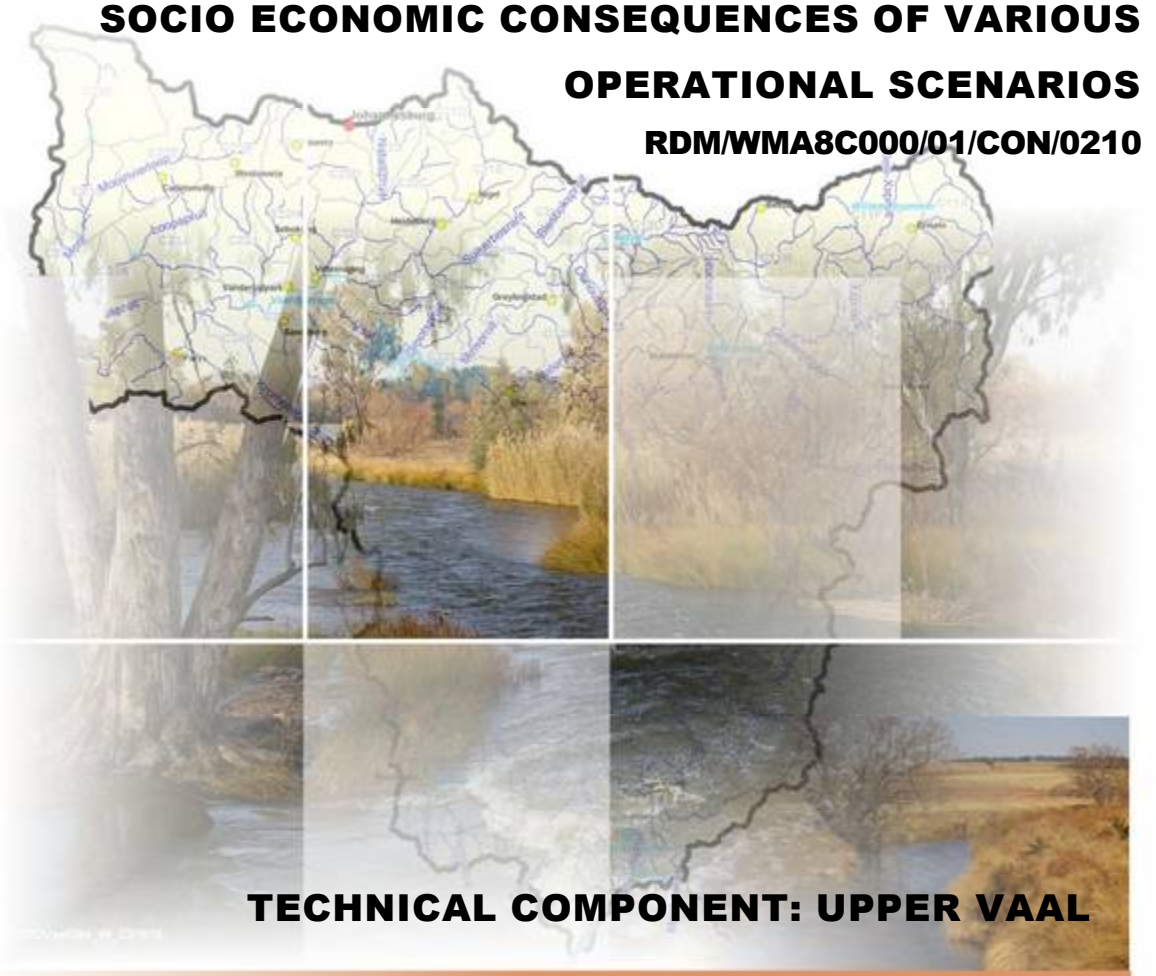
COMPREHENSIVE RESERVE DETERMINATION

INTEGRATED VAAL RIVER SYSTEM

SURFACE WATER

SOCIO ECONOMIC CONSEQUENCES OF VARIOUS OPERATIONAL SCENARIOS

RDM/WMA8C000/01/CON/0210



TECHNICAL COMPONENT: UPPER VAAL

July 2010

REPORT NO.: RDM/WMA8C000/01/CON/0210
PROJECT NO.: 8829/1

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

COMPREHENSIVE RESERVE DETERMINATION STUDY OF THE INTEGRATED VAAL RIVER SYSTEM

UPPER VAAL WATER MANAGEMENT AREA
SOCIO ECONOMIC CONSEQUENCES OF VARIOUS OPERATIONAL SCENARIOS

Report number: RDM/WMA8C000/01/CON/0210

July 2010

This report should be cited as:
Department of Water Affairs (DWA), 2010. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Socio Economic Consequences of various Operational Scenarios. Report authored by Conningarth Consultants and Tlou Consulting Pty (Ltd.). Produced by Koekemoer Aquatic Services and Rivers for Africa. Report no: RDM/WMA8C000/01/CON/0210.

.

Technical document authorised by:

Koekemoer Aquatic Services
PO Box 1100
Parys, 9585
056 811 3082

Rivers for Africa
PO Box 1684
Derdepark, Pretoria, 0035
082 461 1289

DOCUMENT INDEX

Reports as part of this project:

Index number	RDM Report number	Report title
1.1	RDM/WMA8C000/01/CON/0107	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Inception Report
1.2	RDM/WMA8C000/01/CON/0207	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Desktop EcoClassification Report
1.3	RDM/WMA8C000/01/CON/0610	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Basic Human Needs Reserve. Included in the Main Report.
1.4	RDM/WMA8C000/01/CON/0208	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Resource Unit Report
1.5	RDM/WMA8C000/01/CON/0109 Volume 1 and 2	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: EcoClassification Report
1.6	RDM/WMA8C000/01/CON/0209 Volume 1 and 2	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: EWR Scenario Report
1.7	RDM/WMA8C000/01/CON/0110	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Ecological and Goods & Services Consequences of Various Operational Scenarios.
1.8	**RDM/WMA8C000/01/CON/0210**	**Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Socio Economic Consequences of Various Operational Scenarios.**
1.9	RDM/WMA8C000/01/CON/0310	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: EcoSpecs Report
1.10	RDM/WMA8C000/01/CON/0410	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Wetland Report
1.11	RDM/WMA8C000/01/CON/0510	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Estimation Report
1.12	RDM/WMA8C000/01/CON/0610	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Main Report
1.13	RDM/WMA8C000/01/CON/0710	Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Electronic information

Bold indicates this report

APPROVAL

TITLE:	Comprehensive Reserve determination study of the Integrated Vaal River System, Upper Vaal River Management Area. Socio Economic Consequences of various Operational Scenarios.
DATE:	July 2010
EDITORS:	S Koekemoer and MD Louw
REVIEW:	Ms Retha Stassen
LEAD CONSULTANT:	Koekemoer Aquatic Services and Rivers for Africa, Joint Venture
FILE NO.:	26/8/3/10/10
FORMAT:	MSWord and PDF
WEB ADDRESS:	www.dwaf.gov.za

Approved for Koekemoer Aquatic Services/Rivers for Africa Joint Venture:

Ms Shael Koekemoer
Administrative Project Leader

Ms Delana Louw
Technical Project Leader

Approved for the Department of Water Affairs by:

Ms Retha Stassen
Consultant Project Management Team Leader & Manager

Ms Barbara Weston
Deputy Director: Surface Water Reserve Requirements

MANAGEMENT AND STEERING COMMITTEES

Project Management Committee

Barbara Weston	Department of Water Affairs	Project Manager
Jacqueline Jay	Department of Water Affairs	Study Manager
Retha Stassen	Blue Science Consulting	Consultant Project Leader and Manager
Shael Koekemoer	Koekemoer Aquatic Services	Consultant Upper Vaal Technical Team
Delana Louw	Rivers for Africa	Consultant Upper Vaal Technical Team

Project Team

Shael Koekemoer	Koekemoer Aquatic Services	Administrative Project Leader
Delana Louw	Rivers for Africa	Technical Project Manager
Shileen Louw	Rivers for Africa	Project Administrator
Greg Huggins	Rivers for Africa	Team Leader: Basic Human Needs
Mark Rountree	Fluvius Environmental Consultants	Team Leader: Wetlands. Geomorphology
Toriso Tlou	Tlou Consulting	Team Leader: Resource Economics
Dr Patsy Scherman	Scherman Colloty and Associates	Team Leader: Capacity Building
Dr Neels Kleynhans	DWA: RQS	EcoClassification Process
Ms Christa Thirion	DWA: RQS	EcoClassification Process
Dr Drew Birkhead	Streamflow Solutions	EcoHydraulics
Prof Denis Hughes	Institute for Water Research	EcoHydrology
Mr Johan Koekemoer	Koekemoer Aquatic Services	Fish
Dr Pieter Kotze	Clean Stream Biological Services	Fish
Mr James MacKenzie	BioRiver Solutions	Riparian Vegetation
Dr Dawie Mullins	Conningarth Economists	Resource Economics
Mr William Mullins	Conningarth Economists	Resource Economics
Mr Rob Palmer	Nepid Consulting	Macroinvertebrates
Ms Riekie Cloete	Conningarth Economists	Trainee
Ms C Engelbrecht	Rivers for Africa	GIS
Mr Ahmed Desai	Rivers for Africa	Trainee
Mr Bennie Haasbroek	Innovative Solutions	Trainee
Mr Lindokuhle Hlongwane	Wetland Consulting Services (Pty.) Ltd.	Trainee
Ms Nonkanyiso Maphumulo	Wetland Consulting Services (Pty.) Ltd.	Trainee
Mr David Mosaka	Conningarth Economists	Trainee
Mr Brenton Niehaus	Clean Stream Biological Services	Trainee
Mr Ntaki Senoge	Clean Stream Biological Services	Trainee
Ms Lindi Schwartz	Conningarth Economists	Trainee
Mr Lungile Gaulana	DWA: RQS	Trainee
Ms Pumza Maseti	DWA: RQS	Trainee
Ms Nceba Ncaphayi	DWA: RQS	Trainee
Mr Ramogale Sekwele	DWA: RQS	Trainee

Members of Project Steering Committee

Barbara Weston	Resource Directed Measures, Surface Water Reserve Requirements
Jackie Jay	Resource Directed Measures, Surface Water Reserve Requirements
Yakeen Atwaru	Resource Directed Measures, Surface Water Reserve Requirements
Nancy Motebe	Resource Directed Measures, Groundwater Reserve Requirements
Shane Naidoo	Resource Directed Measures, Classification System
Ndeleka Mohapi	Resource Directed Measures, Compliance
Bonani Madikizela	WRC
Valerie Killian	Water Abstraction and Instream Use (Environment & Recreation)
Seef Rademeyer	National Water Resource Planning
Niel van Wyk	National Water Resources Planning
Dragana Ristic	National Water Resources Planning
Jurgo van Wyk	Water Resource Planning Systems
Peter Pike	Option Analysis
Churchill Mkwalo	Stream flow Reduction
Marius Keet	Gauteng Regional Office
Nndanganeni (Lucky) Musekene	Resource Protection and Waste
Abe Abrahamse	Northern Cape Regional Office
Hanke Du Toit	Northern Cape Regional Office
Sam Dywili	Northern Cape Regional Office
Willem Grobler	Free State Regional Office
Dr Neels Kleynhans	Resource Quality Services
Reghardt Strauss	Spatial & Land information management
Frans Matfield	SAPPI
Maryna Mohr	Chamber of Mines of SA
Retha Stassen	Arcus GIBB/ Blue Science Consulting Project Management team
Beyers Havenga	Arcus GIBB/ Blue Science Consulting Project Management team

AKNOWLEDGEMENTS

WRP Engineering for support in interpreting the Operational Scenarios.
Eskom for supplying the water use at individual power stations.
Rand Water for supplying water use detail.

EXECUTIVE SUMMARY

INTRODUCTION

Water, due to its physical nature, is a "high-exclusion" cost resource which means that exclusive property rights, being the basis of a market economy, are relatively difficult and expensive to establish and enforce. It is therefore useful to group the water values into the following water consumer categories with the benefits realised from the use of water allocated to each:

- Irrigation Agriculture.
- Commercial business and industries.
- Mining.
- Manufacturing, and
- Domestic water supply.

STUDY AREA

The Upper Vaal WMA is one of three WMAs in the Vaal River catchment, which is the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers (DWAF, 2004).

The major tributaries in the Upper Vaal WMA include the Vaal, Klip, Waterval, Wilge, Liebenbergsvlei, Suikerbosrand, Klipspruit and Mooi Rivers and extend to the confluence of the Mooi and Vaal Rivers. It covers a catchment area of 55 565 km^2.

THIS REPORT

The purpose of this report is to determine the Present Economic State (PES) of the Upper Vaal WMA, and to evaluate both the social and economic returns of the existing water use by the various water users within this WMA (WMA 8) and the macro-economic impacts for the possible introduction of the operational EWR scenarios. The objective for determining the PES is to provide a baseline for the comparison of the impacts of the different operational scenarios.

PRESENT STATE EVALUATION

For analysis purposes the names given to the economic zones are as follows:

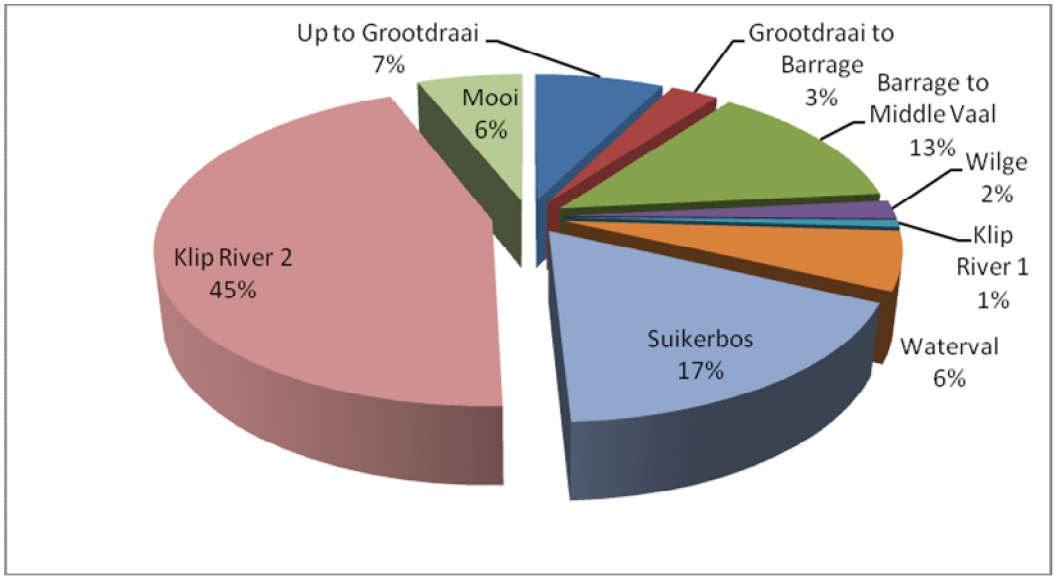
- Economic Zone 1: Main stem – up to Grootdraai Dam
- Economic Zone 2: Main stem – between Grootdraai Dam and the Barrage
- Economic Zone 3: Main stem – between Barrage and the Middle Vaal WMA
- Economic Zone 4: Tributary – Wilge
- Economic Zone 5: Tributary – Klip River 1
- Economic Zone 6: Tributary – Waterval
- Economic Zone 7: Tributary – Suikerbosrand/Blesbok
- Economic Zone 8: Tributary – Klipriver 2
- Economic Zone 9: Tributary – Mooi

In the tables and figures below the GDP and Employment of the main water users are expressed per economic zone.

Total Direct Gross Domestic Product (GDP) per Economic Zone (Rand Million)

Economic Zone	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
Total	18 530	6 937	32 787	4 712	1 858	14 903	43 163	111 236	15 162	249 290

Direct GDP

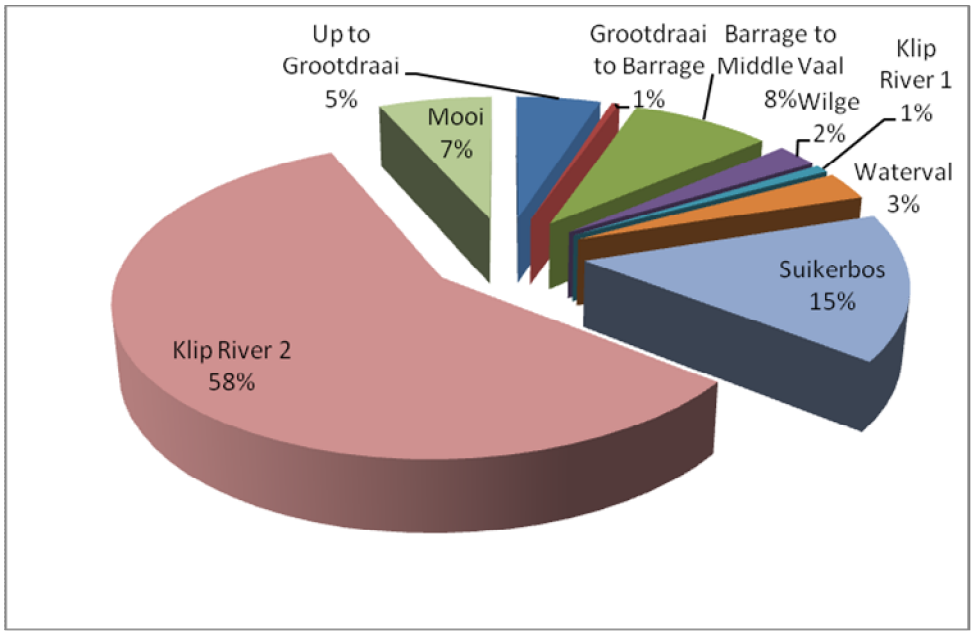


The table and the figure shows that, as far as GDP is concerned, Klip River 2 is the largest contributor with 45%, followed by Blesbok-Suikerbos with 17% and the Barrage to Middle Vaal with 13% economic zones.

Total Direct Employment per Economic Zone

Economic Zone	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
Total	139 318	12 982	231 888	68 698	23 363	83 261	430 687	1 610 966	187 641	2 788 805

Direct Employment



The above table and figure shows that 58% of the employment is in the Klip River 2 economic zone, followed by 15% in Hartebeest-Suikerbos economic zone, with 8% in the Barrage to Middle Vaal economic zone.

The above shows the very important position of the three economic zones representing 70% of the GDP and 71% of the employment in the Upper Vaal Water Management area.

OPERATIONAL SCENARIOS

The calculation of the macroeconomic impacts of a specific scenario in a tributary is guided by a number of assumptions and operational realities. The base assumptions are the following:

- The population, industry and mining will receive the expected water demand within Water Conservation and Demand Management targets. These targets have been determined outside of the present study and it is assumed that they will be applied.
- Eskom power stations will receive the water needed for power generation.
- Curtailments will be instituted against irrigation if necessary to implement EWR targets.

The operational realities referred to include the following:

- Except for certain smaller urban areas, the urban population receive their water from the main stem of the Vaal River, via Water Boards and pumping schemes.
- Water is pumped from the main stem into the catchment of certain tributaries to satisfy the demand. The VRESSAP line pumping water to the Secunda complex is an example.
- A few mines and smaller industries still receive water from sources in the tributary.
- It is too expensive to pump water into the tributaries for irrigation purposes.

With the above in place the impact per EWR site was restricted to irrigation activities, accepting that all other demands will be met.

For the evaluation of operational scenarios, a EWR site approach was used. These sites are situated in the economic zones used in the present state analysis. The table below shows the overlaying of the economic zones and the EWR sites of which quantitative analyses were performed.

Economic Zone	River Type	Economic Zones	Catchment for Scenarios	EWR sites in EZs
EZ 1	Main Stem	Up to Grootdraai Dam	Klein Vaal; Vaal River at Uitkoms	RE-EWR 1; EWR 1
EZ 4	Tributary	Wilge	Wilge at Bavaria	EWR 8
EZ 5	Tributary	Klip River 1	Klip River	EWR 6
EZ 6	Tributary	Waterval	Waterval*	EWR WA1 and EWR WA2
EZ 9	Tributary	Mooi	Mooi River (Klipdrift Dam)	EWR M2

* Not included in the ecological study.

A number of scenarios were considered by the rest of the project team, but the water volumes supplied to the economic team are Scenarios 7 and 8. With Scenario 7 representing the full water utilisation at a specific EWR site in 2020 without the introduction of the EWR. Scenario 8 represents the full utilisation in 2020 at a specific site with the introduction of the EWR. The impact of the introduction of the EWR is then the difference in water volume to the irrigators, which is then expressed in macroeconomic parameters.

RESULTS

The following table presents the results of the introduction of the EWR, comparing the impact with base situation for irrigation per economic zone.

Economic Zone	GDP		Employment		Households	
	Base	EWR Impact	Base	EWR Impact	Base	EWR Impact
EZ 1. Main Stem Up to Grootdraai Dam	R 160.55	R -3.59	2271	-28	R 56.18	R -1.18
EZ 2. Main Stem - Grootdraai to Vaal Barrage	R 238.09	R 0.00	3050	0	R 83.12	R 0.00
EZ 3. Main Stem - Vaal Barrage to Middle Vaal WMA	R 143.69	R 0.00	1841	0	R 50.16	R 0.00
EZ 4. Wilge Tributary	R 232.61	R 0.00	3999	0	R 79.63	R 0.00

Economic Zone	GDP		Employment		Households	
	Base	EWR Impact	Base	EWR Impact	Base	EWR Impact
EZ 5. Klip 1 Tributary	R 47.19	R -0.63	590	-15	R 15.39	R -0.23
EZ 6. Waterval Tributary	R 66.50	R -0.57	942	-15	R 22.25	R -0.21
EZ 7. Suikerbosrand Tributary	R 98.45	R 0.00	1975	0	R 114.10	R 0.00
EZ 8. Klip 2 Tributary	R 195.08	R 0.00	4285	0	R 69.50	R 0.00
EZ 9. Mooi Tributary	R 143.13	R 0.00	1925	0	R 47.73	R 0.00
Total	**R 1 325.29**	**R -4.79**	**20877**	**-59**	**R 538.07**	**R -1.62**

From the table it appears that the operational scenarios are only impacting on three of the nine economic zones and that the projected impact on the three economic zones will be very small. With a possible 59 jobs lost compared to a total employment of over 20 000 in the sector and a loss of R1.62 million in payments to low-income households.

However, it is important to keep in mind that although irrigation agriculture is not a very important sector in the WMA, it still contributes to food security with over 40 000 irrigated hectares in grain production and overall it supports 20 877 employment opportunities, mostly in the rural areas. The grain (cereal) production is a mix of maize, wheat and grain sorghum, with maize and grain sorghum production in the summer, followed by wheat during the winter.

For two tributaries, Suikerbosrand and Klip River 2, no operational scenarios have been presented for analysis.

The weakness of the specific methodology used is that it only gives an overall picture of the impact with no indication of an impact on an individual irrigator.

It is recommended that at the time of the introduction of the EWR a detailed study be implemented to identify the possible economic impacts on individual producers in areas where major irrigation water curtailments are foreseen.

ACRONYMS AND ABBREVIATIONS

EWR	Environmental Water Requirement
GWh	Giga Watt Hour
LM	Local Municipality
MFM	Macroeconomic Forecasting Model
PES	Present Economic State
SAFRIM	South African Inter-industry Model
SAM	Social Accounting Matrix
URV	Unit Reference Values
WIM	Water Impact Model
WMA	Water Management Area
WRPM	Water Resource Planning Model
WRYM	Water Resource Yield Model
WSM	Water Satellite Model

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

1 BACKGROUND AND INTRODUCTION

1.1 BACKGROUND

In order for the Department of Water Affairs (DWA) to make informed decisions regarding the authorization of future water use and the magnitude of the impacts of the present and proposed developments in the Vaal River System, higher levels of confidence is needed for the Reserve Determination within this study area. Therefore a Comprehensive Reserve determination study within Water Management Area (WMA) 8 has been undertaken to provide an input to the reconciliation studies and the integrated water quality management plan recently undertaken by the National Water Resources Planning Directorate (D: NWRP) of DWA.

During the evaluation of this part of Comprehensive Ecological Reserve Study (scenario evaluation); aspects other than ecology have also been considered for the evaluation of various operational flow scenarios and/or future development scenarios. The purpose of this is to provide the decision-maker with sufficient information to make informed decisions regarding the implications of the flow scenario and the Ecological Category which will be signed off as the Ecological Reserve. This will in future form part of the Classification System.

The Comprehensive Ecological Reserve Methodology was followed in accordance with the 8 - step Ecological Reserve process (Figure 1.1). Step 5 refers to the ecological consequences of operational scenarios. However, as part and parcel of the Ecological Reserve approach, this step has been extended since the early 2000s to include the Goods and Services (G&S) and macro-economic consequences. In the absence of a Classification System, this was specifically to provide DWA with a greater understanding of the consequences of decisions to either protect or use the water resources in the Upper Vaal River catchment.

The objective of this Reserve Step is therefore to provide sufficient information to the decision maker regarding the operational scenarios and the consequences of these in terms of:

- Ecology.
- Goods and Services (G&S).
- Socio Economics.

This should then allow for informed decision-making regarding which Ecological Category and Reserve should be signed off.

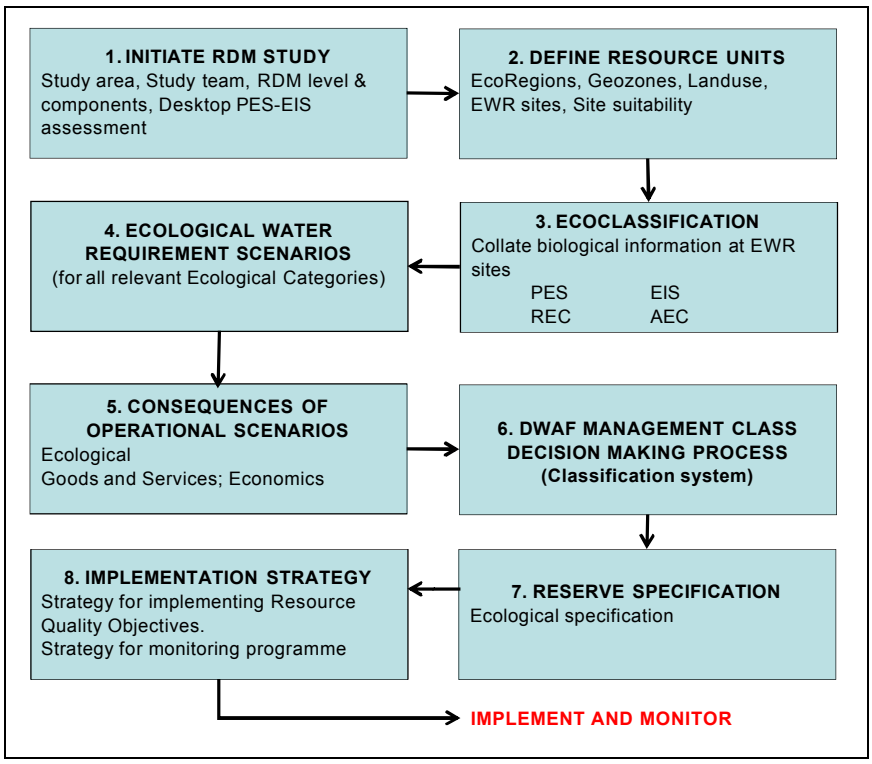


Figure 1.1 The 8-step Ecological Reserve procedure (adapted from DWAF, 1999)

The status of this part of the project and report within the broader study is the determination of the present state evaluation of the socio economic contribution of the main water users of the Upper Vaal Management Area (WMA) and the possible consequences of the introduction of various operational flow scenarios.

1.2 INTRODUCTION

Water, due to its physical nature, is a “high-exclusion” cost resource which means that exclusive property rights, being the basis of a market economy, are relatively difficult and expensive to establish and enforce. It is therefore useful to group the water values into the following water consumer categories together with the benefits realised from the use of water allocated to each:

- Irrigation Agriculture.
- Commercial business and industries.
- Mining.
- Manufacturing, and
- Domestic water supply.

In order to determine the value of water for the various uses in the Upper Vaal River WMA, it is necessary to identify the benefits accrued from its use in each sector to which the available water of the Upper Vaal River has been allocated, as well as the water that is left in the river. This exercise will provide the baseline for comparison purposes, to determine the changes in water availability for the different operational scenarios (refer to report produced by WRP, RDM/C000/01/CON/0607; DWA, 2010a).

1.3 STUDY AREA

The Upper Vaal WMA is one of three WMAs in the Vaal River catchment, which is the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers (DWAF, 2004).

The major tributaries in the Upper Vaal WMA include the Vaal, Klip, Waterval, Wilge, Liebenbergsvlei, Suikerbosrand, Klipspruit and Mooi Rivers and extend to the confluence of the Mooi and Vaal Rivers. It covers a catchment area of 55 565 km^2.

1.4 PURPOSE OF THE REPORT

The purpose of this report is to determine the Present Economic State (PES) of the Upper Vaal WMA and evaluate the social and economic returns of the existing water use by the various water users within this WMA (WMA 8) and the macroeconomic impacts of the possible introduction of the operational scenarios. The objective of determining the PES is to provide a baseline for the comparison of the impacts of the different operational scenarios.

1.5 OUTLINE OF THE REPORT

The report outline is given below.

1.5.1 Chapter 2: Economic Zones

In calculating the present state economic situation in the Upper Vaal WMA, nine economic zones were identified. These are described in this section.

1.5.2 Chapter 3: Methodology: Determination of the Present Economic State

This section describes how the overall modelling system is validated in terms of its ability to estimate actual water demand developments, other economic indicators, as well as the ability to forecast possible future developments.

1.5.3 Chapter 4: Data and Data Sources: Present State Evaluation

This section outlines the data used to evaluate the Present Economic State.

1.5.4 Chapter 5: Methodology: Evaluation of Operational Scenarios

This chapter includes the methods used to determine the impact of the operational scenarios.

1.5.5 Chapter 6: Data and Data Sources: Operational Scenarios

The operational scenarios are summarised in this chapter.

1.5.6 Chapter 7: Results and Recommendations: Present State and Consequences of the Operational Scenarios.

The Present Economic State and consequences of the operational scenarios are provided.

2 ECONOMIC ZONES

The Upper Vaal WMA is the most developed, industrialised and most populous of the Vaal WMAs. From a water resource management perspective it is the pivotal WMA in the country. The potential for future economic growth in this WMA remains strong. Future growth will largely be attracted to the already strong urban and industrial areas in the Johannesburg-Vereeniging-Vanderbijl Park complex and the very fast developing Mpumulanga Highveld region of Secunda and surrounding areas.

The Upper Vaal WMA covers a relatively vast area and includes a portion of the southern Gauteng industrial and urban areas. For the purpose of this study the WMA area is divided into two groups; namely the main stem and tributaries. This was necessary due to the different nature of water supply in the two entities. The water supply to the different sectors in the main stem is all supplied from the Vaal River and related structures, while the water from tributaries are destined for irrigation and originates from sources in the tributary, while industrial, mining and other urban needs are mostly supplied from water sourced in the Vaal River or other basins. Future water demand growth in the other sectors, excluding irrigation, will be supplied from the main stem. For purposes of analysing the SPS and the later possible impact of the introduction of the EWR, the main stem of the river is divided into three economic zones (EZs) and the tributaries into six zones.

For reporting purposes the names given to the economic zones are as follows:

- Economic Zone 1: Main stem – up to Grootdraai Dam
- Economic Zone 2: Main stem – between Grootdraai Dam and the Barrage
- Economic Zone 3: Main stem – between Barrage and the Middle Vaal WMA
- Economic Zone 4: Tributary – Wilge
- Economic Zone 5: Tributary – Klip River 1
- Economic Zone 6: Tributary – Waterval
- Economic Zone 7: Tributary – Suikerbosrand/Blesbok
- Economic Zone 8: Tributary – Klipriver 2
- Economic Zone 9: Tributary – Mooi

Figure 2.1 illustrates the different economic zones within WMA 8 – Upper Vaal.

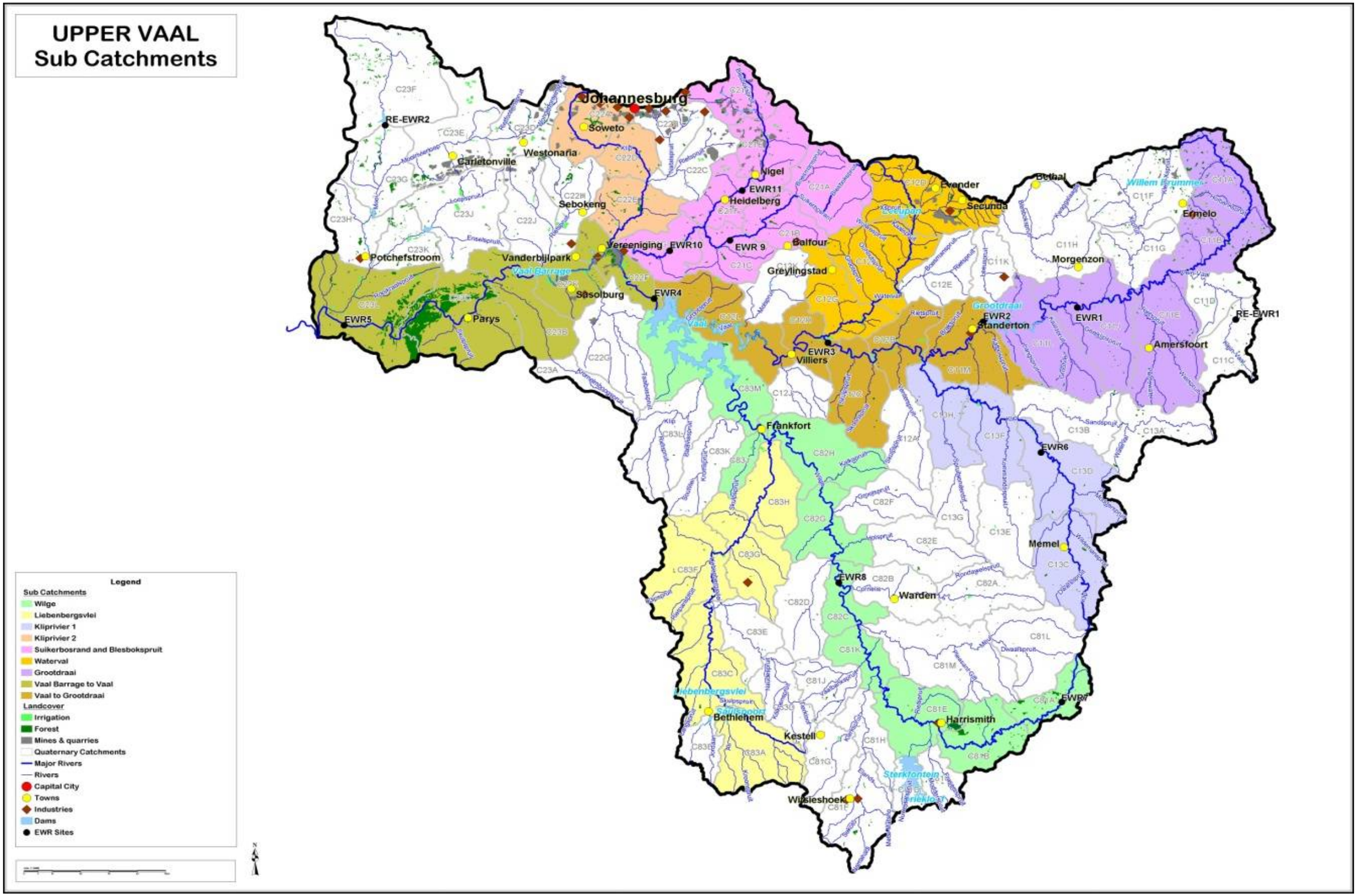


Figure 2.1 Economic Zones of the Upper Vaal WMA

2.1 DESCRIPTION OF THE MAIN STEM ECONOMIC ZONES

2.1.1 EZ 1: Up to Grootdraai Dam

EZ1 is situated in the eastern part of the Upper Vaal and comprises the area around the main stem up to the Grootdraai Dam. The zone hosts various power stations extracting water from both the Vaal River and the Usutu River. Ermelo, Bethal and Carolina are the main urban centres in this key area.

2.1.2 EZ 2: Between Grootdraai Dam and the Barrage

EZ 2 is situated in the central region of the Upper Vaal WMA. This area is a significant importer of water from the Grootdraai and Vaal Dams. In the Highveld Ridge Magisterial District (MD), both the gold and coal mines receive water from the Vaal Dam via the Rand Water supply infrastructure. The Highveld Ridge and Standerton (Lekwa) Local Municipalities (LM) are the main urban centres in this area. The largest water users within this key area are the Tutuka, Matla, Lethabo and Grootvlei Power Stations and their associated collieries, where applicable, and third party users.

2.1.3 EZ 3: Between the Barrage and the Middle Vaal WMA

EZ 3 lies in the western part of the Upper Vaal WMA. The Vaal River flows through the WMA and then enters the Middle Vaal WMA. The water supply of this area is dominated by the transfer of potable water from the Vaal Dam. Most transfers are by Rand Water to urban and industrial users in the Crocodile West WMA, to Heilbron LM in the Middle Vaal WMA, to urban and industrial users in the region of the Klip, Suikerbosrand and Mooi Rivers, and the Vaal Dam and Grootdraai Dam key areas. Bulk requirements by industries such as Eskom, Sasol I and Iscor are also significant and emphasises the highly industrialised nature of this key area. The main urban centres are Vereeniging, Vanderbijl Park and Sasolburg which also receive bulk water from the Rand Water network.

2.2 DESCRIPTION OF THE EZs OF THE TRIBUTARIES

2.2.1 EZ 4: Wilge

EZ 4 lies at the bottom of the Upper Vaal WMA. The main rivers flowing through the EZ are the Wilge River and the Liebenbergsvlei River. Phuthaditjhaba, Harrismith, Bethlehem and Frankfort are the most significant urban centres in the area. The Wilge EZ has the largest number of livestock in the WMA.

2.2.2 EZ 5: Klip River 1

EZ 5 lies in the eastern part of the Upper Vaal WMA. The main river flowing through the zone is the Klip River. Volksrust, Balfour and Vrede are the main urban centres in this key area.

2.2.3 EZ 6: Waterval

EZ 6 lies in the northern part of the central area of the Upper Vaal WMA. Agricultural and rural domestic requirements are significant with Sasol II/III petrochemical industry at Secunda being the main industry in the region. Secunda, Leandra, Kinross and Evander are the main urban centres in this key area.

2.2.4 EZ 7: Suikerbosrand/Blesbok

EZ 7 is located in the northern part of the WMA. The main rivers flowing through the area are the Blesbokspruit and the Suikerbosrand Rivers. This area is urban in nature and is a significant importer of water from the Vaal Dam (via the Rand Water network). This covers the East Rand area with main centres Benoni, Brakpan, Springs, Nigel and Heidelberg.

2.2.5 EZ 8: Klip River 2

EZ 8 is located in the northern part of the Upper Vaal WMA. The main river flowing through the WMA is the Klip River. This area is highly urbanised and is a significant importer of water from the Vaal Dam (via the Rand Water network). Soweto, Germiston, Boksburg and Alberton are the main towns in this area.

2.2.6 EZ 9: Mooi River

EZ 9 lies in the western part of the Upper Vaal WMA. The Mooi River and also Loopspruit are part of the WMA water resources. This area imports water from the Vaal Dam and the Zuurbekom Wellfield pumping station (via the Rand Water network) for the West Rand towns of Westonaria, Carltonville, Fochville and Potchefstroom.

3 METHODOLOGY: DETERMINATION OF THE PRESENT ECONOMIC STATE

3.1.1 Background to the Present State Economic Modelling Methodology

To accommodate the different situations in the main stem of the Vaal River and the tributaries, two models were used to calculate the macro economic impacts of water use in the different economic zones. This was necessitated by the difference in water sources in the two main economic zone types. In the tributaries the irrigation water is drawn from local sources with a large percentage, if not all, of the required demand for the mining and other urban requirements pumped from the main stem.

On the main stem the irrigation water, together with the rest of the water, is sourced from the river. A decision was taken by the project team that water demand quantities drawn from the main stem will be supplied by external sources if needed.

On the main stem of the river and for the urban, mining and industrial requirements on the tributaries, the South African Inter-industry Model (SAFRIM[1]) was used to calculate the impact of the introduction of the EWR. For the irrigation from the tributaries the Water Impact Model (WIM[2]) was used to calculate the impact of the introduction of the EWR.

3.2 THE SAFRIM MODEL

3.2.1 Description of the SAFRIM Model

In line with the Australian approach (i.e. to link a sectoral based macro-econometric model with a regionally based water demand/supply structure), SAFRIM was linked to a so-called Water Satellite Model (WSM). Figure 3.1 below illustrates the linkage of these two models.

[1] Water Research Commission: K5/1570 – Development of an Econometric Model to Predict the Effect that Various Water Resource Scenarios Would Have on South Africa's Economic Development.

[2] Department of Water Affairs: 2005 – High Confidence Reserve Determination of the Letaba River Catchment: Development of a Water Impact Model.

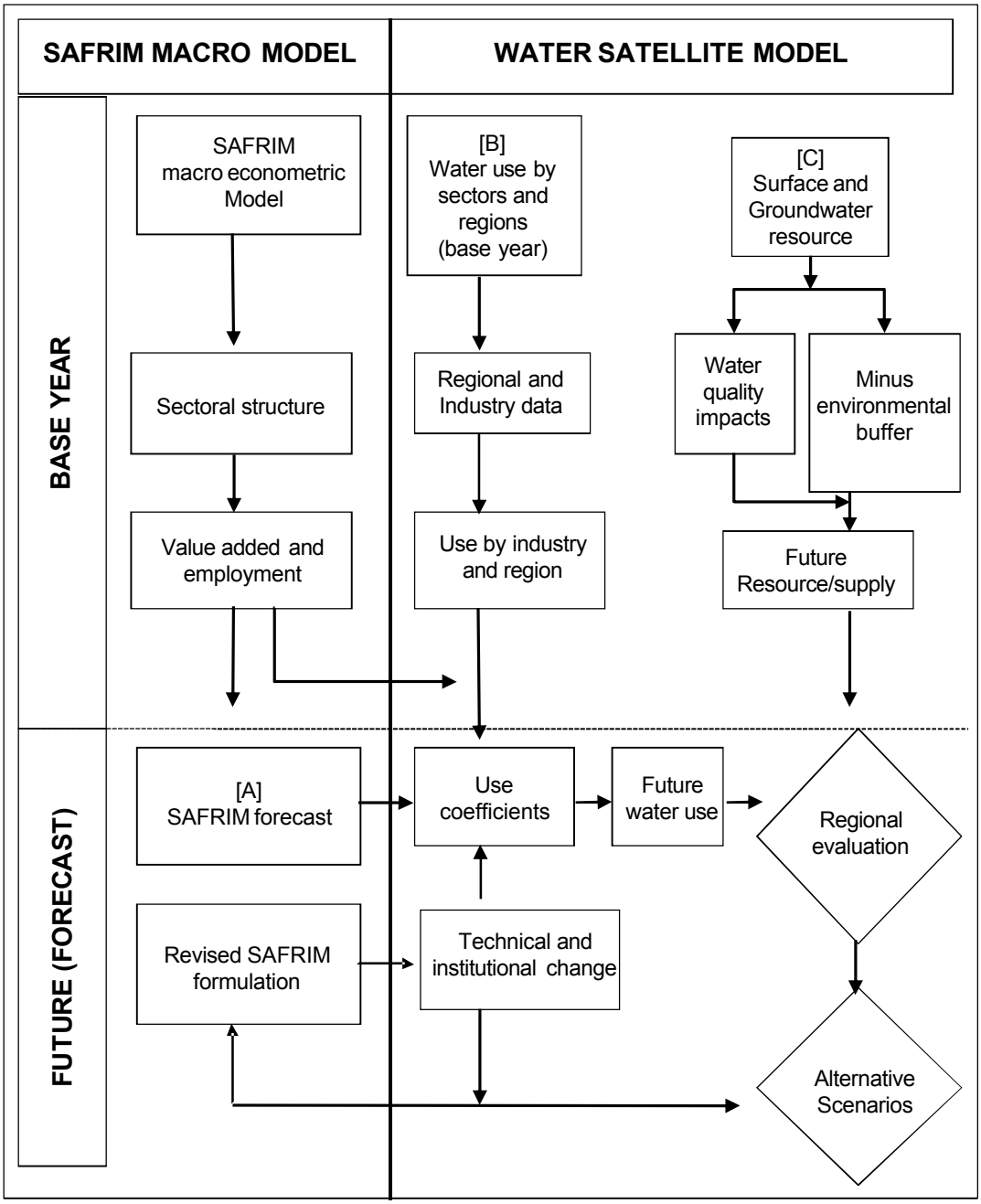


Figure 3.1 Inforum Model

As can be seen from the above diagram, a large measure of synergy exists between the two model configurations. SAFRIM, on the left hand side, provides the sectoral value added “drivers” for the water demand functions of the WSM which are reflected on the right-hand side. These water demand functions were 'borrowed' from the so-called Water Allocation Model which was originally used for a study of the water situation in the Upper Vaal WMA.

3.2.2 Approach to the SAFRIM/WSM Model

This section presents water multipliers which were calculated using the integrated SAFRIM/WSM infrastructure in such a way that, wherever an exogenous impact is administered, its ultimate impact on endogenous economic aggregates (i.e. GDP, employment, investment, household consumption demand, etc.) represents the total effect (i.e. direct, indirect and induced impacts).

The following steps were followed in preparing the model for the calculation of water multipliers:

Step 1: The SAFRIM produces, *inter alia*, 46 sectoral production figures as the endogenous outcomes of an exogenous change originating from any part of the model's configurations, e.g., changes in government expenditure, exports, etc.

A change in water demand per sector was proportionately aligned with a production increase/decrease. This ratio is directly based on the average water consumption per unit of production, or average water coefficients. For the purpose of this calculation, it is assumed that each sector in turn receives an additional one million m^3 of water, whilst keeping water demand of the other sectors in the economy constant.

Step 2: Having established the production value equivalent of one million m^3 of water consumed per sector, it is now possible to increase the final demand of each sector with this calculated amount. This demand vector is then fed into SAFRIM which then in turn estimates the total increase in production per sector (46) flowing from this increase in water input per sector. It is important to emphasise again that the increase in production estimated by the model encompasses the total (i.e. direct, indirect and induced) impact of an increase in water consumption.

Step 3: The third and crucial step is to use these resultant production impact figures to "shock" the WSM. As is well-known by now, this WSM consists of 65 sectors, and that agriculture is "driven" by the number of hectares irrigated. As such, the production figure derived at in Step 2 has to be converted into hectares in order to activate that part of the model. Ultimately, the WSM provides the total water consumption per sector which is associated with a one million m^3 increase in water consumption per sector.

Step 4: Lastly, the results of Steps 2 and 3 are divided by one another to provide a Water Multiplier as such – i.e. the amount of GDP, employment, investment and household income per (additional) cubic meter of water consumed (this can, to some extent, be construed as a crude measure of water's marginal productivity).

3.2.3 Approach for Production Inputs: Macro-economic Forecasting Model

The Macro-economic Forecasting Model (MFM)[3] model, developed by Conningarth Economists, in this study forecasts economic activity (measured as production output) and household growth (measured in household units) for the national economy, as well as at Magisterial District [4] level for the 14 year period from 2006 to 2026.

The MFM model captures the integrated nature of the South African economy in terms of the linkages that occur between economic sectors and households throughout the national economy and between geographical areas as represented by the Magisterial Districts. Furthermore, the model also captures the linkages that exist between the South African national economy and its international trading partners by incorporating imports and exports into the model. As such, the forecasts produced by the MFM model are based on macroeconomic data which provides a 'top-down' perspective on the broader national economy.

[3] ESKOM: Thabile Engineering – 2008- Economic Modelling for the Load Forecast and Strategic Study of the Watershed Network Master Plan.

[4] It is important to note that the Magisterial Districts used in this study have been derived from Census 2001 data. As such, these Magisterial Districts reflect their old, original names and boundaries.

The output of the MFM model was compared with that produced by the strategic socio economic study undertaken by Conningarth Economists. In this way, it was possible to compare the results of a bottom-up and a top-down approach to forecasting economic activity and household growth, with the result that it will be possible to produce more accurate and more reliable forecasts for production demand.

For the purpose of this Upper Vaal study the production estimates for the year 2006 was used. The sectoral classification reflected in the MFM estimates do not conform to the SAFRIM Water Satellite Model classification in respect to every sector. Electricity and water, for example, are reflected as one sector in the model while mining and industry are again sub-divided into more detail than is required by the SAFRIM model. In such cases of non-conformity, either a realistic percentage division was made of the sector or the sector sub-divisions were totalled.

3.3 THE WATER IMPACT MODEL (WIM)

3.3.1 Description of the WIM

Although reduced water allocation and/or lowering assurances of supply will directly impact on water users, there are also broader macroeconomic implications at a regional level. In order to assess the indirect impacts of re-allocation of water a WIM developed by the project team, was constructed for each tributary. This model is based on the Input-Output Model. The economic model is based on a steady state social (i.e. low income household, employment and levels of income) and financial contribution made by water users with a water allocation. Gross revenue, gross margins, cash returns and net profits calculated for the base case will be used to compare with the gross revenues and margins of the other allocation scenarios. One of the key inputs is the water allocation to each sector which is provided from the Water Resource Planning Model (WRPM) as basis.

The WIM was structured by economic zones which comprises the quaternary catchment in a specific tributary. It is structured to determine the implications of sectoral changes in water allocations to the social and economic well-being of the communities in the economic zone. In doing so, the impact of changes in water use patterns can be uniquely measured for each water user sector in the economic zone and comparative analyses between various user sectors can be performed in terms of the economic impacts emanating from each water re-allocation scenario.

3.3.2 Economic Multipliers

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

A multiplier summarises the total impact that can be expected from change in a given economic activity. Figure 3.2 illustrates the multiplier concept used in assessing the change in economic activity in a WMA with changes in the available water resources to the users for undertaking economic production.

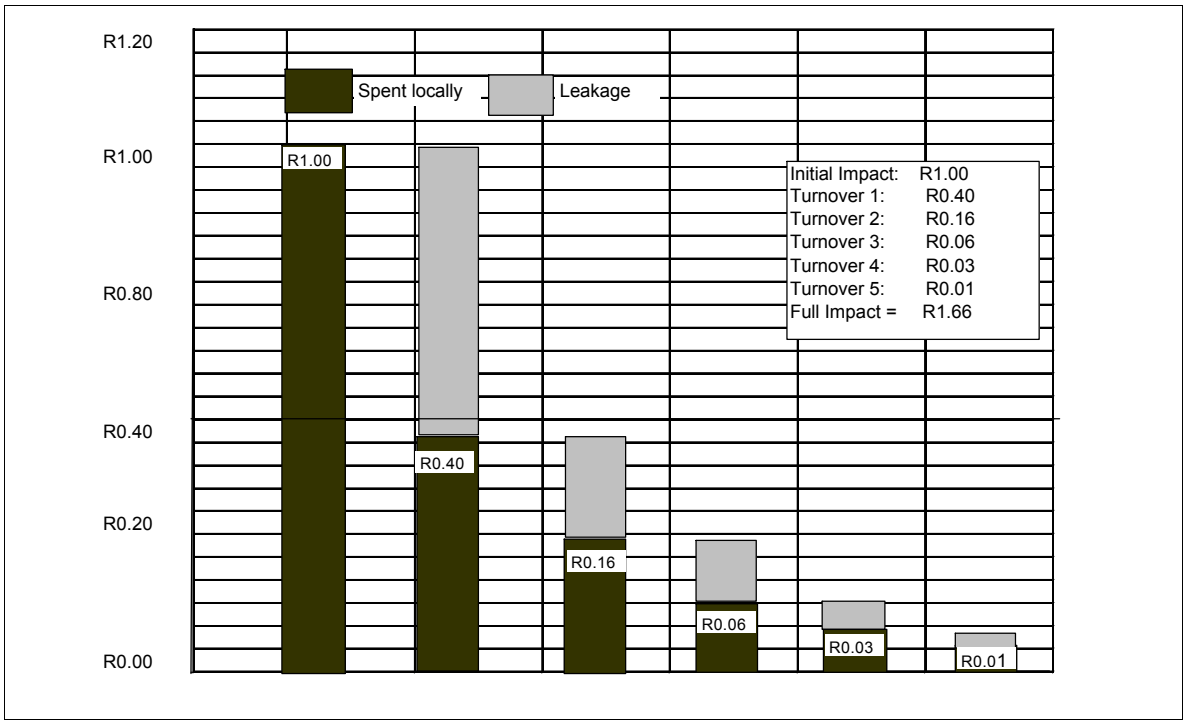


Figure 3.2 Multipliers and Turnover

One Rand is received into the local economy of a Water Management Area (WMA) from sales beyond the WMA borders. Of this one Rand, 40 cents is spent for goods and services within the WMA. The economic sectors and individuals who receive the 40 cents spend 16 cents within the WMA. Of the 16 cents, only six (6) cents is spent locally and so on. The total amount of money received by local firms and residents as a result of the initial one Rand in added exported earnings is R1.66. Therefore the multiplier is R1.66.

The change in economic activity resulting from the change in one factor of production, such as water resources, is measured by different multipliers. Four multipliers are commonly used to assess the impacts of an initial increase in production resulting from an increase in sales, usually called final demand in a multiplier analysis. The four are: (1) Output, (2) Employment; (3) Income; and (4) Value Added Multipliers.

3.3.3 Calculation of Multipliers

Sectoral multipliers are calculated using information contained in the applicable Provincial Social Accounting Matrix (SAM), the National RSA SAM and data obtained from the Reserve Bank of South Africa and Statistics South Africa. These inverse matrices capture all of the direct and indirect relationships among the inputs and outputs of the various entities included in the applicable provincial SAM.

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

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

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

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

These Multipliers were incorporated into the Water Impact Model and used to calculate the macro-economic impacts.

By using a SAM for the applicable region, the above multipliers can be calculated. The multipliers that were used in this study to determine the economic impacts are as follows:

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

A breakdown of the different effects of the agricultural sector multipliers used in this study is as follows:

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

4 PRESENT STATE EVALUATION

In this section the main water users are presented per Economic Zone and per activity.

4.1 IRRIGATION AGRICULTURE

The main irrigation agriculture crops in the Upper Vaal include cereals (maize and wheat), fodder and grazing crops, deciduous fruit, nuts, and horticulture. The inputs the model requires are hectares and water volumes. Table 4.1 indicates the inputs for purposes of the model, namely the numbers of hectares. An amount for double cropping is incorporated into the figures, specifically between the summer and winter cereals and the gradual increase in the production of soya beans.

According to the Department of Water and Environmental Affairs the volume of water allocated to irrigation has been ring fenced and no further volume increases will be allowed. However, nothing is preventing farmers from improving their management practises and upgrading technology resulting in vertical and horizontal expansion with the same volume of water.

Table 4.1 Number of hectares for irrigated agriculture for the Upper Vaal WMA for 2006 disaggregated in EZs (Hectares)

Description	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
	Up to Grootdraai	Grootdraai to Barrage	Barrage to Middle Vaal	Wilge	Klip River 1	Waterval	Suikerbos	Klip River 2	Mooi	
Cereals	4 970	11 139	6 722	5 285	1 454	2 381	1 680	2 065	4 947	40 642
Fodder and Grazing Crops	1 280	594	358	862	379	195	300	557	1 102	5 629
Deciduous fruit	199	16	10	161	37	16	0	15	0	453
Nuts	230	105	63	288	150	10	12	0	0	858
Horticulture	543	669	403	1 676	142	326	1 014	2 335	635	7 742
Total	7 224	12 522	7 557	8 272	2 161	2 929	3 005	4 971	6 683	55 324

Source: DWA Report: P RSA C000/00/4406/05, Water for Africa and Conningarth Economists.

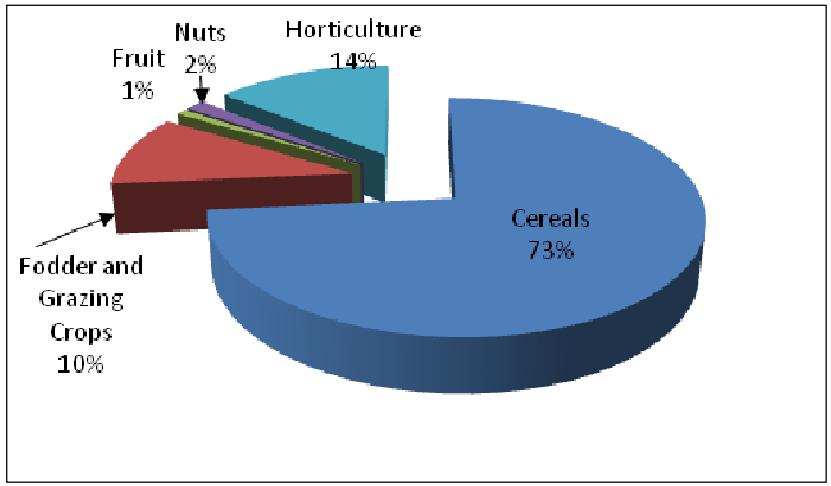


Figure 4.1 Distribution of irrigation crops in the Upper Vaal WMA

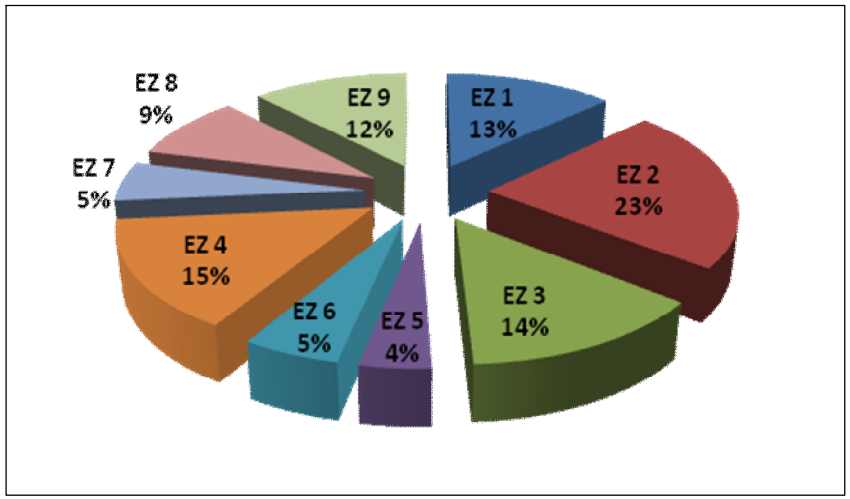


Figure 4.2 Distribution of irrigation in the different economic zones

From the Table 4.1 and Figures 4.1 and 4.2 it is clear that the largest quantity of irrigated hectares used is in the production of cereals, namely 40 462 hectares or 73%. The largest irrigated area is in the Main Stem Grootdraai to Barrage Economic Zone (EZ 2) followed by the Wilge Tributary economic zone (EZ 4).

4.2 LIVESTOCK AND GAME

The livestock number expressed as Large Stock Units (LSU) was disaggregated and allocated to the different economic zones. Analysis showed that the game numbers were not significant enough to be incorporated into the model. Data was sourced from the National Department of Agriculture. Table 4.2 below reflects the inputs for the purpose of the model, namely the number of LSU per economic zone.

Table 4.2 Livestock and game for the Upper Vaal WMA for 2006 disaggregated into EZs (LSU)

Description	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
	Up to Grootdraai	Grootdraai to Barrage	Barrage to Middle Vaal	Wilge	Klip River 1	Waterval	Suikerbos	Klip River 2	Mooi	
Livestock	477 614	221 431	117 411	449 303	238 811	64 189	102 179	17 157	204 353	1 892 447
Game	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	477 614	221 431	117 411	449 303	238 811	64 189	102 179	17 157	204 353	**1 892 447**

Source: Adapted by Conningarth Economists from Department of Minerals Data

The livestock sector in the Upper Vaal WMA consists of almost 1.9 million Large Stock Units as shown in Table 4.2 above. The majority of livestock is located in the Grootdraai and Wilge EZs (EZ 1 and EZ 4) and the least in the Klip River 2 EZ (EZ 2).

4.3 MINING

Mining includes coal, gold and uranium and all other mining such as other non-ferrous metals, including other non-metallic minerals such as quarrying (granite, limestone and other). Mining operations include underground as well as surface mines and quarries.

This data was obtained from the production figures per magisterial district of the MFM and divided into the various economic zones. For the purpose of the mining sector it was calculated exogenously. The water volumes used were from the Upper Vaal Study in 2004 and were allocated to the applicable zones. Table 4.3 below indicate the inputs for the purpose of the model, namely production.

Table 4.3 Production for the mining activities for the Upper Vaal WMA for 2006 disaggregated into EZs (R Million)

Description	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
	Up to Grootdraai	Grootdraai to Barrage	Barrage to Middle Vaal	Wilge	Klip River 1	Waterval	Suikerbos	Klip River 2	Mooi	
Coal	5 183		6 125	-	274	7 206	-		-	18 788
Gold and Uranium	-	-	-	-	-		7 078	3 932	6 291	17 301

Description	EZ 1 Up to Grootdraai	EZ 2 Grootdraai to Barrage	EZ 3 Barrage to Middle Vaal	EZ 4 Wilge	EZ 5 Klip River 1	EZ 6 Waterval	EZ 7 Suikerbos	EZ 8 Klip River 2	EZ 9 Mooi	Total
Other	21		416	-	9	105	4 024	335	990	5 900
Total	5 203		6 541	-	283	7 311	11 102	4 268	7 281	**41 989**

Source: Adapted by Conningarth Economists from Department of Minerals Data.

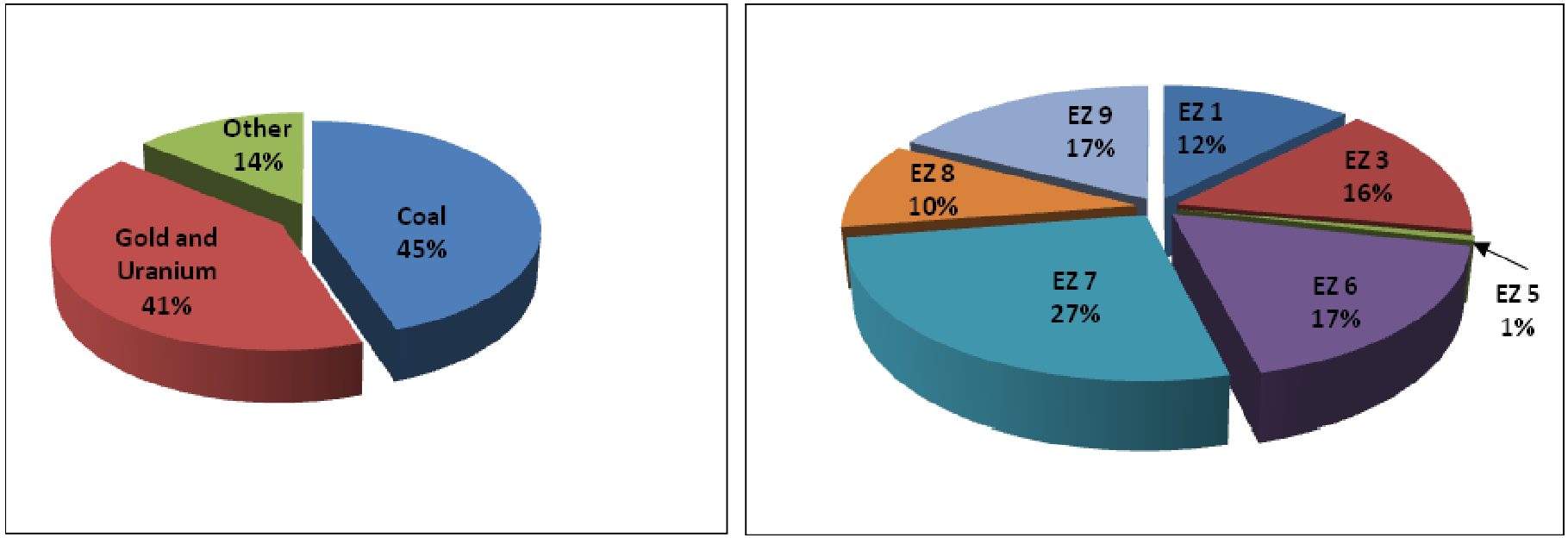


Figure 4.3 Comparison of the value of the mining products in the Upper Vaal WMA

Coal represent 45% of the value of mining followed by gold with 41%, with all the rest making up the balance of 14%. The majority of mining activities are in the Suikerbosrand (EZ 7) area, namely 27% as shown in Figure 4.3 above.

4.4 POWER GENERATION

The power station's data for water volumes was obtained from *Water for Africa* (Pty) Ltd. and the production values from Eskom statistical tables. Nearly 66% of the coal generated power stations occurs in the Upper Vaal WMA catchment and specifically in two of the economic zones. The Camden and Grootvlei power stations have been on line since 2006 and have been included in the analysis. In EZ 1 the main power stations are Kriel, Kendal, Camden and Mujuba and in EZ 2, Tutuka, Matla, Lethabo and Grootvlei power stations. In the Table 4.4 below the electricity generated per economic zone is reflected.

Table 4.4 Electricity generated for the Upper Vaal WMA for 2006 disaggregated into EZs (GWh)

Description	EZ 1	EZ 2	Total
	Up to Grootdraai	Grootdraai to Barrage	
Power Generation	73 947	75 478	149 425
Total	73 947	75 478	149 425

Source: ESKOM Technical Data and adapted by Conningarth Economists.

The water for the Kriel and Kendal Power Stations are mostly transferred from the Usutu Catchment. Table 4.4 above shows that the most power generated in the Upper Vaal takes place in the Grootdraai to Barrage EZ. The Grootdraai EZ is the other main electricity generator.

4.5 MANUFACTURING (HEAVY AND LIGHT INDUSTRIES)

Industry is expected to be the biggest contributor to future economic growth in South Africa. The industrial sector is projected to have the largest growth in water requirements. Much of this growth will occur in the major urban centres which have limited water resources in close proximity. It is imperative to have assured water supplies at a reasonable cost in order to support the industrial development and at the same time for the industrial sector to improve its efficiency of water use and to minimise waste.

The manufacturing sector is divided into heavy and light industries. This data was taken from the MFM and adapted by Conningarth for the purposes of this project. The tertiary sector items required by the model, such as water supply, construction of buildings, civil engineering, financial and business services and others were also included in the light industry sector. The water data was determined by the SAFRIM model.

4.6 HEAVY INDUSTRIES

The heavy industries in the Upper Vaal WMA include ISCOR which consists of the basic iron and steel and basic non-ferrous metals sub-sectors. The Sasol I, II and III plants, being the coke and refined petroleum sub-sector, are also situated in the Upper Vaal WMA as shown in Table 4.5 below.

Table 4.5 Heavy industry production for the Upper Vaal WMA disaggregated into EZs (2006 Prices R Million)

Description	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
	Up to Grootdraai	Grootdraai to Barrage	Barrage to Middle Vaal	Wilge	Klip River 1	Waterval	Suikerbos	Klip River 2	Mooi	
Basic iron and steel	419.0		29 454	-	-		2 553	638	-	33 064
Basic non-ferrous metals	-	-	1 163	-	-		2 704	1 076	-	4 943
Coke and Refined Petroleum	-	-	7 188	-		11 444	-		-	18 632
Total	419.0		37 804	-		11 444	5 257	1 714	-	**56 639**

Source: Adapted by Conningarth Economists.

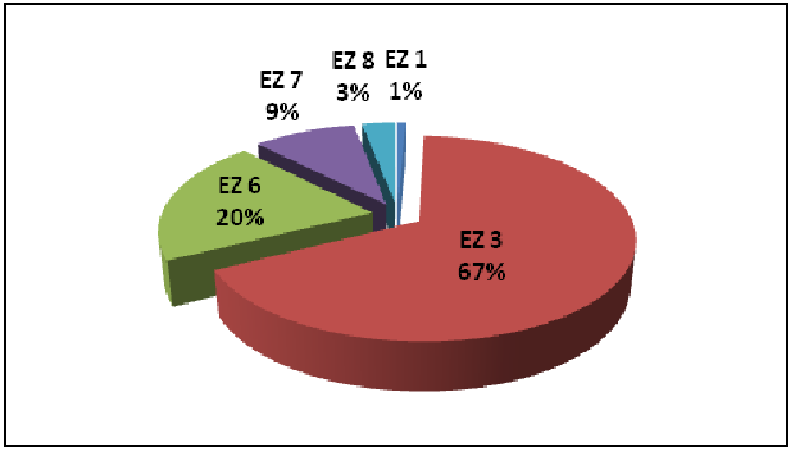


Figure 4.4 Distribution of the heavy industries in the Upper Vaal WMA according to monetary value (2006 prices)

From the Table 4.5 and Figure 4.4 above it is clear that in the Vaal Barrage the highest production takes place and can be attributed to the presence of Mittal Steel and Sasol I. Sasol II and III are situated in the Waterval EZ (EZ 6).

4.7 LIGHT INDUSTRIES

The light industries sector consists of the tertiary sector and a component of the manufacturing sector, and includes the industries that are dependent on water for production purposes. Table 4.6 below shows the production data in the specific EZs.

Table 4.6 Production for light Industries for the Upper Vaal WMA for 2006 (R Million)

Description	EZ 1	EZ 2	EZ 3	EZ 4	EZ 5	EZ 6	EZ 7	EZ 8	EZ 9	Total
	Up to Grootdraai	Grootdraai to Barrage	Barrage to Middle Vaal	Wilge	Klip River 1	Waterval	Suikerbos	Klip River 2	Mooi	
Manufacturing	7 156	28	33 162	1 316	329	12 958	43 605	32 811	760	132 126
Tertiary	13 804	536	16 412	7 142	2 808	5 644	36 886	170 128	17 018	270 378
Total	20 929	564	49 574	8 458	3 136	18 602	80 492	202 939	17 778	**402 503**

Source: Adapted by Conningarth Economists.

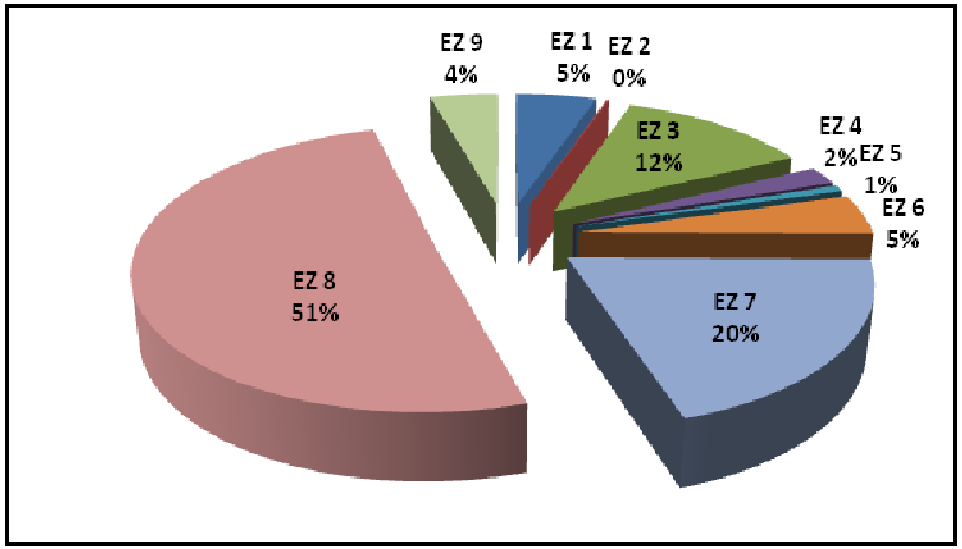


Figure 4.5 Distribution of the light industries in the Upper Vaal WMA according to monetary value (2006 prices)

The largest production of light industry activity is generated in the Upper Vaal WMA, namely EZ 8 with 51% followed by EZ 7 zone with 20% of the activity.

4.8 SERVICES, PARKS and OTHER PUBLIC USE

Public Services, Parks and other Public institutions are water users and are as such represented.

4.9 HOUSEHOLDS

4.9.1 Population

The largest urban area in South Africa and the largest urban water user within the WMA, namely the Greater Johannesburg Metropolitan Council, straddles part of the northern catchment divide between the Klip key area in the Upper Vaal WMA and the Crocodile River (West) and Marico River WMA. For modelling purposes this area is under the jurisdiction of the Greater Johannesburg Metropolitan Council and has been split into Johannesburg South (in the Upper Vaal WMA) and Johannesburg North (in the Crocodile River (West) and Marico River WMA). Other large metropolitan areas in the WMA include:

- Germiston, Boksburg, Alberton, Benoni, Brakpan, Springs and Nigel on the East Rand.
- Vereeniging, Vanderbijl Park and Sasolburg.
- Westonaria and Carltonville on the West Rand.

These areas also represent the most heavily populated areas in the WMA and all of these towns and cities are supplied with bulk water from the Vaal Dam via the Rand Water bulk water network.

Other significant urban centres are Bethlehem and Phuthaditjhaba (Witsieshoek) in the Wilge River catchment, Highveld complex, Standerton and Ermelo in the Vaal River catchment upstream of Vaal Dam and Potchefstroom in the Mooi River catchment.

The method used in calculating the population consisted of the following:

- Firstly, data was obtained per municipal area in the Upper Vaal Area. Data from the major municipalities was obtained from Water for Africa in this catchment. The number of people and the l/c/d was used to calculate the water volumes.
- This data did not reflect urban high, urban low and rural divisions. Subsequently the census 2001 data and also 1995 census data was used and the population was divided into urban high, urban low and rural.
- With the experience gained from the Upper Vaal catchment, which formed part of the Vaal Study, the 2001 data was adjusted to 2006 data. This was done, as data was lacking for several places, and subsequently the whole area's population was determined in this manner.

Experience gained in this kind of research has shown that for modelling purposes, the following household categories are sufficient:

- High income;
- Low income; and
- Rural income.

Table 4.7 below shows the population distribution in the Upper Vaal EZs.

Table 4.7 Population distribution for the Upper Vaal WMA for 2006 (Numbers)

Description	EZ 1 Up to Grootdraai	EZ 2 Grootdraai to Barrage	EZ 3 Barrage to Middle Vaal	EZ 4 Wilge	EZ 5 Klip River 1	EZ 6 Waterval	EZ 7 Suikerbos	EZ 8 Klip River 2	EZ 9 Mooi	Total
HOUSEHOLDS										
High income	11 905	626	29 105	7 048	2 779	15 593	57 173	166 295	22 054	312 577
Low income	272 300	26 121	351 182	276 795	96 130	162 608	546 187	2 179 298	463 066	4 373 686
Rural	132 577	17 129	176 682	224 906	66 178	67 366	249 630	923 067	160 878	2 018 414
Total	416 782	43 876	556 966	508 749	165 087	245 567	852 991	3 268 661	645 999	**6 704 677**

Source: Census 2001 Magisterial District data adapted by Conningarth Economists.

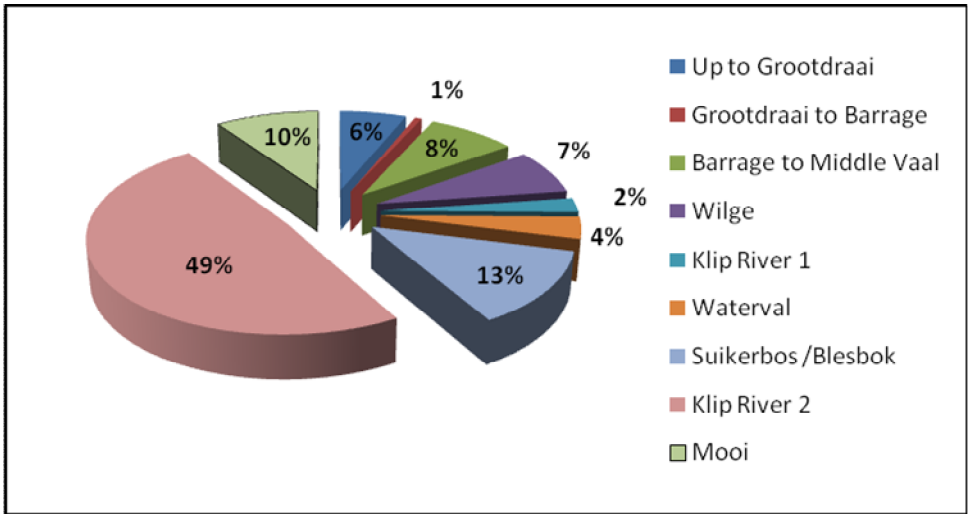


Figure 4.6 Total population distribution in the Upper Vaal WMA (2006 numbers)

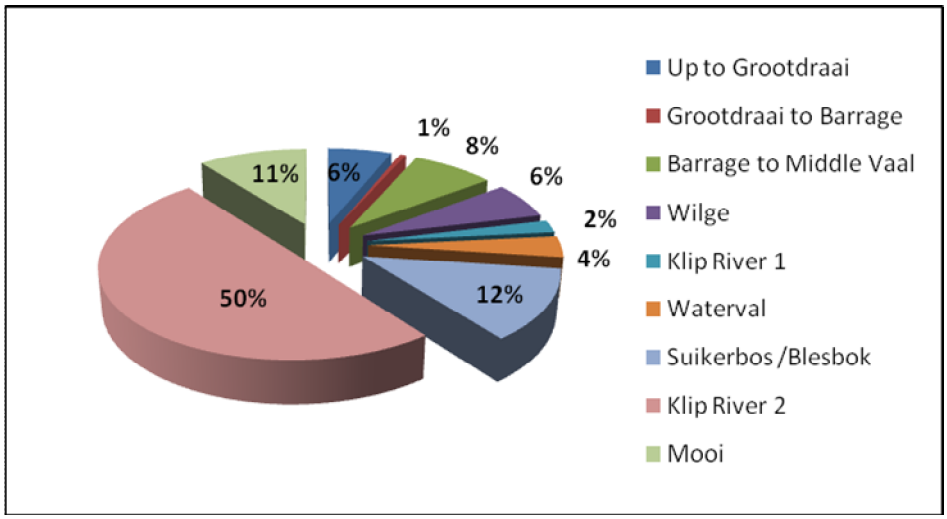


Figure 4.7 Low income population distribution

Table 4.7 and Figures 4.6 and 4.7 show that 50% of the population in the WMA is in the Klip River 2 Economic Zone (EZ 8). This applies to the total as well as the low-income section of the population.

5 METHODOLOGY: EVALUATION OF OPERATIONAL SCENARIOS

The approach to the study differs in respect of the introduction of the EWR operational scenarios for the tributaries and main stem of the Vaal River, although the main stem above the Grootdraai Dam is treated as a tributary. The difference in approach is dictated by Departmental policies and is explained in the next section.

5.1 POLICY APPROACH

5.1.1 Main Stem

The approach to the economic impact of the application of the operational scenarios in the main stem is guided by the following directives:-

- The expected demand will be provided, and
- Water Conservation and Demand Management policies will be in place and applied.

Figure 5.1 gives an indication of how the Department of Waters Affairs is approaching the supply of additional water to the Vaal system. When interpreting the graph please take note that the values and years mentioned are fictitious and is only an illustration to convey the concept.

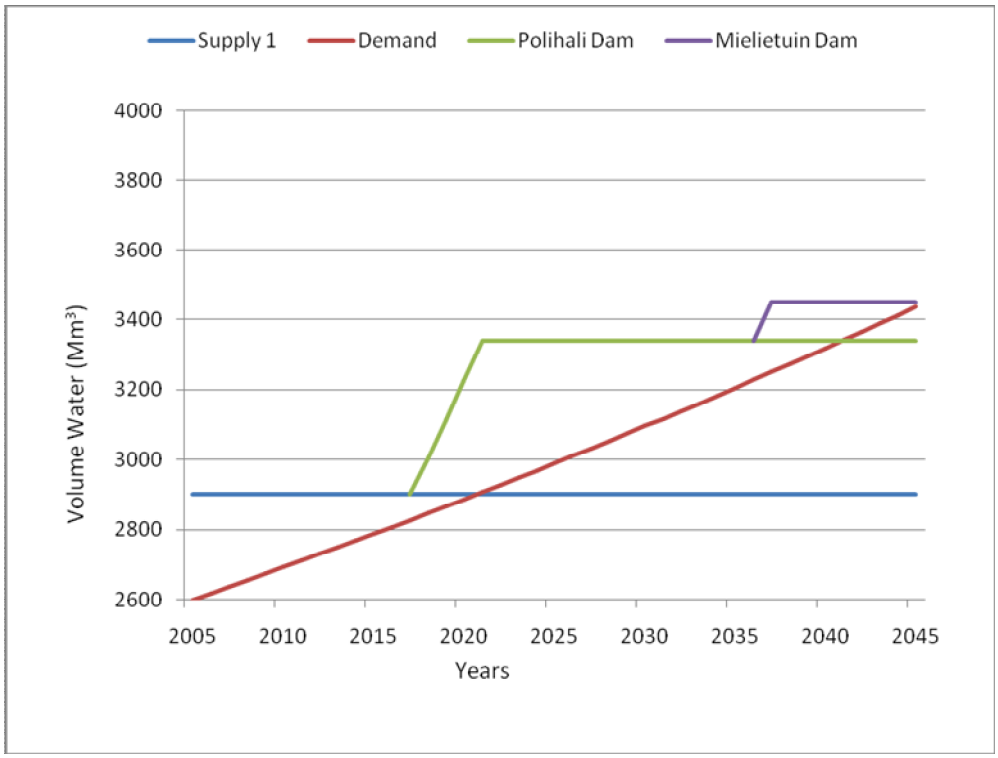


Figure 5.1 Illustration of the planned dam construction to supply the Vaal River system

The blue line represents the current supply available, before the introduction of the EWR, with the red line representing the estimated growth in demand. According to the present projected planning scenario the Polihali Dam in Lesotho will be build first (represented by the green line), followed by the Mielietuin Dam in the Tugela (purple line) and later to be followed by the Jana Dam also in the Tugela.

The Polihali and Jana Dams are very large dams with the Mielietuin a much smaller dam.

In terms of the economic evaluation this is then established as the current situation, any deviation from this position will affect the economic position. Moving the delivery date for the Polihali Dam will be a deviation, and changing the order of construction will be a deviation which will have economic implications.

The original projection was that the introduction of the EWR will reduce the available present supply, which will probably require that the Jana Dam be constructed before the Mielietuin Dam and even force the construction of the Polihali Dam to an earlier date. Figure 5.2 gives an indication of such a possible scenario.

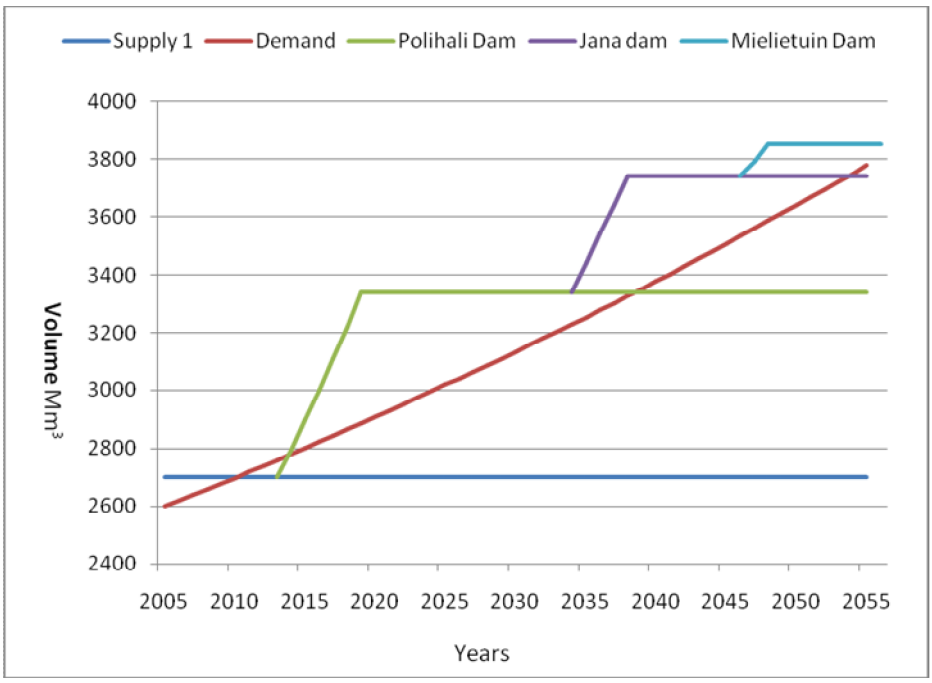


Figure 5.2 Theoretical illustration of the possible impact of the introduction of the EWR on the water provision situation on the Vaal System

Figure 5.2 indicates that the supply available will be less than the pre-EWR supply and that the Jana Dam will have to be constructed before the Mielietuin Dam to accommodate the expected volume growth in demand.

The Unit Reference Values (URV) for the three dams is within acceptable limits if kept in the same order of construction; the Rand per m^3 cost to deliver the water do not differ much. However, with the Polihali and Jana Dams being very large dams and the Mielietuin Dam being a much smaller dam, the result is that the total construction cost for the Mielietuin Dam will be much less than for Jana. Expressed in 2007 prices the estimated cost for the Polihali Dam is R5 175.35 million, for the Jana Dam R6 425.24 million and for the Mielietuin Dam R2 100.00 million.

Constructing the Jana Dam first will involve much more capital than the construction of the Mielietuin Dam, resulting in a large capital investment being required earlier than anticipated and resulting in higher water tariffs than originally projected.

If the construction cost of the Jana Dam is presented by RXj and that of the Mielietuin Dam by RXm:

- RXj>RXm, then
- The difference RXj – RXm represents the extra capital cost involved,

- And taking into consideration that the water volume demand per annum will have to cover the extra capital cost, because although a larger volume is available it will not be used immediately. The impact on the tariffs is then capital and maintenance divided by incremental annual increase in the volume water. With RXj more than RXm it follows that the tariff paid for water from the Jana dam will be more than the tariff from the Mielietuin dam.
- Annual growth will take a number of extra years to reach the full capacity of the Jana Dam compared to the smaller Mielietuin Dam. Resulting in the consumers paying a higher tariff for water than the original planning projection.

This was the anticipated result on the main stem if the EWR is implemented; however, the water demand projections have now shown that it would not be necessary as the projected supply from Polihale and Mielietuin Dams will support the introduction of the EWR, with minor adjustments.

The following are quotes from the Comprehensive Reserve Determination Study for the Integrated Vaal River System: Water Resource Modelling. Main Report (RDM/C000/01/CON/0607):

- Implementation of the EWR resulted in more water to be transferred via the VRESSAP pipeline (an additional amount of 55.6 million m^3/a is to be transferred for Scenario 8).
- Implementation of the EWR did not impact on the date on which the next augmentation scheme would be required; and
- Implementation of the EWR resulted in Sterkfontein Dam to be operated at lower storage levels (average storage for Scenario 7 was 2 367 million m^3 compared to the average storage of 2 294 million m^3 for Scenario 8).

From the above it appears that the only costs possibly foreseen are the additional pumping cost through the VRESSAP pipeline and possible monetary implications of the increased risk during times of drought because the Sterkfontein Dam storage is operating at a slightly lower level than without the EWR in place.

5.1.2 Tributaries

The calculation of the macro-economic impacts of a specific scenario in a tributary is guided by a number of assumptions and operational realities. The base assumptions are the following:

- The population, industry and mining will receive the expected water demand within Water Conservation and Demand Management targets. These targets have been determined outside of the present study and it is assumed that they will be applied.
- Eskom power stations will receive the water needed for power generation.
- Curtailments will be instituted against irrigation if necessary to implement EWR targets.

The operational realities referred to include the following:

- Except for certain smaller urban areas, the urban population receive their water from the main stem of the Vaal River, via Water Boards and pumping schemes.
- Water is pumped from the main stem into catchment of certain tributaries to satisfy the demand. The VRESSAP line pumping water to the Secunda complex is an example.
- A few mines and smaller industries still receive water from a source in the tributary.
- It is too expensive to pump water into the tributaries for irrigation purposes.

With the above in place the impact per EWR site was restricted to irrigation activities, accepting that all other demands will be met.

According to the Department of Water Affairs the volume of water allocated to irrigation in the Upper Vaal WMA has been ring fenced and no further volume increases will be allowed. However, nothing prevents farmers from improving their management practises and upgrading technology which will result in both vertical and horizontal expansion of their enterprises with the same volume of water.

Ecological consequences are determined at EWR sites which represent a Management Resource Unit. For comparison purposes, the EWR sites had to be allocated to the EZ zones. Table 5.1 below shows the overlaying of the economic zones and the EWR sites of which quantitative analyses were performed.

Table 5.1 Detailed information regarding the distribution of Economic Zones to tributary catchments

Economic Zone	River Type	Economic Zones	Catchment for Scenarios	EWR sites in EZs
EZ 1	Main Stem	Up to Grootdraai Dam	Klein Vaal; Vaal River at Uitkoms	RE-EWR 1; EWR 1
EZ 4	Tributary	Wilge	Wilge at Bavaria	EWR 8
EZ 5	Tributary	Klip River 1	Klip River	EWR 6
EZ 6	Tributary	Waterval	Waterval	EWR WA1 and EWR WA2
EZ 9	Tributary	Mooi	Mooi River (Klipdrift Dam)	EWR M2

5.2 CALCULATING THE IMPACTS OF OPERATIONAL SCENARIOS

The current economic activities were calculated using the economic models described in Section 3. This together with the water demand per economic activity was used to calculate the appropriate multipliers per activity.

The available water volumes for the specific EWR sites in the economic zones were obtained from DWA (2010).

The economic impacts of the scenarios are calculated by using the multipliers which were derived from the present state evaluation (discussed in Section 3) with the volume changes per EWR site. If the EWR site was situated in Economic Zone 1, a specific multiplier was developed for that zone. For example the employment multiplier is calculated as follows:

Employment [Numbers] (EZ1) / Water Volume [Mm^3] (EZ1)

This multiplier is used together with the change in water volume at a EWR site situated per scenario. The impact on employment is therefore represented in the following:

Change in Water Volume [Mm^3] (EWR site in Zone 1) x Employment multiplier [Number/Mm^3] (EZ1)

= *Employment Impact of EWR in EZ1 [Number]*

The same methodology was applied to calculate the impacts on GDP and households.

6 DATA AND DATA SOURCES: OPERATIONAL SCENARIOS

6.1 DATA SOURCE

Water volume data, required to determine the economic impacts of the operational scenarios, were provided from WRP (DWA, 2010). The analysis of the water resource modelling in the Upper Vaal WMA was the result of evaluating a number of scenarios shown below.

Table 6.1 Summary of scenarios analysed

Scenario	WRPM Reference	Development Level	EWR Status	Comments
1	V8RES05	2008	Excluded	**Base scenario representing the status quo.**
2	V8RES06	2008	Included	**Based on Scenario 1.** EWR Scenario: All EWRs included with JMRBS EWRs adopted for Usutu.
3	V8RES07	2008	Included	**Based on Scenario 1.** EWR Scenario: Including all EWRs in Vaal but with sub-system EWRs excluded.
4	V8RES08	2008	Included	**Based on Scenario 1.** EWR Scenario: With exception of EWR 4 and EWR 5, all EWRs in Vaal and one EWR in Thukela downstream of Driel Barrage were included.
5	V8RES09	2020	Excluded	**Base scenario representing the future 2020 development conditions excluding the EWRs.** Includes VRESSAP pipeline from Vaal Dam to Eastern Sub-system. Includes proposed Polihali Dam and conveyance infrastructure. Includes proposed re-use of mine water. Includes projected possible transfer to the Crocodile catchment.
6	V8RES10	2020	Included	**Based on Scenario 5.** EWR Scenario: With exception of EWR 4 and EWR 5, all EWRs in Vaal and one EWR in Thukela downstream of Driel Barrage were included.
7	V8RES13	Full utilization	Excluded	**Scenario representing the full utilization of available water.** Based on current infrastructure. Includes VRESSAP pipeline from Vaal Dam to Eastern Sub-system.
8	V8RES14	Full utilization	Included	**Based on Scenario 7.** EWR Scenario: With exception of EWR 4 and EWR 5, all EWRs in Vaal and one EWR in Thukela downstream of Driel Barrage were included.

Source: Report RDM/C000/01/CON/0607.

The scenarios that were in the end identified to measure specific water volume and there economic impacts at the specific EWR sites were Scenario 7 and Scenario 8. These volumes of water were used by the economics team, to determine the economic impacts for those consequences of the operating scenarios.

6.2 ASSUMPTIONS

The following assumptions for the main stem as well as the rivers in the tributary catchments were applied.

- The basket of irrigation crops were not changed when the water was reduced in the scenarios.
- The water volumes identified for the lawful and unlawful use were combined to determine a total economic impact of what the economic value of water provides.

7 RESULTS AND RECOMMENDATIONS: PRESENT STATE AND CONSEQUENCES OF THE OPERATIONAL SCENARIOS

In the following section the results obtained through the various modelling processes are presented. It is addressed per economic zone. The three Main Stem EZs will be discussed followed by the tributaries of the Upper Vaal. The results presented are as follows:

- The first table under each section shows the present state economic activity results. This reflects the direct GDP and the direct employment opportunities in 2006 for all the water users estimated in the baseline study. Direct macroeconomic impacts are used to give a picture of the economic activities in the specific economic zone.
- In the second table the present state irrigation results of agriculture are shown in more detail. As the irrigation agriculture is the only sector that can in some cases be affected by the consequences of the introduction of the EWRs under various operating scenarios, the different irrigated crops are shown in GDP, employment opportunities as well as in household income.
- The third table represents the impacts of the operational scenario in 2009 values per Economic Zone if the EWR scenarios are to be implemented. Those zones where operating scenarios were identified through the testing of the EWR sites in the economic zones and water volumes determined will be shown in total GDP and the total employment values, where applicable. It was decided to present the total economic impact to give a full picture of the impact of a specific operational scenario.

7.1 MAIN STEM

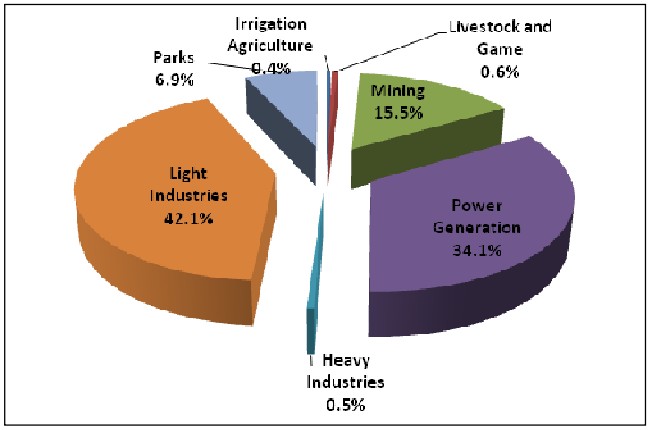
7.1.1 EZ 1: Up to Grootdraai

In the following tables the macroeconomic indicators of EZ 1 are presented.

Table 7.1 EZ 1: Present state macroeconomic indicators for the water use sectors (2009 prices)

Sectors	Direct GDP		Direct Labour	
	(R million)	(%)	(Number)	(%)
Irrigation Agriculture	68.0	0.4%	1 304	0.9%
Livestock and Game	115.5	0.6%	3 184	2.3%
Mining	2 876	15.5%	9 200	6.6%
Power Generation	6 312.3	34.1%	4 185	3.0%
Heavy Industries	93.7	0.5%	381	0.3%
Light Industries	7 792.1	42.1%	111 100	79.7%
Services	1 272.8	6.9%	9 964	7.2%
Total	**12 124**	**100%**	**139 318**	

The GDP and the Direct Labour per economic activity is presented in Figure 7.1 and Figure 7.2 respectively.



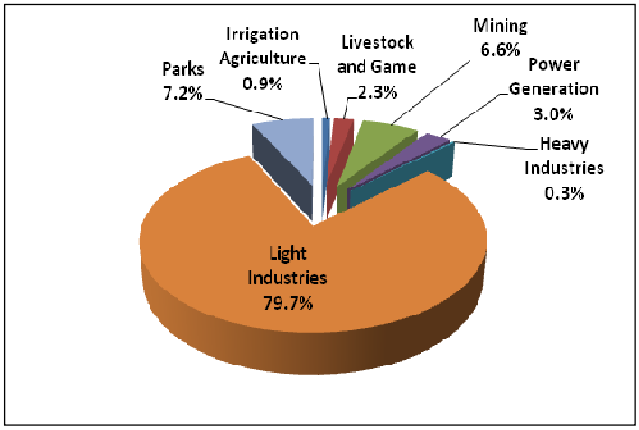


Figure 7.1 Direct GDP generated in EZ 1 **Figure 7.2 Direct Labour created in EZ 1**

Light Industries are by far the largest of the activities and is responsible for 64% of the GDP and 80% of the labour. It is followed by mining which is responsible for 24% of the GDP, but only 7% of the employment. A feature of the zone is that power generation contributes 34.2% to the GDP of the zone, but only 3% of the employment. Irrigation agriculture represents a relative small portion of the economic activities of the EZ, 0.4% of the GDP and 0.9% of the employment. Please keep in mind that this is only the irrigation part and not the total agricultural sector.

As irrigation agriculture is the only sector where operating scenarios will be applied, the economic impacts of the different crops under irrigation are presented below.

Table 7.2 EZ 1: Present state results of detailed irrigation agriculture (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	31.8	82.2	232	795	101.8	28.2
Fodder and Grazing Crops	9.1	23.0	45	186	28.7	7.7
Deciduous fruit	9.4	17.4	260	332	18.1	6.3
Nuts	1.7	3.6	35	55	4.1	1.2
Horticulture	16.0	34.4	732	904	40.0	12.7
Total	**68.0**	**160.6**	**1 304**	**2 271**	**192.7**	**56.2**

Table 7.2 indicates that cereal production generates the largest contribution to GDP but that vegetable production supports the largest number of employment opportunities. From the above table it also appears that although irrigation agriculture only represents 0.9% of the employment in the economic zone it is still responsible for 1 304 direct employment opportunities and R56 million annual payments to low-income households.

In evaluating the impacts of the EWR scenario, it must be kept in mind that the demand is the present demand and that the Scenario 7 is the estimated supply in 2020 without the EWR in place. Scenario 8 is the 2020 estimated supply with the EWR in position. The impacts are presented as the differences between Scenario 7 and Scenario 8.

The values and numbers are expressed in terms of constant 2009 prices and it is also accepted that the crop basket will not change and the efficiency is at 2009 levels. The impact of the proposed EWR is presented for the two sites namely RE-EWR 1 and RW 1.

Table 7.3 EZ 1: Klein Vaal RE-EWR 1 – Macro economic impact of the operating scenario on irrigation agriculture (2009 prices)

	Total GDP (R Mil)	Total Employment (Numbers)	Low Income HH (R Mil.)
	Values	Values	Values
Impact	R -0.88	-8	-R 0.33
Deviation	-3.8%	-1.5%	-3.5%

The analysis in Table 7.3 shows that the introduction of the EWR at this site will have a very small impact. The impact on GDP is -3.8%, on employment -1.5% and the payments low-income households will decrease by 3.5% The net impact of the EWR introduction will be a loss of R0.88million in GDP and 8 employment opportunities in the immediate vicinity of RE-EWR 1.

Table 7.4 EZ 1: EWR 1 – Macro economic impact of the operating scenario on irrigation agriculture (2009 prices)

	Total GDP (R Mil)	Total Employment (Numbers)	Low Income HH (R Mil.)
	Values	Values	Values
Impact	R -0.90	-19	-R 0.33
Deviation	-0.69%	-1.04%	-0.72%

The analysis in Table 7.4 shows that the introduction of the EWR at this site will have a very small impact. The impact on GDP is -0.69%, on employment -1.04% and the payments to low-income households will decrease by 0.72% The net impact of the EWR introduction will be a loss of R0.90 million in GDP and 19 employment opportunities in the immediate vicinity of EWR 1.

7.1.2 EZ 2: Grootdraai to Barrage

In the following table the macro-economic indicators of EZ 2 are presented.

Table 7.5 EZ 2: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	95.9	1.4%	1 513	11.7%
Livestock and Game	64.1	0.9%	1 476	11.4%
Mining	-	0.0%	-	0.0%
Power Generation	6 443.0	92.9%	5 175	39.9%
Heavy Industries	-	0.0%	-	0.0%
Light Industries	266.8	3.8%	4 294	33.1%
Services	66.9	1.0%	524	4.0%
Total	**6 936.7**	**100%**	**12 982**	**100%**

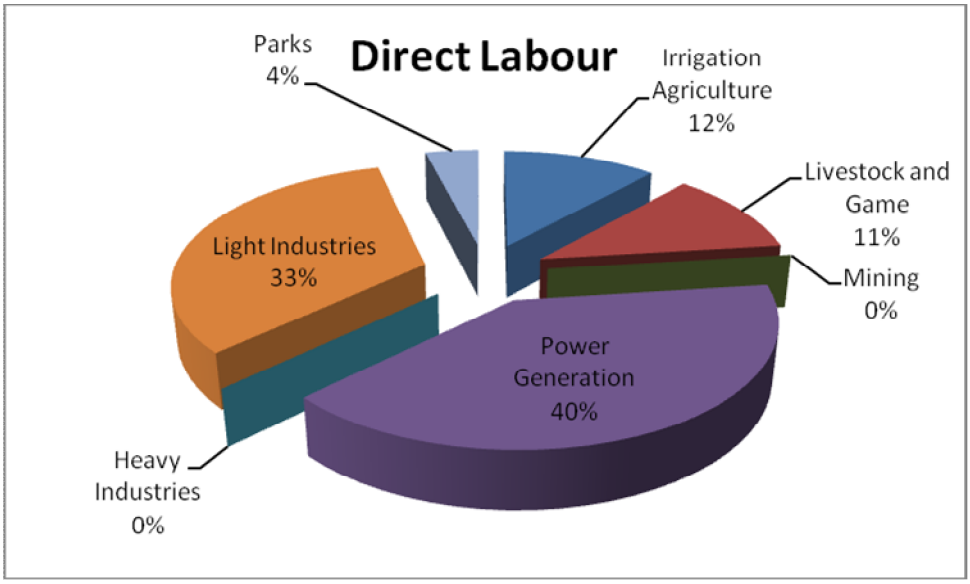


Figure 7.3 Employment opportunity sector distribution

From Table 7.5 and Figure 7.3 it is clear that power generation dominates the GDP in the economic zone, but is not so overwhelming in terms of employment opportunities. Power generation represents 93.7% of the GDP but only 40% of the employment in the economic zone. Irrigation agriculture and light industry activities also feature as employment creators in the economic zone. Irrigation agriculture is more prominent in this Economic Zone representing 1.4% of GDP but 11.7% of employment.

Table 7.6 EZ 2: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	70.5	182.0	553	1 798	226.1	62.8
Fodder and Grazing	4.3	10.6	21	86	13.2	3.6
Deciduous fruit	0.8	1.4	21	27	1.5	0.5
Nuts	0.8	1.6	16	25	1.9	0.6
Horticulture	19.7	42.4	902	1 114	49.2	15.7
Total	**95.9**	**238.1**	**1 513**	**3 050**	**291.9**	**83.1**

The largest contribution to the irrigation GDP is by cereal production followed by horticulture. In terms of direct employment in the zone, horticulture is the largest contributor (Table 7.6). Although two EWR sites namely EWR 2 and 4 are situated in the zone no operational scenarios were proposed for the zone

7.1.3 EZ3 Barage to Middle Vaal WMA

In the following tables the macroeconomic indicators of the Barrage to Middle Vaal Economic Zone are presented in the following table.

Table 7.7 EZ 3: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP (R Million)		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	57.9	0.2%	913	0.4%
Livestock and Game	136.6	0.4%	783	0.3%
Mining	3 615	11.1%	11 564	5.0%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	9 002	27.5%	31 789	13.7%
Light Industries	16 864	51.4%	162 482	70.1%
Services	3 111	9.5%	24 357	10.5%
Total	**32 708**	**100%**	**231 888**	**100%**

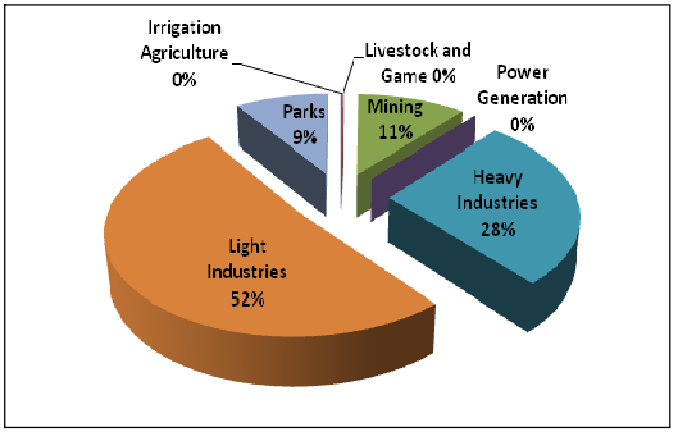


Figure 7.4 Contribution of different water user sectors to GDP

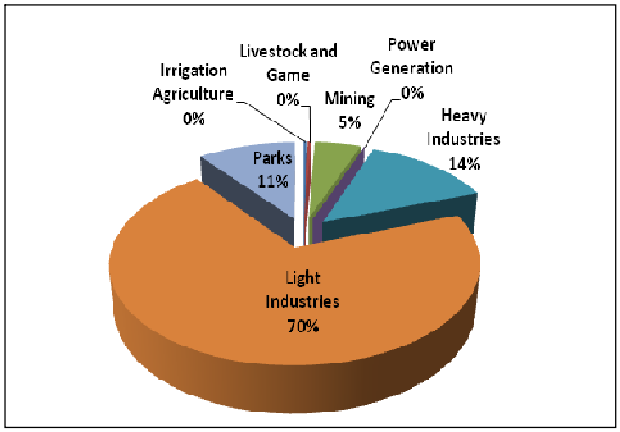


Figure 7.5 Contribution of different water user sectors to Employment

From Table 7.7 and Figures 7.4 and 7.5 it is clear that light industries are the largest contributors to GDP and employment in the zone, followed by heavy industries. The irrigation sector is very small in the specific zone representing only 0.2% of GDP and 0.4% of employment.

In Table 7.8 the contribution of individual irrigation crops are presented.

Table 7.8 EZ 3: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	42.5	109.8	334	1 085	136.5	37.9
Fodder and Grazing	2.6	6.4	13	52	8.0	2.1
Deciduous fruit	0.5	0.9	13	16	0.9	0.3
Nuts	0.5	1.0	10	15	1.1	0.3
Horticulture	11.9	25.6	544	672	29.7	9.5
Total	**57.9**	**143.7**	**913**	**1 841**	**176.2**	**50.2**

The irrigation sector is not very large, but still supports 913 direct employment opportunities and annually pays R 50.2 million to low-income households (Table 7.8). No operational scenario volumes were presented for evaluation in this economic zone.

7.2 TRIBUTARIES

7.2.1 EZ 4: Wilge

In the following tables the macroeconomic indicators of the Wilge Economic Zone are presented.

Table 7.9 EZ 4: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP (R. Mil.)		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	**101.4**	**2.2%**	**2 799**	**4.1%**
Livestock and Game	63.3	1.3%	2 692	3.9%
Mining	-	0.0%	-	0.0%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	-	0.0%	-	0.0%
Light Industries	3 775.1	80.4%	56 790	83.3%
Services	753.6	16.1%	5 899	8.7%
Total	**4 693.3**	**100%**	**68 179**	**100%**

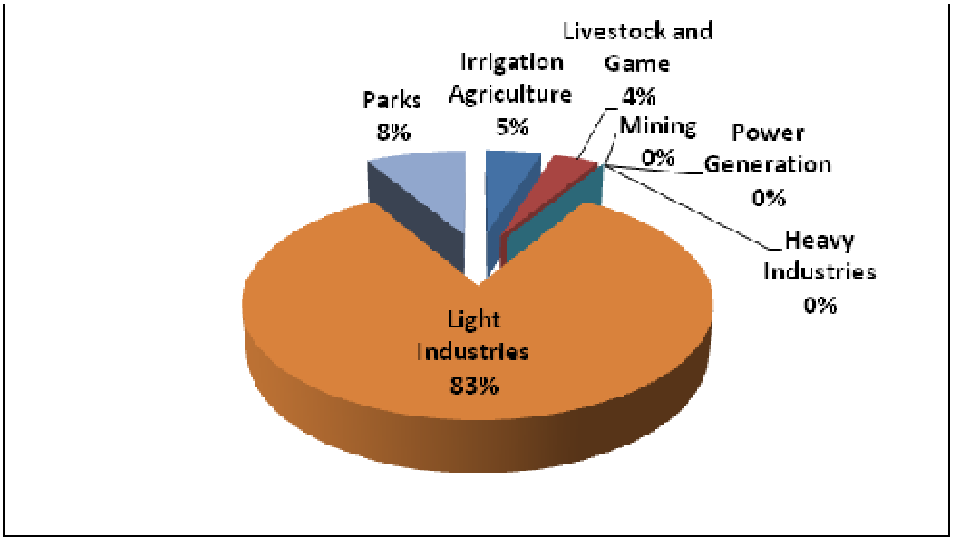


Figure 7.6 Contribution of different water using sectors to Employment

Table 7.9 and Figure 7.6 indicate that 83% of the 68 698 employment opportunities are supported by light industries and that irrigation agriculture supports 5% or 3 317 employment opportunities. Table 7.10 presents the contribution of the individual irrigation crops.

Table 7.10 EZ 4: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Individual crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	36.0	92.4	252	746	104.1	28.6
Fodder and Grazing Crops	6.3	15.4	31	124	18.8	5.1
Deciduous fruit	7.6	14.1	211	269	14.7	5.1
Nuts	2.2	4.5	43	69	5.1	1.6

Individual crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Horticulture	49.3	106.3	2 261	2 792	123.4	39.3
Total	**101.4**	**232.6**	**2 799**	**3 999**	**266.1**	**79.6**

Horticulture is by far the largest contributor to the irrigation sector GDP and employment. In the next table the macroeconomic impacts of Scenarios 7 and 8 are presented at EWR 8.

In the Wilge River tributary at site EWR 8 (Bavaria), the introduction of the EWR was calculated and it appears that the introduction of the EWR will not impact on the available irrigation water volume and therefore no economic impact is anticipated.

7.2.2 EZ 5: Klip River 1

In the following tables the macroeconomic indicators of the economic zone is presented with the analysis of the impacts of the future introduction of the operational EWR scenario.

Table 7.111 EZ 5: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	20.0	1.1%	340	1.5%
Livestock and Game	18.4	1.0%	1 493	6.4%
Mining	156.5	8.4%	500	2.1%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	-	0.0%	-	0.0%
Light Industries	1 366.1	73.5%	19 536	83.6%
Parks	297.2	16.0%	1 493	6.4%
Total	**1 858.1**	**100%**	**23 363**	**100%**

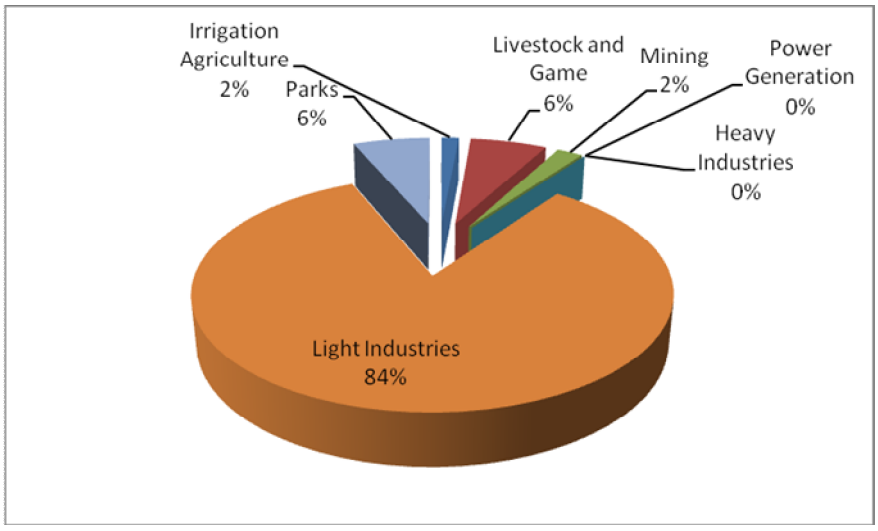


Figure 7.7 Contribution of different water using sectors to Employment

The light industry sector is the largest contributor to GDP and employment creation in the economic zone (Figure 7.7). Irrigation agriculture contributes 1.1% to the GDP and 1.5% the employment in the zone.

Table 7.12 presents the detailed macroeconomic contribution of the different irrigation crops.

Table 7.12 EZ 5: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Direct	Low
Cereals	10.3	25.9	64	202	28.7	7.9
Fodder and Grazing	2.7	6.7	14	54	8.3	2.2
Deciduous fruit	1.7	3.2	48	61	3.3	1.2
Nuts	1.1	2.4	23	36	2.7	0.8
Horticulture	4.2	9.0	191	236	10.4	3.3
Total	**20.0**	**47.2**	**340**	**590**	**53.4**	**15.4**

The irrigation sector is small with a GDP of only R20 million and 340 direct employment opportunities. Table 7.13 provides the macroeconomic impacts of the introduction of the operating scenario at EWR site 6.

Table 7.133 EZ 5: EWR 6 – Macroeconomic impacts of the operating scenarios on irrigation agriculture (2009 prices)

	Total GDP (R Mil)	Total Employment (Numbers)	Low Income HH (R Mil.)
	Values	Values	Values
Impact	R -0.57	-14	-R 0.21
Deviation	-1.34%	-2.61%	-1.49%

In the Klip River tributary at EWR 6, the macroeconomic impact of the introduction of the operating scenario will have a very small impact. The impact on the GDP is only R0.57 million, on employment only 14 jobs will be lost and the payments to low-income households will decrease by R0.21 million, representing respectively 1.34% of GDP, 2.61% of employment and 1.49% of payments to low-income households.

7.2.3 EZ 6: Waterval

In the following tables the macroeconomic indicators of the Waterval Economic Zone are presented.

Table 7.144 EZ 6: - Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	26.0	0.2%	578	0.7%
Livestock and Game	55.0	0.4%	428	0.5%
Mining	4 041	27.1%	12 925	15.5%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	3 416	22.9%	6 291	7.6%
Light Industries	5 725	38.3%	49 989	60.0%

Sectors	Direct GDP		Direct Labour	
	(Value)	(%)	(Number)	(%)
Services	1 667	11.2%	13 051	15.7%
Total	**14 929**	**100%**	**83 261**	**100%**

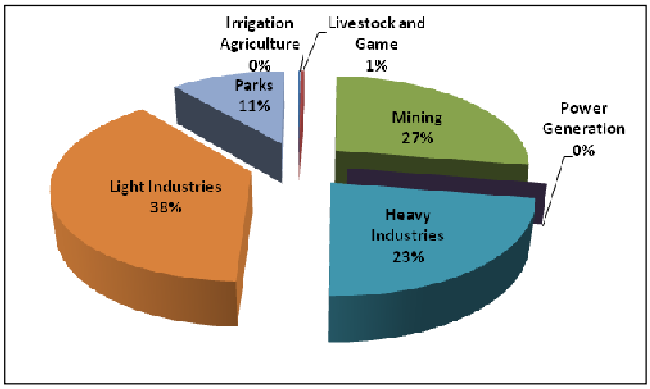


Figure 7.8 Contribution of different water user sectors to GDP

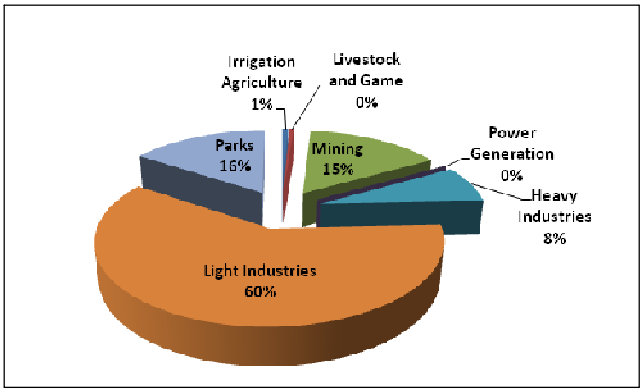


Figure 7.9 Contribution of different water user sectors to Employment

The light and heavy industrial sectors are the dominant features of EZ 6 representing 61% of the GDP and 68% of the employment opportunities. Mining is also important with 27% of the GDP and 15% of employment being supported (Table 7.15 and Figures 7.8 and 7.9). The irrigation sector is very small in the zone representing only 0.2% of GDP and 0.7% of employment.

In the next table the contribution of the different irrigation crops to the sector is presented.

Table 7.155 EZ 6: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	14.1	36.8	108	306	42.1	11.6
Fodder and Grazing	1.4	3.5	7	28	4.3	1.1
Deciduous fruit	0.8	1.4	21	27	1.5	0.5
Nuts	0.1	0.2	2	2	0.2	0.1
Horticulture	9.6	20.7	440	543	24.0	7.6
Total	**26.0**	**62.5**	**578**	**907**	**72.0**	**21.0**

The irrigation sector is relatively small with cereals and vegetable production being the most important crops (Table 7.15). Table 7.16 presents the macroeconomic impact of the introduction of the operating scenario for the specific EWR sites.

Table 7.166 EZ 6: (EWR WA1 and EWR WA2) – Macroeconomic impacts of the operating scenarios on irrigation agriculture (2009 prices)

	Total GDP (R Mil)	Total Employment (Numbers)	Low Income HH (R Mil.)
	Values	Values	Values
Impact	R -0.56	-15	-R 0.21
Deviation	-0.85%	-1.57%	-0.94%

In the Waterval River tributary at EWR WA1 and EWR WA2, the macroeconomic impact on the GDP will be R0.56 million or 0.85%, employment 15 or 1.57% and on payment to low-income households R.012 million or 0.94%. The introduction of the EWR will have a very small impact in this tributary.

7.2.4 EZ 7: Suikerbosrand/Blesbok

In the following tables the macroeconomic indicators of the Suikerbosrant/Blesbok Economic Zone are presented.

Table 7.17 EZ 7: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	43.1	0.1%	1 468	0.3%
Livestock and Game	80.4	0.2%	681	0.2%
Mining	6 496	15.0%	47 893	11.1%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	1 205	2.8%	4 780	1.1%
Light Industries	29 301	67.8%	328 014	76.2%
Services	6 113	14.1%	47 852	11.1%
Total	**43 238**	**100%**	**430 687**	**100%**

The table is an indication of the very important position of this economic zone in the economic picture of not only the Upper Vaal WMA, but also the rest of the country, with over 430 000 people employed and dependent on water.

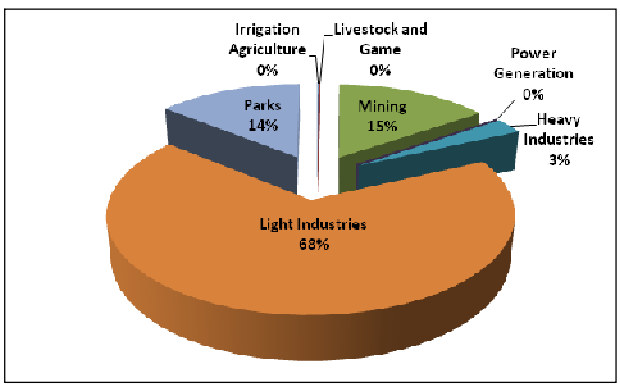


Figure 7.10 Contribution of different water using sectors to GDP

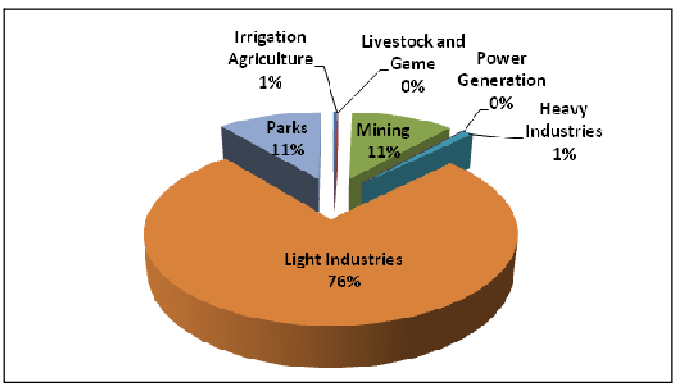


Figure 7.11 Contribution of different water using sectors to Employment

The Table 7.17 and Figure 7.10 and 7.11 shows very clearly the dominant position of the light industry sector in GDP and employment creation, namely 68% and 76% respectively. The contribution of the different irrigation crops are presented in Table 7.18.

Table 7.188 EZ 7: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	11.0	28.7	86	241	33.0	9.1
Fodder and Grazing Crops	2.2	5.2	12	42	6.2	1.7
Deciduous fruit	-	-	-	-	-	-
Nuts	0.1	0.2	2	3	0.2	0.1
Horticulture	29.8	64.3	1 368	1 689	74.7	23.8
Total	**43.1**	**98.4**	**1 468**	**1 975**	**114.1**	**34.6**

Vegetable production is the dominant crop with 1 368 employment opportunities and an annual payment of R34.6 million to low-income households. Although there are at least two EWR sites in the tributary no operational scenario volumes were presented for analysis purposes as the analysis show that sufficient water will be available after the introduction of the EWR.

7.2.5 EZ 8: Klip River 2

In the following tables the macroeconomic indicators for the Klip River 2 Economic Zone is presented.

Table 7.199 EZ 8: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP (R.Mil.)		Direct Labour	
	Value.	(%)	(Number)	(%)
Irrigation Agriculture	87.6	0.1%	3 292	0.2%
Livestock and Game	97.8	0.1%	114	0.0%
Mining	2 558	2.3%	23 247	1.4%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	395	0.4%	1 558	0.1%
Light Industries	90 382	81.2%	1 443 572	89.6%
Services	17 779	16.0%	139 182	8.6%
Total	**111 301**	**100%**	**1 610 966**	**100%**

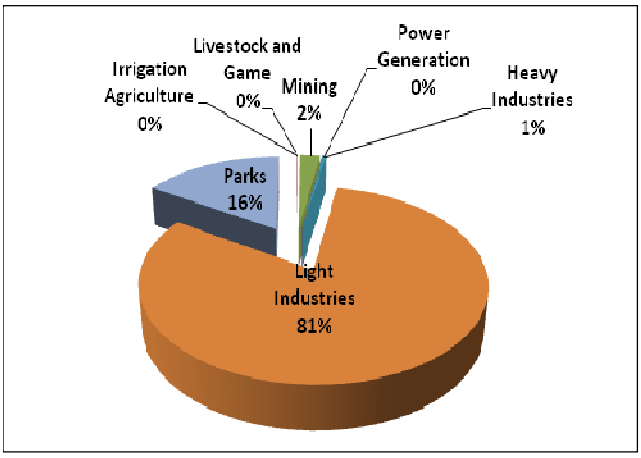


Figure 7.12 Contribution of different water user sectors to GDP

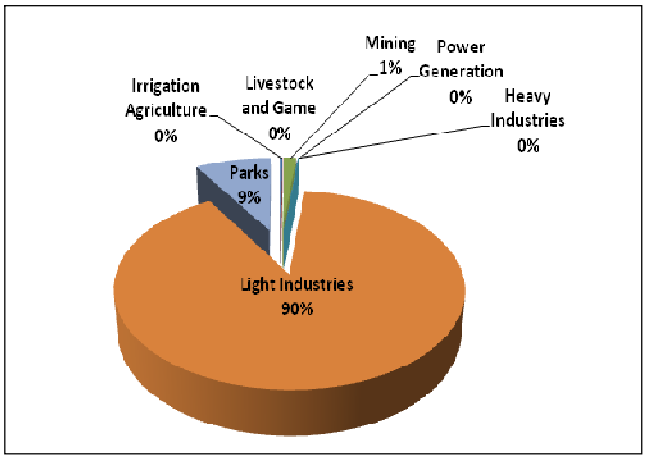


Figure 7.13 Contribution of different water user sectors to Employment

Table 7.19 is an indication of the important role of this economic zone in the Upper Vaal, providing employment to over 1.6 million people supported by the availability of water.

In the economic zone the light industry sector is very dominant with 81% of the GDP and 90% of the employment (Figures 7 12 and 7.13). In the next table the contribution of the different irrigation crops are presented (Table 7.20).

Table 7.20 EZ 8: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	14.0	36.0	99	292	40.7	11.2
Fodder and Grazing Crops	4.2	9.7	22	78	11.4	3.1
Deciduous fruit	0.7	1.3	19	24	1.3	0.5
Nuts	-	-	-	-	-	-
Horticulture	68.7	148.1	3 151	3 890	172.0	54.7
Total	**87.6**	**195.1**	**3 292**	**4 285**	**225.4**	**69.5**

Although irrigation is very limited in the total economic picture of the zone, it still supports 3 292 employment opportunities and has an annual payment of R69.5 million to low-income households. Vegetable production (horticulture) is the dominant crop followed by the cereals. No water data was presented to analyse as part of a possible operational EWR scenario.

7.2.6 EZ 9: Mooi River

In the following tables the macroeconomic indicators for the Mooi River Economic Zone is presented.

Table 7.211 EZ 9: Present state results of the main water sectors (2009 prices)

Sectors	Direct GDP		Direct Labour	
	(Value)	(%)	(Number)	(%)
Irrigation Agriculture	58.7	0.4%	1 164	0.6%
Livestock and Game	58.4	0.4%	1 362	0.7%
Mining	4 343.9	28.6%	37 997	20.2%
Power Generation	-	0.0%	-	0.0%
Heavy Industries	-	0.0%	-	0.0%
Light Industries	8 343.2	55.0%	128 660	68.6%
Parks	2 357.9	15.6%	18 458	9.8%
Total	**15 162.2**	**100%**	**187 641**	**100%**

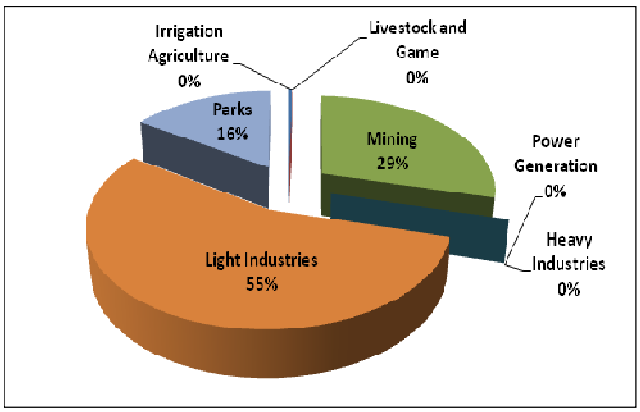


Figure 7.14 Contribution of different water user sectors to GDP

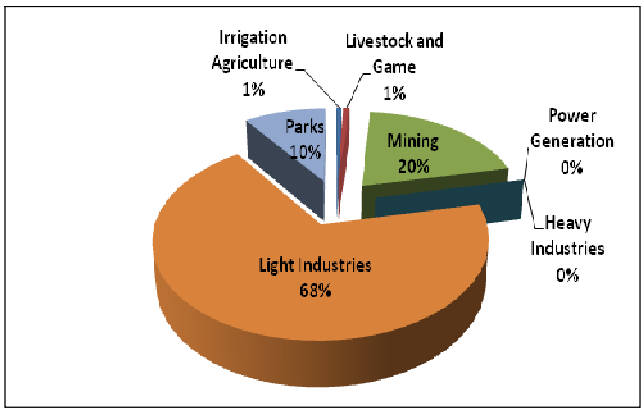


Figure 7.15 Contribution of different water user sectors to Employment

The light industry and mining sectors are the dominant sectors in the economic zone representing 84% of the GDP and 88% of the employment (Figure 7.14 and 7.15). In the next table the contribution of the different irrigation crops are disaggregated. The irrigation sector is relatively small representing only 0.4% of the GDP and 0.6% of the employment.

Table 7.222 EZ 9: Contribution of individual crops to the irrigation agriculture sector (2009 prices)

Crops	GDP (R Mil)		Employment (Numbers)		Household Income (R Mil)	
	Direct	Total	Direct	Total	Total	Low
Cereals	31.7	83.7	263	714	97.1	26.8
Fodder and Grazing Crops	8.4	19.1	45	154	22.1	6.1
Deciduous fruit	-	-	-	-	-	-
Nuts	-	-	-	-	-	-
Horticulture	18.7	40.2	856	1 057	46.7	14.9
Total	**58.7**	**143.1**	**1 164**	**1 925**	**166.0**	**47.7**

Vegetables and cereals are the two largest crops contributing 87% of the GDP and 93% of the employment opportunities.

No operational scenarios were presented for analysis as the present demand is fully supplied before and after the introduction of the EWR.

7.3 EVALUATION OF THE OPERATIONAL EWR SCENARIOS

In evaluating the impact of the scenarios it is necessary that it is done against the background of a number of factual realities and assumptions, namely:

- That the water demands at a specific EWR point is not representative of the total irrigation water use in the economic zone. However it gives a good indication of the situation in the rest of the zone.
- The multipliers used to calculate the impact at the specific point is calculated using the total irrigation activity in the zone, there is therefore a chance that the crop mix at the EWR point will differ from the mix in the total zone.
- The base irrigation water use is fixed in 2008 terms. It was assumed that the present crop mix would not change during the coming years.
- The impacts are based on the use of the total water per zone, without making a distinction between lawful and unlawful use.

In the following sections the impact of the operational scenarios are extrapolated to compare the macroeconomic impacts on the total economic zones and the WMA and not only the area around the EWR point.

Table 7.23 Comparison of the impact of Scenario 7 and 8 in all the Economic Zones of the Upper Vaal WMA

Economic Zone	GDP		Employment		Households	
	Base	EWR Impact	Base	EWR Impact	Base	EWR Impact
EZ 1. Main Stem Up to Grootdraai Dam	R 160.55	R -3.59	2271	-28	R 56.18	R -1.18
EZ 2. Main Stem - Grootdraai to Vaal Barrage	R 238.09	R 0.00	3050	0	R 83.12	R 0.00
EZ 3. Main Stem - Vaal Barrage to Middle Vaal WMA	R 143.69	R 0.00	1841	0	R 50.16	R 0.00
EZ 4. Wilge Tributary	R 232.61	R 0.00	3999	0	R 79.63	R 0.00
EZ 5. Klip 1 Tributary	R 47.19	R -0.63	590	-15	R 15.39	R -0.23
EZ 6. Waterval Tributary	R 66.50	R -0.57	942	-15	R 22.25	R -0.21
EZ 7. Suikerbosrand Tributary	R 98.45	R 0.00	1975	0	R 114.10	R 0.00
EZ 8. Klip 2 Tributary	R 195.08	R 0.00	4285	0	R 69.50	R 0.00
EZ 9. Mooi Tributary	R 143.13	R 0.00	1925	0	R 47.73	R 0.00
Total	**R 1 325.29**	**R -4.79**	**20877**	**-59**	**R 538.07**	**R -1.62**

From Table 7.23 it appears that Scenario 8 is only impacting on three of the nine economic zones and that the projected impact on the three economic zones will be very small. With a possible 59 jobs lost compared to a total employment of over 20 000 in the sector.

However, it is important to keep in mind that although irrigation agriculture is not a very important sector in the WMA, it still contributes to food security with over 40 000 irrigated hectares in grain production and overall it supports 20 877 employment opportunities, mostly in the rural areas. The grain (cereal) production is a mix of maize, wheat and grain sorghum, with maize and grain sorghum production in the summer, followed by wheat during the winter.

The present water situation in the Suikerbosrand and Klip River 2 tributaries prevents the formulation of any operational scenarios for analysis.

The weakness of the specific methodology used is that it only gives an overall picture of the impact with no indication of an impact on an individual irrigator.

8 REFERENCES

Department of Water Affairs and Forestry, South Africa (DWAF). 2004. Upper Vaal Water Management Area: Internal Strategic Perspective. Prepared by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning. DWAF Report No P WMA 08/000/00/0304.

Department of Water Affairs (DWA), 2010a. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Water Resource Modelling Report. Report produced by DMM Development Consultants/Hydrosol/WRP Consulting Engineers. Report no: RDM/ C000/01/CON/0607.