation	Such as storm protection, the presence of coastal ecosystems such as mangroves and coral reefs can dramatically reduce the damage caused by hurricanes or large waves.	Likely

Regulating services	Relevance and definition in the context of the entity	
Food	Provision of food from crops, livestock, marine and freshwater capture fisheries, aquaculture or wild plant and animal food products	Likely
Fresh water	Ecosystems provide storage and retention of water for domestic, industrial, and agricultural use	Likely
Wood and fibre	Direct benefits from wood for timber and pulp, biomass energy (fuelwood and charcoal consumption) and from the production of agricultural fibres such as cotton, silk and hemp	Likely
Biochemical and pharmaceutical products	Ecosystems provide natural products that have been used for biochemicals and pharmaceuticals and other natural products (such as cosmetics, personal care, bioremediation, biomonitoring and ecological restoration).	Likely
Genetic resources	The potential in biodiversity for new products and industries, such as medicine, genes for plant pathogen resistance or ornamentals. Conserving genetic diversity maintains the potential to yield larger future benefits and ensures options for adapting to changing environments.	Likely

Types of services in the category	**Relevance and definition in the context of the entity**	**Examples**	
Aesthetic	The quality of the aggregate viewscape as seen by residents in and visitors to the entity	Perceived quality of viewscapes	Likely
Spiritual	The degree to which the entity satisfies human needs for religious or other spiritual fulfilment	Use of opportunities for religious tourism (e.g. pilgrimages)	Possible
Inspirational	The degree to which the entity inspires creativity among residents and visitors	Activity in art, literature and music dependent on the state of the entity	Likely
Knowledge and education	The degree to scientific knowledge which arises from the study of the entity contributes to intellectual fulfilment among residents and visitors	Level of use of research and educational opportunities unique to the entity.	Likely
Recreation and ecotourism	The degree to which the entity is enjoyed for leisure activity.		Likely
Sense of place	The degree to which people depend on the particular features of the entity for their cultural identity.	Potential culture loss in local communities (inverse measure)	Possible
Cultural heritage values	The degree to which the cultural heritage within the entity is enjoyed by residents and visitors	Use and enjoyment of cultural heritage opportunities within the entity	Possible

10 Step 2(b): Describe the relationships that determine how economic value and social wellbeing are influenced by the ecosystem characteristics and the sectoral use of water[10]

The MEA provides a sound and well-established framework for the assessment of ecosystem services and the benefits to human well-being. The MA established the concept of ecosystem services as an essential model for linking the functioning of ecosystems to human welfare benefits. Ecosystems are considered to be assets that yield a flow of services of benefit to people, much like other capital stocks.

The influence of and feedbacks between human well-being, drivers of change and ecosystem services are demonstrated in the figure below. For instance, increased demand of water by upstream water users reduces water supplied downstream, resulting in changes in water quality, riparian zones, aquatic biodiversity and direct and indirect effects to a suite of ecosystem services to downstream beneficiaries. This problem can be exacerbated by the degradation of catchments affecting the capability of aquatic ecosystems to provide services and regulate natural and human-induced stressors and shocks to socio-ecological systems. The degradation of ecosystems in a bid to maximise the delivery of a small group of services, such as agricultural crops for food, water supply or grazing, jeopardises the delivery of other ecosystem services. It also often jeopardises the sustainable supply of the ecosystem services that are being maximised. Therefore, human well-being[11] is affected not only by the gap between the supply and demand of ecosystem services, but also by the diminished prospects for sustainable development thus increasing vulnerability of individuals and communities.

Humans, and their cultural diversity, are recognised as an integral part of socio-ecological systems and human well-being is the central focus for assessment. Inherent to this 'ecosystem approach' of the MA is the understanding that socio-ecological systems are complex and dynamic "with the changing human condition serving to both directly and indirectly drive change in ecosystems and with changes in ecosystems causing changes in human well-being. At the same time, many other factors independent of the environment change the human condition, and many natural forces influence ecosystems" (MA 2003).

Perturbations resulting from ecosystem change propagate through systems spatially, affecting local people as well as downstream users, and temporally, affecting current and future users. A multi-scale approach to assessment is required for proper evaluation of driving forces internal and external to the system in question and the differential effect of ecosystem changes on different areas and populations within a system i.e. upstream and downstream communities.

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[10] WRC 2010

[11] "Human well-being is a human experience that includes the basic materials for a good life, freedom of choice and action, health, good social relationships, a sense of cultural identity, and a sense of security. The sense of well-being is strongly dependent on the specific cultural, geographical, and historical context in which different human societies develop, and is determined by cultural-socioeconomic processes as well as by the provision of ecosystem services. However, the well-being of the vast majority of human societies is based more or less directly on the sustained delivery of fundamental ecosystem services, such as the production of food, fuel, and shelter, the regulation of the quality and quantity of water supply, the control of natural hazards, etc." (Diaz et al. 2006).

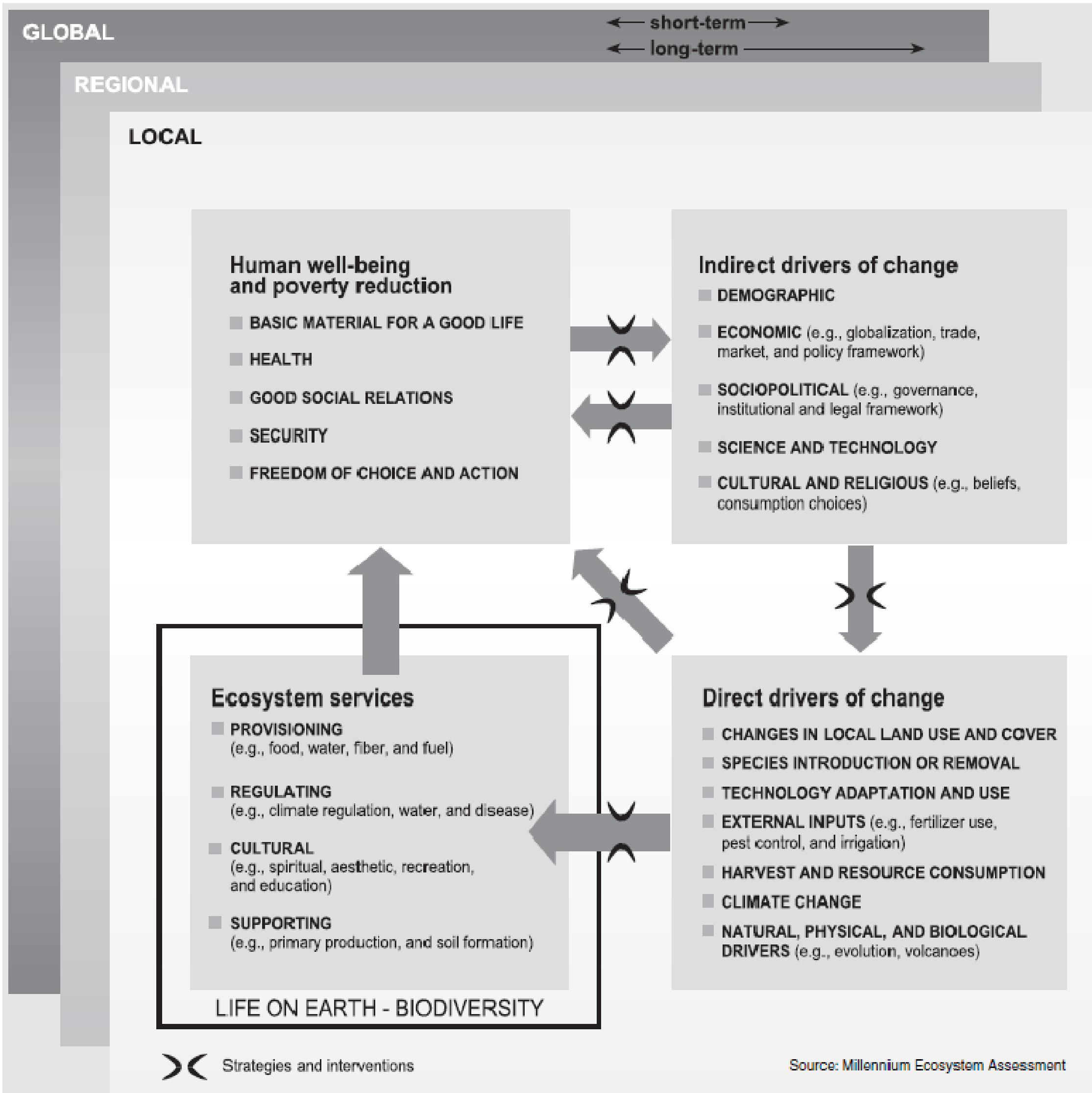

Figure 26. Conceptual framework of the Millennium Ecosystem Assessment (MA 2003)

The MEA conceptual framework thus lays the thinking of a causal chain between drivers of change in ecosystems, the delivery and distribution of ecosystem services and the benefits to human well-being.

The definition of ecosystem services as ecological phenomena, which include ecosystem organisation, structure, process and/or function, provides some explanation for the variety of terms used in the literature to describe ecosystem services. It is important to note that there is a difference between the organisation (physical constitution) of an ecosystem, the process or functioning (operation) of an ecosystem, and the outcome or link to human well-being. The latter introduces an important concept, that some ecosystem services (ecological phenomena) are intermediate to the delivery of others.

The notion of intermediate versus final consumption ecosystem services is crucial in the context of valuation and avoiding double accounting. For instance nutrient cycling and water regulation and erosion regulation (intermediate services) interact to deliver water flow, nutrients and a certain range of sediment loads to a downstream estuary, which supports a large fishery and beautiful estuarine environment (food provision and recreation are the final services). In this example, the value of water regulation, nutrient cycling and erosion regulation would be captured in the benefits yielded by recreation and subsistence fishing service. The fish as well as the safe and healthy shoreline and water body are the benefits that are the endpoints that have a direct effect on human well-being.

One intermediate service may also input into multiple benefits (for instance water regulation is intermediate to flood protection and avoided damage or injury, water provision for multiple purposes, riparian subsistence agriculture, downstream aquatic ecosystems and recreation).

Although intermediate services are valued through final services and benefits, they are important to consider, especially with regards to their long-term sustainability and the effects of changes in these services on final services (in terms of resilience and thresholds). This has numerous important valuation and trade-off implications.

The MEA framework sufficiently assists to address two key requirements for environmental resource economic valuation:

- it enables diligent and comprehensive analysis of all the benefits provided by aquatic ecosystems to humans; and
- it allows for the logical analysis of the causal chains producing these ecosystem services.

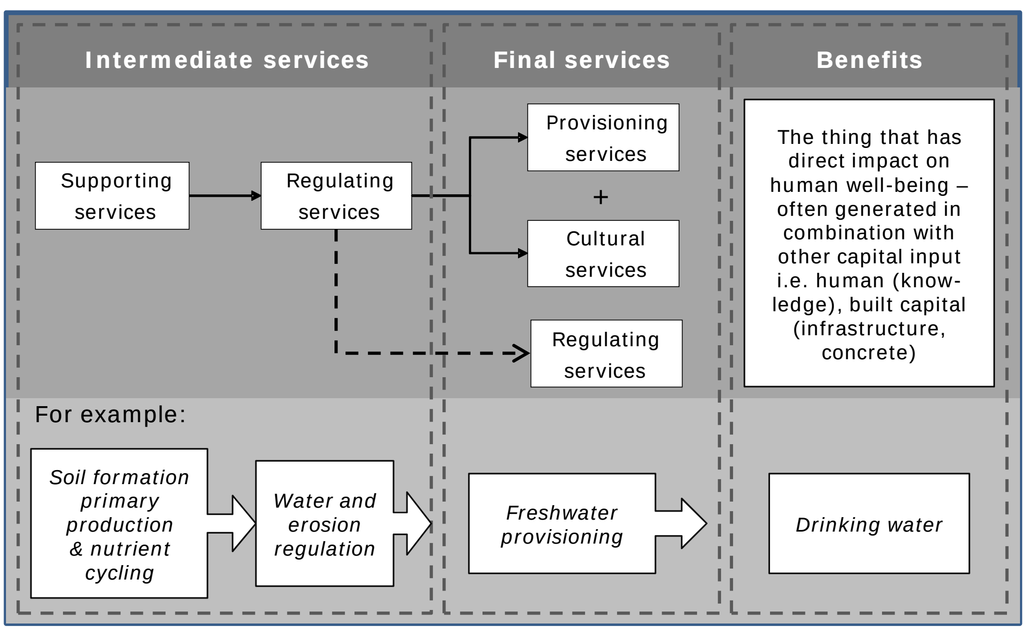

Figure 27. The distinction between intermediate services, final services and benefits (adapted from Fisher et al. 2008) illustrated by the stylised relationship between supporting, regulating, provisioning and cultural services as defined by the Millennium Ecosystem Assessment (MA) (Perrings 2007, Hassan 2007) and simplified example.

11 Step 2(c): Define the scoring system for evaluating scenarios

11.1 Overview

The decision-analysis framework to be used in this study, and defined in Step 1(i) above, lends itself to a cost-benefit analysis (CBA) for evaluating scenarios. The decision-analysis framework internalises the relevant water economy transactions and no additional absolute scoring system is required.

Where required, comparative risk assessment (CRA) will be used as a scoring system for estimating changes in delivery of ecosystem services.

In the CRA method, experts formulate the chains of causality between a development activity or management scenario, the resulting change in ecosystem assets and effect on ecosystem services. In addition, the CRA serves to rate the consequences associated with the subsequent environmental effects and its uncertainty.

Comparative risk assessment (CRA) is both an analytical process and a methodology for prioritizing complex problems. Comparative risk assessment is a multi-attribute evaluation procedure which allows for a theoretically sound and structured progression by way of manageable individual steps. For each step (such as structuring the problem, structuring and weighting the attributes, sensitivity analysis) a range of practically tested techniques exist. The strength of the CRA is that it facilitates an explicit examination of assumptions and values and thus aids in a transparent comparative risk evaluation. This approach is therefore eminently suitable for those comparative risk assessment processes in which a variety of evaluators, both experts and other stakeholders take part.

This examination of the data is also a factual prerequisite for comparative analyses. Risk evaluation constitutes the link between the predominantly scientific / technical risk assessment and a socio-economic oriented valuation of risks.

A benefit of a CRA lies in the comparison of a new development fields (and by inference also complex systems), in the comparison of public risk perceptions for different cases, and in the comparison of cost and benefit effects.

11.2 CRA Methodology

Various management scenarios could pose a variety of hazards to the Olifants WMA water resources and the ecosystem services it delivers. Any management scenario that results in a change from present ecological condition will result in changes to the delivery and distribution of ecosystem services.

With the assets and scenarios spatially and temporally bound, the effect of the scenario on each asset in terms of ecosystem service delivery is assessed. For each scenario-asset combination, the ecosystem services identified are assessed.

For each scenario-asset-service combination, the question asked is 'What is the likelihood that this ecosystem service in this significant water resource will be affected under this scenario? What would be the consequences of this scenario in this significant water resource to the delivery of this ecosystem service?'

The likelihood is the probability of the scenario having an effect on the asset. Likelihood takes into account an element of uncertainty, in that the likelihood that an ecosystem service will be affected under the scenario in question over a specified time frame is rated. Uncertainty with regards to the knowledge upon which the statements or connections between scenario-asset-service linkage are made, is also stated explicitly for each CRA. This level of certainty (e.g. high, medium or low) is a statement based on the expert's judgement of the certainty of and confidence in the risk assessment. For example, a low level of certainty indicates that evidence to bear out the assessment is weak or lacking.

Table 96. Qualitative and quantitative classes of likelihood of a scenario (environmental effect, or resultant change in the flow of an ecosystem service) eventuating from a management decision and of having an environmental consequence to a service from an environmental asset in the ecosystem adapted from the classification adopted by the IPCC (2007).

Likelihood rating	Assessed probability of occurrence	Description
Almost certain	$> 90\%$	Extremely or very likely, or virtually certain. Is expected to occur.
Likely	$> 66\%$	Will probably occur
Possible	$> 50\%$	Might occur; more likely than not
Unlikely	$< 50\%$	May occur
Very unlikely	$< 10\%$	Could occur
Extremely unlikely	$< 5\%$	May occur only in exceptional circumstances

The consequence is the change in the service from the environmental effect of the management scenario on the exposed asset. The assessment of consequences can follow, or adapt in an appropriate manner, the severity ratings (Table 97).

Table 97. Qualitative measures of consequence to environmental services in an ecosystem arising from the hazards linked to a management decision.

Level of consequence		Environmental effect
1	Severe	Substantial permanent loss of environmental service, requiring mitigation or offset.
2	Major	Major effect on the on the asset or service, that will require several years to recover, and substantial mitigation.
3	Moderate	Serious effect on the on the asset or service, that will take a few years to recover, but with no or little mitigation.
4	Minor	Discernable effect on the asset or service, but with rapid recovery, not requiring mitigation.
5	Insignificant	A negligible effect on the asset or service.

During the CRA it is useful to identify all appropriate compensation measures (mitigation and offsets).

The level of risk is the product of likelihood and consequence in the event of an environmental effect on an asset. Figure 28 combines the likelihood and consequence rating to determine risk as:

- Low (L) requiring no to little response;
- Medium (M) requiring local level response;

- High (H) requiring regional level response; or
- Very High (VH) requiring national level response.

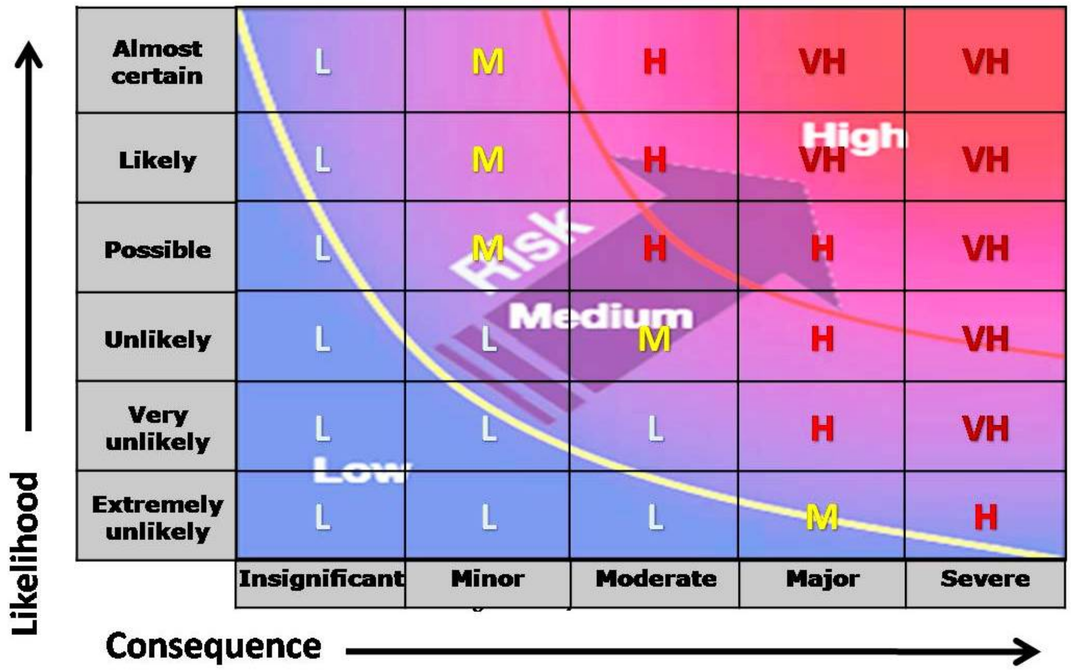

Figure 28. Levels of risk, assessed as the product of likelihood and consequence in the event of an environmental effect on an ecosystem asset (Adapted from Australian/New Zealand Standard on Risk Management (2004)).

The outcome of the CRA should include:

- Description of the environmental effect statement, including hazard and effect statement, scope of consequence, outcome statement and likelihood of outcome.
- Table of ecosystem services with the likelihood and consequence of environmental effect, and the level of risk (see Figure 28).
- Statement of the level of certainty associated to the above risk assessment, based on the availability of existing evidence and certainty of expert knowledge.

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