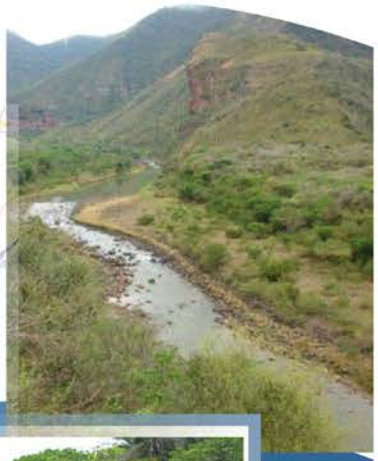
REPORT NO: RDM/WMA11/00/CON/CLA/1014

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

PROJECT NUMBER: WP 10679

VOLUME 5: CONSEQUENCES OF OPERATIONAL SCENARIOS ON ECOSYSTEM SERVICES

NOVEMBER 2014



water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

RfA17_2014

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

VOLUME 5: CONSEQUENCES OF OPERATIONAL SCENARIOS ON ECOSYSTEM SERVICES

Report Number: RDM/WMA11/00/CON/CLA/1014

NOVEMBER 2014

REFERENCE
This report is to be referred to in bibliographies as:
Department of Water and Sanitation, South Africa, November, 2014. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 5: Consequences of Operational Scenarios on Ecosystem Services. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Greg Huggins.

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DEPARTMENT OF WATER AND SANITATION

CHIEF DIRECTORATE: WATER ECOSYSTEMS

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

VOLUME 5: CONSEQUENCES OF OPERATIONAL SCENARIOS ON ECOSYSTEM SERVICES

Approved for RFA by:

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Date

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REPORT SCHEDULE

Version	Date	Comments received on
First draft	*November 2014*	*20 February 2015*
Final	*April 2015*	

EXECUTIVE SUMMARY

BACKGROUND

The Chief Directorate: Water Ecosytems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2012 for the provision of professional services to undertake the Comprehensive Reserve, classify all significant water resources and determine the Resource Quality Objectives (RQOs) in the Mvoti to Umzimkulu Water Management Area (WMA). Rivers for Africa was appointed as the Professional Service Provider (PSP) to undertake this study.

*This report forms **part** of the outcomes of Step 4 within the integrated approach (DWA, 2012). The objective of this task was to provide the scenario analysis, assumptions and results and document the consequences of the scenarios for the various components under Task D4 which are provided as seven report volumes under Report 8. All the report volumes apart from report 8.7 are supporting information that feeds into Report 8.7 and will integrate all this information to derive at Water Resource Classes for the various scenarios.*

The purpose of this report is to describe and document the Ecological Goods and Services Attributes (EGSA) responses to the scenarios.

METHOD

An ecosystem services analysis of multiple sites along the Lovu, Mvoti, uMngeni and uMkhomazi Rivers was undertaken. This included a profile of ecosystem services associated with each site, keeping in mind they represent a wider area, and thereafter assessed against the planning scenarios applicable to the site.

Specifically an analysis of the Ecological Water Requirement (EWR) sites on the Lovu River, uMngeni, the three EWR sites on the uMkhomazi and Mv_I_EWR2 on the Mvoti was undertaken. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. A list of the relevant ecosystem services that were found in the various reaches examined, and deemed to be significant, was generated as a table. These were cross checked with the biophysical experts that formed part of the project team at a specialist workshop held in 2014.

The biophysical specialists then identified the potential change that each of the key ecosystem services may undergo in each of the scenario clusters. The potential change will be noted as a factor and used in later calculations. For example, no change = 1, a 50% increase = 1.5, and a 20% decrease = 0.8.

The scenario impact on various ecosystem services (including botanical or fish species) were then amalgamated into overall categorisation of provisioning, regulating, cultural, and supporting services. The scenarios are also weighted with respect to the importance of the services at each EWR site. As such the score given to each of the services when the Sub Quaternary catchments (SQs) are evaluated is examined against the nature of the particular EWR site and associated area. In an instance where regulating services, for example are deemed to be important, then these services are given a higher weight. The same goes for the other services. All weightings are normalised against a base score of 1. Where all four services are deemed to be of equal importance then a score of 0.25 would be allocated to each.

The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites. Here the perceived vulnerability of households dependent on the provisioning aspect of ecosystem services played a major role. Again all scores are normalised against a base score of 1.

RESULTS

For the Mvoti River all scenarios considered were deemed to be positive. For the Mvoti estuary Scenario Group B and D were negative with the others either neutral or positive. For the Lovu River all scenarios were either neutral or marginally positive. The same applies to the uMngeni system. For the uMkhomazi River Scenario (Sc) MK21 was marginally positive, while Sc MK22, MK32 and MK42 were marginally negative. Scenario MK2 was the most negative. For the estuary Scenario Group A (Sc 2 and 4 in terms of river assessment) were negative while Scenario Group Sc C (Sc2 2, 23 and 42 in terms of the river assessment), D (Sc 31 in terms of river assessment), and E (Sc 32, 33 in terms of the river assessment) were considered to be largely neutral. Scenario Group B (Sc 21 and 41) + modification and G and H were positive.

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TERMINOLOGY AND ACRONYMS

CD: WE	*Chief Directorate: Water Ecosystems*
DWA	*Department Water Affairs (Name change from DWAF applicable after April 2009)*
DWAF	*Department Water Affairs and Forestry*
DWS	*Department Water and Sanitation (Name change from DWA applicable after May 2014)*
EGSA	*Ecological Goods and Services Attributes*
ESS	*Ecosystems Services*
EWR	*Ecological Water Requirement*
GIS	*Geographic Information System*
MEA	*Millennium Ecosystems Assessment*
MWP	*Ngwadini Off-channel Dam*
OCD	*Off-channel Dam*
PSP	*Professional Service Provider*
REC	*Recommended Ecological Category*
RQO	*Resource Quality Objective*
Sc	*Scenario*
SCI	*Socio Cultural Importance*
SQ	*Sub Quaternary*
WMA	*Water Management Area*
WWTW	*Waste Water Treatment Works*

1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2012 for the provision of professional services to undertake the Comprehensive Reserve, classify all significant water resources and determine the Resource Quality Objectives (RQOs) in the Mvoti to Umzimkulu Water Management Area (WMA). Rivers for Africa was appointed as the Professional Service Provider (PSP) to undertake this study.

1.2 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the National Water Classification System, the Reserve and RQOs are supplied in Table 1.1.

Table 1.1 Integrated study steps

Step	Description
1	*Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s) (completed).*
2	*Initiation of stakeholder process and catchment visioning (on-going).*
3	*Quantify the Ecological Water Requirements and changes in non-water quality ecosystem goods, services and attributes.*
4	**Identify and evaluate scenarios within the integrated water resource management process.**
5	*Evaluate the scenarios with stakeholders and determine Water Resource Classes.*
6	*Develop draft RQOs and numerical limits.*
7	*Gazette and implement the class configuration and RQOs.*

*This report forms **part** of the outcomes of Step 4 (red above) within the integrated approach (DWA, 2012). The objective of this task was to provide the scenario analysis, assumptions and results and document the consequences of the scenarios for the various components under Task D4 which are provided as seven report volumes under Report 8. All the report volumes apart from report 8.7 are supporting information that feeds into Report 8.7 and will integrate all this information to derive Water Resource Classes for the various scenarios.*

The purpose of this report is to describe and document the consequences of the operational scenarios on Ecosystem Services (ESS) in the Mvoti, uMngeni, Lovu and uMkhomazi catchments. This report presents the approach and methodology used to evaluate the different operational scenarios as well as the results obtained in terms of economic variables.

1.3 REPORT STRUCTURE

The report outline is provided below.

Chapter 1: Introduction
This Chapter provides general background to the project Task.

Chapter 2: Background
This Chapter provides a summary of the different scenarios assessed.

Chapter 3: Approach and Methodology

This chapter provides the approach used during this study to determine the ESS consequences of the operational scenarios.

Chapter 4: Results

The results of the different operational scenarios for each of the catchments are presented in terms of the ESS values as assessed.

Chapter 5: References

Chapter 6: Appendix A: Report Comments

Comments from the Client are provided.

2 BACKGROUND

2.1 INTRODUCTION

The main aim of the scenario (Sc) evaluation process is to determine the appropriate balance between the level of environmental protection and the use of the water to sustain the status quo socio-economic activities. Once the preferred scenario has been selected the Water Resource Class is defined by the level of environmental protection embedded in that scenario.

There are three main variables to consider in this integration process, namely the Ecology, Ecosystem Services and the Economic benefits obtained from the use of a portion of the water resource. The scenario evaluation process therefore estimates the consequences each scenario from a plausible set of scenarios will have on these variables. The evaluation process uses the quantification of selected metrics to compare the scenarios on a relative basis with one another.

2.2 CATCHMENTS AND SCENARIOS

The investigation focused on the impact of the different operational scenarios in the following four catchments:

- *Mvoti.*
- *Lovu,*
- *uMkhomazi, and*
- *uMngeni*

In the following paragraphs the different operational scenarios are presented.

2.2.1 uMkhomazi River Catchment

Table 2.1 provides a summary of the operational scenarios identified for the Mkomazi catchment. Detail regarding the scenarios and the yield modelling is supplied in Report 7 (DWS, 2014a).

Table 2.1 Scenarios for ESS consequences determination: uMkhomazi River

Scenarios	Scenario Variables					EWR Drivers		
	Update water demands	Ultimate development demands and return flows (2040)	EWR[1]	Mkomazi Water Project (MWP) (Smithfield Dam)	Ngwadini Off-channel Dam (OCD)	Mk_I_EWR1	Mk_I_EWR2	Mk_I_EWR3
MK1	Yes	No	No	No	No	Yes	Yes	Yes
MK2	Yes	Yes	No	Yes	Yes (no support)	Yes	Yes	Yes
MK21	Yes	Yes	REC tot[2] (EWR 2)	Yes	Yes (no support)	Yes	Yes	Yes
MK22	Yes	Yes	REC low (EWR 2)	Yes	Yes (no support)	Yes	Yes	Yes
MK23	Yes	Yes	REC low[3]+ (EWR 2)	Yes	Yes (no support)	Yes	Yes	Yes
MK31	Yes	Yes	REC tot (EWR 3)	Yes	Yes (no support)	Yes	Yes	Yes
MK32	Yes	Yes	REC low (EWR 3)	Yes	Yes (no support)	Yes	Yes	Yes
MK33	Yes	Yes	REC low+ (EWR 3)	Yes	Yes (no support)	Yes	Yes	Yes

Scenarios	Scenario Variables					EWR Drivers		
	Update water demands	Ultimate development demands and return flows (2040)	EWR[1]	Mkomazi Water Project (MWP) (Smithfield Dam)	Ngwadini Off-channel Dam (OCD)	Mk_I_EWR1	Mk_I_EWR2	Mk_I_EWR3
MK4	Yes	Yes	No	Yes	Yes (with support)	Yes	Yes	Yes
MK41	Yes	Yes	REC tot (EWR 2)	Yes	Yes (with support)	Yes	Yes	Yes
MK42	Yes	Yes	REC low (EWR 2)	Yes	Yes (with support)	Yes	Yes	Yes

1 Ecological Water Requirement.
2 Total Recommended Ecological Category (REC) requirements.
3 Based on total flows for January, February, March and low flows for remaining months.

Scenario MK2, MK21, MK22, MK31, MK32, MK4, MK41 and MK42 were evaluated at MK_I_EWR1 and MK_I_EWR2. At all the EWR sites, the analysis of the operational scenarios indicated that Sc MK22 was similar to Sc MK23 and Sc MK32 was similar to Sc MK33 and no distinguishable ESS responses could be differentiated. Therefore Sc MK22 and Sc MK32 represent these scenarios respectively at the EWR sites.

Scenario MK2, MK21, MK22, MK32 and MK42 were evaluated at MK_I_EWR3. The analysis of the operational scenarios indicated that the following scenarios were similar and no distinguishable ecological responses could be differentiated:

- *Sc MK2 was similar to Sc MK4.*
- *Sc MK21 was similar to Sc MK31 and Sc MK41.*
- *Sc MK22 was similar to Sc MK23.*
- *Sc MK32 was similar to Sc MK33*

Therefore Sc MK2, MK21, MK22 and MK32 represent these scenarios respectively.

uMkhomazi Estuary:

Detail regarding the scenarios will be supplied in Report 8.2 (DWS, 2014b, in progress). For the purposes of analysis scenarios were grouped according to similarity or management options as follows:

- *Scenario Group A: Sc MK2 and MK4.*
- *Scenario Group B: Sc MK21 and MK41.*
- *Scenario Group C: Sc MK22, 23 and MK 42.*
- *Scenario Group D: Sc MK31.*
- *Scenario Group E: Sc MK32 and MK33.*
- *Scenario Group F: Group B (Sc MK21 and MK42) and a WWTW.*
- *Scenario Group G: Group B (Sc MK21 and MK42)*
- *Scenario Group H: Group B (Sc MK21 and MK42) in conjunction with a number of management interventions).*

2.2.2 Lovu River Catchment

Table 2.2 provides a summary of the operational scenarios identified for the Lovu catchment. Detail regarding the scenarios and the yield modelling is supplied in Report 7 (DWS, 2014a).

Table 2.2 Scenarios for ESS consequences determination: Lovu River

Scenario	Scenario Variables			EWR Drivers
	Update water demands	Ultimate development demands and return flows (2040)	Reduced abstraction and afforested areas	Lo_R_EWR1
LO1	Yes	No	No	Yes
LO2	Yes	Yes	No	Yes
LO3	Yes	Yes	Yes (25%)	Yes
LO4	Yes	Yes	Yes (50%)	Yes

Scenario LO3 and LO4 were evaluated at LO_R_EWR1. Scenario LO2 was very similar to Sc LO1 with slightly (marginally) lower flows and overall similar to Sc LO1.

2.2.3 Mvoti Catchment

Table 2.3 provides a summary of the operational scenarios identified for the Mvoti catchment. Detail regarding the scenarios and the yield modelling is supplied in Report 7 (DWS, 2014a).

Table 2.3 Scenarios for EGSA determination: Mvoti River

Scenarios	Scenario Variables					EWR Drivers	
	Update water demands	Ultimate development demands and return flows (2040)	EWR	Isithundu Dam	Imvutshane Dam	Mv_I_EWR1	Mv_I_EWR2
MV1	Yes	No	No	No	No	Yes	Yes
MV3	Yes	Yes	No	Yes	Yes	Yes	Yes
MV41	Yes	Yes	REC tot (EWR 2)	Yes	Yes	No	Yes
MV42	Yes	Yes	REC low (EWR 2)	Yes	Yes	No	Yes
MV43	Yes	Yes	REC low[1]+ (EWR 2)	Yes	Yes	No	Yes

1 Based on total flows for Jan - Mar and low flows for remaining months.

There were no impacts on the Heinespruit (Mv_1_EWR1) and impacts on the scenarios at this site were not evaluated. Scenario MV3, MV42 and MV43 were evaluated at MV_I_EWR2. Scenario MV1 and MV41 were not evaluated as they are similar to PD.

Mvoti Estuary

Detail regarding the scenarios will be supplied in Report 8.2 (DWS, 2014b, in progress). For the purposes of analysis scenarios were grouped according to similarity or management options as follows:

- *Scenario Group A: Sc MV21, MV22 and MV41.*
- *Scenario Group B: Sc MV3.*
- *Scenario Group C: Sc MV42 and MV43.*
- *Scenario Group D: Sc Mv 5 (sensitivity testing scenario)*
- *Scenario Group E: Is based on the freshwater inflow simulated for Scenario Group A (MV 21, MV22 and MV41) in conjunction with the following management interventions:*
  - *Remove the organics from the Sappi effluent to improve oxygen levels in the estuary;*
  - *Reduce the nutrient input from the catchment by 20% to control growth of reeds and aquatic invasive plants; and*

- *Remove the sugarcane from the Estuary Functional Zone (below 5 m contour) to allow for a buffer against human disturbance and the development of a transitional vegetation ecotone between estuarine and terrestrial ecosystems.*

2.2.4 uMngeni Catchment

Table 2.4 provides a summary of the operational scenarios identified for the uMngeni catchment. Detail regarding the scenarios and the yield modelling is supplied in Report 7 (DWS, 2014a).

Table 2.4 Scenarios for ESS consequences determination: uMngeni River

Scenarios	Scenario Variables								EWR Drivers	
	Update water demands	Demands and return flows (2023)	Ultimate development demands and return flows (2040)	EWR	MMTS2	MWP	Darvill Re-use	EThekwini Re-use	Mg_I_EWR2	Mg_I_EWR5
UM1	Yes	No	No	No	No	No	No	No	Yes	Yes
UM2	No	Yes	No	No	Yes	No	No	No	Yes	Yes
UM41	Yes	No	Yes	No	Yes	Yes	No	No	Yes	Yes
UM42	Yes	No	Yes	No	Yes	Yes	No	No	Yes	Yes
UM51	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
UM52	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

Scenario MG2 and MG41 were evaluated at MG_I_EWR2. The analysis of the operational scenarios indicated that Sc MG41 was similar to Sc MG42, MG51 and MG52 and no distinguishable ecological responses could be differentiated. Scenario MG41 and MG51 were evaluated at MG_I_EWR5.

3 APPROACH AND METHODOLOGY

3.1 OVERVIEW OF ECOLOGICAL GOODS AND SERVICES ATTRIBUTES AND THEIR VALUES

The Mvoti to Umzimkulu Water Management Area (WMA 11) is one of four major WMAs located within KwaZulu-Natal, with an estimated total area of 34,966km^2, or 37% of the total area of the province. It also covers seven district municipalities, notably the eThekwini Metropolitan and the uMgungundlovu District Municipalities, the economic and administrative heartlands of KwaZulu-Natal.

WMA11 contains a number of major river systems including the Mvoti, Tongaat, Mdloti, uMngeni, Mkomazi and Umzimkulu Rivers. The uMngeni River in particular functions are the main source of water for the Durban to Pietermaritzburg area, with a number of fully regulated large dams such as Midmar, Inanda, Albert Falls and Nagle Dams. Other river systems in WMA 11 vary in terms of the level of development and rivers such as the Mkomazi and Umzimkulu remain largely undeveloped (DWAF, 2004)

Based on Census 2011, a total population of just under 7 million individuals are located in the WMA 11 area. The average population density is 166 individuals per square kilometre (km^2). The spatial distribution of this population shows a sharp transition from low density rural populations with limited development to high density urban environments where water is largely sourced from formal systems.

In terms of generating data for this report the most important step was to provide and integrated assessment of the current population of all three areas. Analysis was undertaken using four primary tools. These were:

- *The 2011 census data.*
- *Geographic Information System (GIS) overlays of quaternary catchments and the census "sub place name" data. "Sub place name" data fields are the most detailed subsets of data released by Statistic South Africa. This allows for the population for each quaternary to be calculated and a profile of the population for each unit to be analysed. Data was analysed to select areas in which populations likely to be dependent on riverine goods and services were possibly or probably present.*
- *Cross checking of the GIS data sets with available mapping to determine likely livelihood styles and profiles.*
- *Limited site visits to likely "hot spots".*

A second level of analysis based on the typology of settlements in the area and their likely associated dependence on goods and services for livelihoods was undertaken for this report. This was sourced from information available from Statistics South Africa and cross referenced with an examination of aerial photography, largely that provided by Google Earth. This allowed for an analysis of land use types associated with the settlement typology.

Further, each quaternary catchment of the Mvoti to Umzimkulu WMA has been examined in detail via the analysis of socio-cultural importance. The Socio Cultural Importance (SCI) was determined from (a) a site visit that covered points along the river, (b) extrapolation to sites not visited by reference to available literature as well as to exiting mapping. Given the size of the budget and the geographical scope of the work most of the information used to influence the score was derived

from direct observation and consideration of the literature available. A limited number of direct interviews were held with people who are resident proximate to the river

WMA 11, because of the nature of the communities that it intersects, plays an important role in maintaining important ESS to both on-site as well as other users. EGSA are also often called ESS. Natural habitats and ecosystems such as rivers, wetlands and estuaries provide a range of goods and services that contribute to human well-being. Their value to society depends both on the structure and functioning of the ESS in question, which determines their capacity to supply useful services, and on their socio-economic context, which determine the demand for those services. As such an Ecosystem Service is a product that emerges from processes or features within largely natural environments, which enhances human wellbeing and is directly used by people.

The value provided by ESS is usually described in terms of the Total Economic Value framework, which breaks values into direct use, indirect use, option and non-use values.

Direct use values associated with ESS can be derived from consumptive use (such as fishing, hunting and the harvest of plant resources) or non-consumptive use (such as photographic tourism). Grazing by livestock, harvesting medicinal plants and animals, and harvesting indigenous or endemic plants for roadside sale constitute productive activities whose economic values are realised in the form of profits from sale of final goods such as livestock, medicinal services, and the natural resources themselves.

Indirect-use values are derived from ecosystem functions such as production of nutrients, maintenance of well-functioning riverine ecosystems, water purification, maintenance of specific gaseous qualities and hydrological cycles, and formation of soil and organic matter. These values do not accrue directly to users but support direct use by people. Very important in the context of the Mvoti to Umzimkulu WMA is the capacity of a water body to assimilate or dilute wastes. This represents a real economic value when the costs of water-quality impacts are considered.

Option values are values attached by individuals to the maintenance and preservation of environmental goods in order to reserve an option to use them, directly or indirectly, in the future. A different notion of option value known as vicarious value relates to creating use options for contemporary generations. Value is not derived from use but from creating an option for use by others in the same generation.

Non-use value is the value derived from knowing that something exists, and can be realised in monetary terms.

For the purposes of this report and in order to analyse the ESS within a scenario context the Millennium Ecosystems Assessment (MEA) approach was largely followed. The MEA approach partitions ESS into four broad categories:

- *Provisioning services are the most familiar category of benefit, often referred to as ecosystem 'goods', such as foods, fuels, fibres, bio-chemicals, medicine, and genetic material, that are in many cases: directly consumed; subject to reasonably well-defined property rights (even in the case of genetic or biochemical material where patent rights protect novel products drawn from ecosystems); and are priced in the market.*
- *Cultural services are the less familiar services such as religious, spiritual, inspirational and aesthetic well-being derived from ecosystems, recreation, and traditional and scientific knowledge that are: mainly passive or non-use values of ecological resources (non-*

consumptive uses); that have poorly-developed markets (with the exception of ecotourism); and poorly-defined property rights (most cultural services are regulated by traditional customs, rights and obligations); but are still used directly by people and are therefore open to valuation.

- *Regulating services are services, such as water purification, air quality regulation, climate regulation, disease regulation, or natural hazard regulation, that affect the impact of shocks and stresses to socio-ecological systems and are: public goods (globally in the case of disease or climate regulation) meaning that they offer non-exclusive and non-rival benefits to particular communities; and are thus frequently undervalued in economic markets; many of these are indirectly used being intermediate in the provision of cultural or provisioning services.*
- *Supporting services are an additional set of ESS referred to in the MEA, such as nutrient and water cycling, soil formation and primary production that captures the basic ESS functions and processes that underpin other services.*

3.2 METHOD

An ESS analysis of multiple sites along the Lovu, Mvoti, uMngeni and uMkhomazi Rivers was undertaken. This included a profile of ESS associated with each site, keeping in mind they represent a wider area, and thereafter assessed against the planning scenarios applicable to the site.

Specifically an analysis of the EWR sites on the Lovu River, uMngeni, the three EWR sites on the uMkhomazi and Mv_I_EWR2 on the Mvoti was undertaken. ESS associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. A list of the relevant ESS that were found in the various reaches examined, and deemed to be significant, was generated as a table. These were cross checked with the biophysical experts that formed part of the project team at a specialist workshop held during 2014.

The biophysical specialists then identified the potential change that each of the key ESS may undergo in each of the scenario clusters. The potential change will be noted as a factor and used in later calculations. For example, no change = 1, a 50% increase = 1.5, and a 20% decrease = 0.8.

The scenario impact on various ESS (including botanical or fish species) were then amalgamated into overall categorisation of provisioning, regulating, cultural, and supporting services. The scenarios are also weighted with respect to the importance of the services at each EWR site. As such the score given to each of the services when the sub quaternary (SQ) catchments are evaluated is examined against the nature of the particular EWR site and associated area. In an instance where regulating services, for example are deemed to be important, then these services are given a higher weight. The same goes for the other services. All weightings are normalised against a base score of 1. Where all four services are deemed to be of equal importance then a score of 0.25 would be allocated to each.

The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites was undertaken for the uMkhomazi where multiple sites were considered. Here the perceived vulnerability of households dependent on the provisioning aspect of ESS played a major role. Again all scores are normalised against a base score of 1.

4 RESULTS

4.1 MVOTI RIVER SYSTEM

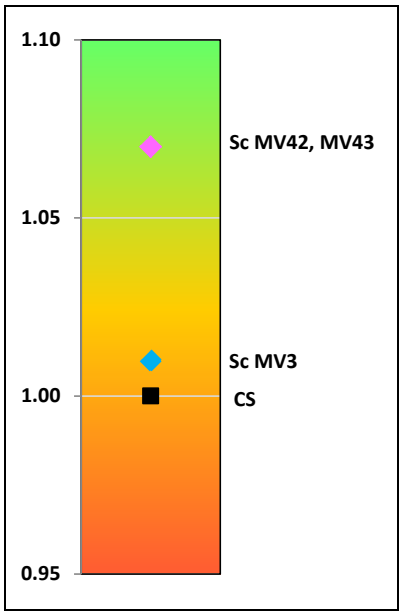
4.1.1 MV_I_EWR 2: Mvoti River

Given the relatively high abundance of natural resources and the moderate and high utilisation of these resources, the provisioning services are given the highest weighting of 0.35. Both regulating and cultural services are provided an equal weighting of 0.25. Supporting services are given the lowest weighting of 0.15.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (See Table 4.1). Scenario MV42 and Sc MV43 are considered as equivalent in terms of the impact on ESS including an improvement in riparian vegetation growth, water quality, waste dilution and groundwater recharge. Scenario MV3 shows some potential reduction in provisioning services, but an improvement in regulating services around flood regulation from stabilised baseflows. Results are presented in Figure 4.1 below.

Table 4.1 Mvoti River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MV_I_EWR2

Service	Sc MV3	Sc MV42	Sc MV43	Weight
Provisioning services	*0.97*	*1.02*	*1.02*	*0.35*
Regulating services	*1.02*	*1.22*	*1.22*	*0.25*
Cultural services	*1.00*	*1.00*	*1.00*	*0.25*
Supporting services	*1.10*	*1.05*	*1.05*	*0.15*
Score	**1.01**	**1.07**	**1.07**	**1.00**



CS = Current state

Figure 4.1 Integrated scenario results for the Mvoti River

4.1.2 Mvoti Estuary

The Mvoti Estuary provides limited provisioning services with respect to fish but has a moderate abundance of riparian vegetation which is underutilised. Hence, provisioning services is given a

value of 0.2. The estuary provides moderate levels of regulating services, specifically flood attenuation, storm control, sediment supply to beach; but also have elevated levels of water-borne diseases (bilharzia and cholera). Hence regulating services are given the highest weighting of 0.4. The estuary provides limited cultural services with the exception of ritual uses. Recreational fishing and birding is limited. Hence cultural services are given a weighting of 0.3.

Scenarios, where the PES EWRs are reduced by 5 and 15% show a commensurate drop in ESS (Table 4.2). The reduction is likely in provisioning, regulating and cultural services. Provisioning services are likely impacted by the reduction in fish abundance, while there is likely to be reductions in regulating services associated with flood attenuation and increases in water-borne diseases. Cultural services, related to aesthetic value, ritual use and birding is likely to be reduced.

The maintenance of the PES with a reduction in organics will see improvements in provisioning, regulating and cultural services (Table 4.2). This includes greater abundance of fish species, reduction in water-borne diseases and improved cultural services. Results are presented in Figure 4.2 below.

Table 4.2 Mvoti River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at the Mvoti Estuary

Service	PES (A+C)[1]	B (-5%)[2]	D (-15%)[3]	A+C-Organics[4]	Weight
Provisioning services	*1.00*	*0.98*	*0.93*	*1.16*	*0.2*
Regulating services	*1.00*	*0.89*	*0.78*	*1.16*	*0.4*
Cultural services	*1.00*	*0.88*	*0.55*	*1.55*	*0.3*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*0.1*
Score	**1.00**	**0.92**	**0.78**	**1.26**	**1.0**

1 Refer to Section 2.2.3 for outline of scenario grouping.
2 PES EWRs are reduced by 5%.
3 PES EWRs are reduced by 15%.
4 The maintenance of the PES with a reduction in organics undr Scenario Group A and C.

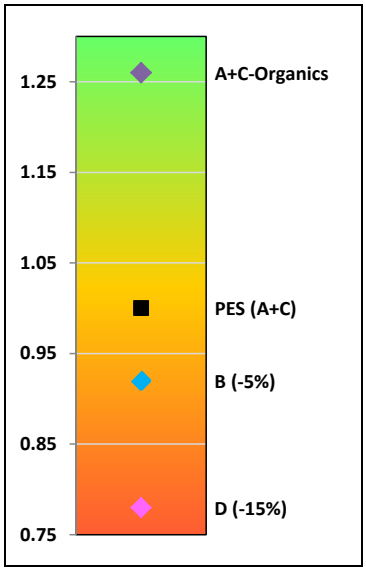


Figure 4.2 Integrated scenario results for the Mvoti Estuary

4.2 LOVU RIVER SYSTEM

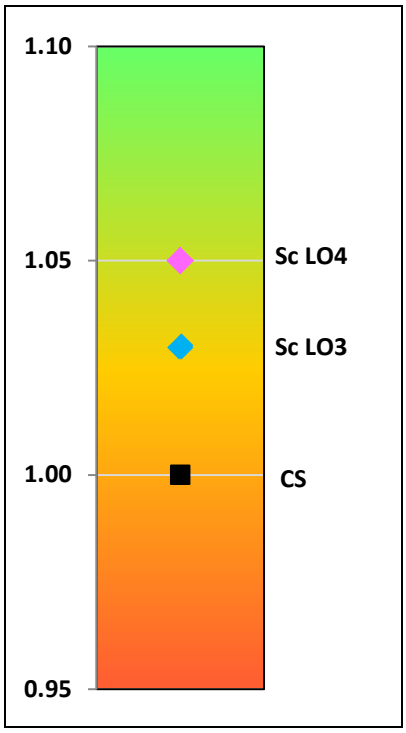
4.2.1 LO_I_EWR1: Lovu River

This site has a moderate abundance of provisioning resources and moderate utilisation by local people, thus provisioning services are given the highest weighting of 0.4. Cultural service is weighted as 0.3 due to the utilisation of the river for recreational and subsistence fishing. Regulating and supporting services is given a weighting of 0.2 and 0.1 respectively.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (Table 4.3). Both Sc LO3 and Sc LO4 show improvements in provisioning and regulating services, while Sc LO4 is the higher of the two. This is attributed to the improvements in river fish abundance as well as improvements in waste assimilation and dilution. There is no expected change in cultural and supporting services for either of the two scenarios. Results are presented in Figure 4.3 below.

Table 4.3 Lovu River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at LO_R_EWR1

Service	Sc LO3	Sc LO4	Weight
Provisioning services	*1.05*	*1.07*	*0.40*
Regulating services	*1.05*	*1.12*	*0.20*
Cultural services	*1.00*	*1.00*	*0.30*
Supporting services	*1.00*	*1.00*	*0.10*
Score	**1.03**	**1.05**	**1.00**



CS = Current state

Figure 4.3 Integrated scenario results for the Lovu River

4.3 uMNGENI RIVER SYSTEM

4.3.1 MG_I_EWR2: uMngeni River

The EWR site provides limited provisioning services with respect to fish but has a moderate abundance of riparian vegetation. Utilisation by local people is likely to be low due to the site being located in a conservation area. Hence provisioning services are provided a weighting of 0.15. The conservation status of the EWR site elevates the weighting of both cultural and regulating services to 0.3, while supporting services is weighted as 0.25.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (Table 4.4). Scenario MG2 would likely result in a static level of ESS, with slight improvement in regulation services around waste assimilation and dilution. Scenario MG41 shows better, but slight, improvement in all services barring cultural services, which is linked to improved waste assimilation/dilution, as well as an improvement in fish numbers.

Table 4.4 uMngeni River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MG_I_EWR2

Service	Sc MG2	Sc MG41	Weight
Provisioning services	*1.00*	*1.03*	*0.15*
Regulating services	*1.02*	*1.09*	*0.30*
Cultural services	*1.00*	*1.00*	*0.30*
Supporting services	*1.00*	*0.98*	*0.25*
Score	**1.01**	**1.02**	**1.00**

4.3.2 MG_I_EWR5: uMngeni River

The EWR site provides moderate provisioning services with respect to riparian vegetation, and utilisation of this resource is also moderate. Hence provisioning services are provided the highest weighting of 0.35. Cultural and regulating services are considered to be equal with a weighing of 0.25, while supporting services is given a weighting of 0.15.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (Table 4.5). Scenario MG41 would likely result in a static level of ESS, but with slight improvements in provisioning and regulating services associated with slight increases in low water flow levels relative to PD. Scenario MG51 shows no real change in ecosystem service provision, with a slight reduction in regulating services related to the reduction in low water flows and reduction in stream-flow regulation and groundwater recharge. Unlike the other rivers an integrated traffic diagram is not provided for the uMngeni. This would be redundant as only Sc MG41 is common and this cores the same at both sites. Scenarios are very close to neutral in impact and as such show little sensitivity to ranking.

Table 4.5 uMngeni River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MG_I_EWR5

Service	Sc MG41	Sc MG51	Weight
Provisioning services	*1.04*	*1.01*	*0.35*
Regulating services	*1.04*	*0.97*	*0.25*
Cultural services	*1.00*	*1.00*	*0.25*
Supporting services	*1.00*	*1.00*	*0.15*
Score	**1.02**	**0.99**	**1.00**

4.4 uMKHOMAZI RIVER SYSTEM

4.4.1 MK_I_EWR1: uMkhomazi River

The site provides a relatively moderate to high abundance of provisioning resources (specifically fish and natural riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.4, while cultural services are given a weighting of 0.3. Regulating and supporting services are weighted as 0.2 and 0.1 respectively.

Scenarios that were assessed generally result in low to moderate decreases in ecosystem provision, and no appreciable improvements (Table 4.6). Scenario MK2 and MK31 show the highest reduction in ESS with a weighted scope of 0.78 and 0.79 respectively – or a 20% reduction in function. The highest reductions include the abundance in terms of fish and riparian vegetation and noticeably a significant decrease in waste assimilation/dilution capability, while more moderate reductions are noted for flood regulation, bank protection, stream flow regulation and groundwater recharge.

Scenario MK4, MK32, MK41 and MK42 show moderate reductions in ecosystem function with an average weighted scope of 0.86 – or 14% reduction in ecosystem function. The reduction in ecosystem functions is the same of Sc MK2 and MK31, however the reduction is not considered as significant.

Scenario MK21 and MK22 show the lowest reduction in ecosystem function, although there remain no likely improvements. Reduction in services is largely related to reduction in fish abundance, flood regulation, bank protection, stream flow regulation and groundwater recharge related to potential reductions in baseflows.

Table 4.6 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MK_I_EWR1

Service	Sc MK2	Sc MK4	Sc MK21	Sc MK22	Sc MK31	Sc MK32	Sc MK41	Sc MK42	Weight
Provisioning services	*0.65*	*0.70*	*0.88*	*0.87*	*0.84*	*0.79*	*0.77*	*0.77*	*0.40*
Regulating services	*0.74*	*0.84*	*0.97*	*0.95*	*0.92*	*0.91*	*1.00*	*0.99*	*0.20*
Cultural services	*0.90*	*0.90*	*0.90*	*0.90*	*0.57*	*0.90*	*0.90*	*0.90*	*0.30*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.10*
Score	*0.78*	*0.82*	*0.92*	*0.91*	*0.79*	*0.87*	*0.88*	*0.87*	*1.00*

4.4.2 MK_I_EWR2: uMkhomazi River

The site provides a relatively low to moderate abundance of provisioning resources (specifically natural riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.35. However, the site also provides for relatively high cultural services related to recreation, and is thus this service is provided with a weighting of 0.25. Regulating services with respect to water assimilation and dilution as well as stream-flow regulation is moderate with a weighting of 0.25, while supporting services is weighted as 0.15.

Scenarios that were assessed generally result in low to moderate decreases in ecosystem provision, and no appreciable improvements (Table 4.7). Scenario MK2 shows the highest reduction in ESS with a weighted scope of 0.89, which is specifically related to reductions in fish abundance, as well as reduction in waste assimilation and dilution services.

The remaining scenarios are largely consistent with equivalent reductions in ESS. All scenarios results in the reduction of provisioning services (especially around certain fish and riparian vegetation species). Scenario Mk41 and MK42 show slight improvement in regulating services, while the remaining scenarios show reductions. This is generally attributed to improvements in waste assimilation and dilution services. Flood control related to Sc MK2, MK4, MK21, MK22, MK31 and MK32 show sight improvements in terms of supporting cultivation along the river banks.

Table 4.7 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MK_I_EWR2

Service	Sc MK2	Sc MK4	Sc MK21	Sc MK22	Sc MK31	Sc MK32	Sc MK41	Sc MK42	Weight
Provisioning services	*0.79*	*0.81*	*0.90*	*0.89*	*0.90*	*0.89*	*0.94*	*0.94*	*0.35*
Regulating services	*0.92*	*0.98*	*1.00*	*1.01*	*1.00*	*0.99*	*1.03*	*1.03*	*0.25*
Cultural services	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.25*
Supporting services	*1.10*	*1.05*	*1.05*	*1.05*	*1.05*	*1.05*	*1.00*	*1.00*	*0.15*
Score	*0.89*	*0.91*	*0.95*	*0.95*	*0.95*	*0.94*	*0.96*	*0.96*	*1.00*

4.4.3 MK_I_EWR3: uMkhomazi River

The site provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.35. Cultural and regulating services are provided an equal weighting of 0.25, while supporting services is weighted as 0.15.

Scenarios that were assessed generally result in negligible overall changes (Table 4.8). Scenario MK2 shows the highest reduction in ESS of all the scenarios, although the overall weighted score is only 0.95; related to reduced provisioning services of fish and riparian vegetation and changes in stream-flow.

Scenario MK21 shows slight improvements in provisioning and regulating services, although this is considered to be minor and related to improvement in tree abundance due to improved flood attenuation.

Scenario MK22, MK32 and MK42 are considered to be largely static in terms of any potential changes in ESS. Only very slight reductions in provisioning services (reduced provisioning services of fish) are noted.

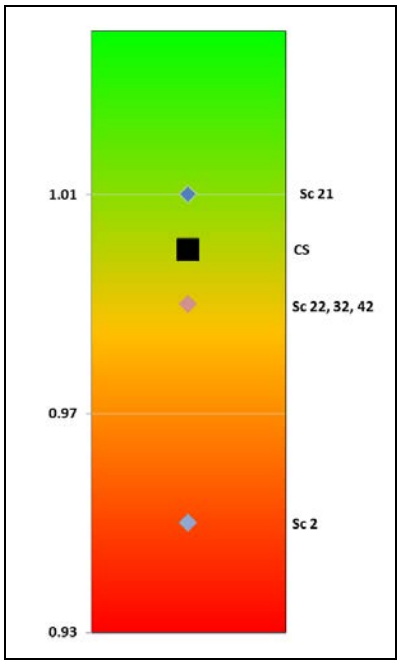
Table 4.8 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MK_I_EWR3

Service	Sc MK2	Sc MK21	Sc MK22	Sc MK32	Sc MK42	Weight
Provisioning services	*0.92*	*1.01*	*0.98*	*0.98*	*0.98*	*0.35*
Regulating services	*0.95*	*1.01*	*1.00*	*1.00*	*1.00*	*0.25*
Cultural services	*0.97*	*1.00*	*1.00*	*1.00*	*1.00*	*0.25*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.15*
Score	*0.95*	*1.01*	*0.99*	*0.99*	*0.99*	*1.00*

4.4.4 uMkhomazi River: Overall Scenario Ranking

Overall the results of the scenarios for the uMkhomazi River were ranked with the EWR sites weighted. Here the perceived vulnerability of households dependent on the provisioning aspect of

ESS played a major role. Again all scores are normalised against a base score of one. Results are presented in Figure 4.4 below.



CS = Current state

Figure 4.4 Integrated scenario results for EWR sites in the uMkhomazi River

4.4.5 uMkhomazi Estuary

The uMkhomazi Estuary provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation and fish species) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.4. Cultural and regulating services are provided a weighting of 0.3 and 0.2 respectively, while supporting services is weighted as 0.1.

Scenarios that were assessed generally result in variable changes (Table 4.9). Scenario Group A (MK2 and MK4) and Scenario Group F (MK21 and MK43) show the greatest reduction in service provision. This is attributed to the reduction in fish abundance, waste dilution potential as well as increases in water-borne diseases.

Scenario Group C, as well as Group D and Group E are considered to be largely static in terms of any potential changes in ESS. Only very slight reductions in provisioning services (reduced fish abundance) and regulating services are noted.

Scenarios MK21 and MK41 + mods, Scenario Group G and Scenario Group H are the only that show positive trends in service provision. This is largely related to improved fish abundance, cultural use and improvement in human health. Results are presented in Figure 4.5 below.

Table 4.9 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at the uMkhomazi Estuary

Service	A	Sc 21 + 41 + mods	C	D	E	F	G	H	Weight
Provisioning services	*0.79*	*1.02*	*0.97*	*0.98*	*0.90*	*0.81*	*1.17*	*1.32*	*0.4*
Regulating services	*0.67*	*0.95*	*0.95*	*0.95*	*0.95*	*0.76*	*0.99*	*1.03*	*0.2*
Cultural services	*0.96*	*1.04*	*1.00*	*1.04*	*1.00*	*0.86*	*1.22*	*1.32*	*0.3*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.1*
Score	*0.84*	*1.01*	*0.98*	*0.99*	*0.95*	*0.83*	*1.13*	*1.23*	*1*

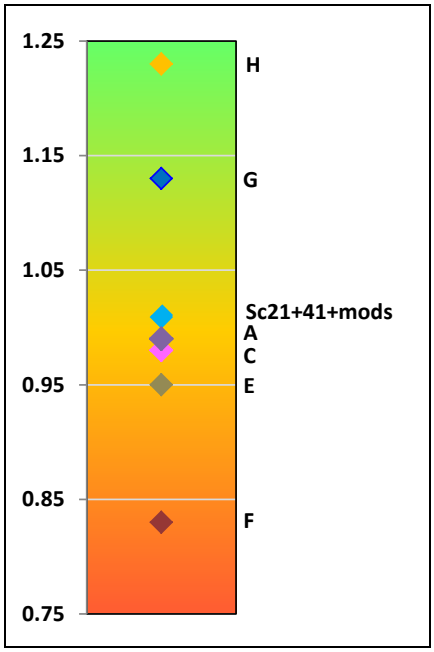


Figure 4.5 Integrated scenario results for the uMkhomazi Estuary

4.5 CONCLUSION

The various operational scenarios all present positive results and should all make a positive contribution to the economic growth and employment creation in the four catchments. The final preferable option will depend on the interaction between the economic values, the ESS and the environmental impacts.

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6 APPENDIX A: REPORT COMMENTS

Page / Section	Report statement	Comments	Changes made?	Author comment
Comments from: Mmaphefo Thwala – 20 February 2015				
Ii Executive summary		*Remove reference to figure.*	*Yes*	
4-6		*Provide Scenario names as well as number.*	*Yes*	
4		*Provided additional traffic diagrams for integrated scenario results bar uMngeni as per inserted comment on page 4-4.*	*Yes*	