



# SOCIAL, ECONOMIC AND ENVIRONMENTAL IMPACTS OF WATER ALLOCATION IN THE SABIE RIVER CATCHMENT, WITH REFERENCE TO STRATEGIC WATER SOURCE AREAS WITHIN THE INKOMATI-USUTHU WATER MANAGEMENT AREA

FINAL CONSOLIDATED REPORT

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## Executive Summary

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### Preamble

The Kruger2Canyons Biosphere Region has contracted Prime Africa to undertake a resource economic study of the social, economic and environmental impacts of water allocation in the Sabie River Catchment, with reference to Strategic Water Source Areas (SWSA's) in the Inkomati-Usuthu Water Management Area (IUWMA). The contracted services are in support of the WWF-SA Green Trust funded, Sabie Water Stewardship Project.

### Study Area

The Sabie Catchment is a diverse system which provides water to a number of different sectors, communities, the environment and directly to Mozambique. Most of the allocatable water is sourced from the Inyaka Dam and several users abstract directly from the Sabie and Sand Rivers for a number of uses. The Catchment is situated in the Inkomati-Usuthu Water Management Area (WMA and falls within drainage region X31. The study site is primarily located within the Mbombela Local Municipality (LM), but the catchment also falls within the Thaba Chweu and Bushbuckridge LMs. The main towns and urban centres in the study site include, Hazyview, Marite, Hoxani, Thulamahashe and Acornhoek (Figure 1-1). Approximately 40% of the allocation of available water within the catchment is for the agro-forestry sector followed by bulk water abstraction for domestic water supply.

### Water Balance

The current water balance shows that the system is in deficit, both with and without releases for the Ecological Water Requirement (EWR). The EWR refers to the quality, quantity and timing of freshwater inflows reserved to support ecosystem function. Under the condition of no EWR releases, the urban water requirements already exceed the available resources at a 98% assurance of supply level. When the irrigation allocations are added to the urban requirements, the resources are insufficient for both the requirements with and without EWR releases options.

Taking this deficit into consideration, one of the key objectives of this study is to assess development scenarios listed in the Draft Mbombela Reconciliation Strategy (DWS, 2020) by using estimated water requirements. In addition, as the headwaters of the catchment falls within the Mpumalanga Drakensberg WSA, it is important to understand how developmental scenarios as well as sustainable land use practices may impact on water yield of these areas.

### Water Augmentation Scenarios

Based on the options proposed in the Mbombela Reconciliation Strategy (DWS, 2020), four scenarios were selected for analysis. Changes in yield will have an impact on the delivery of ecosystem services and on socio-economic parameters. Scenario 1 can be considered as the ecological scenario, while scenarios 2, 3 and 4 can be considered developmental scenarios, where hard infrastructure will need to be put in place. The water augmentation scenarios are given below:

Scenario Number	Scenario Name	Description	Additional Yield (Mm <sup>3</sup> /annum)
SC1	Ecological Scenario	The removal of alien invasive species within the upper reaches of the X31E catchment could lead to an increase in yield for the Inyaka Dam. Additionally, the implementation of sustainable land management (SLM) practices and stewardship incentives with private and government landowners of primarily forestry land in the upper reaches of the X31E catchment would also lead to an increase in yield for the Inyaka Dam.	3
SC2	Increased return flows from wastewater treatment works (WWTW)	The conversion of the oxidation ponds to treated effluent WTW could result in additional return flows.	6
SC3	Development of groundwater resources	Sustainable development of groundwater resources in the Bushbuckridge LM.	10,5
SC4	Construction of a new dam.	Construction of the new Dingleydale Dam in the Sand River Catchment.	20,6

### Economic Costs of Scenarios

The clearing of invasive alien plants (IAP) exhibits the greatest variation in costs but would appear be a logical first step in the process of water augmentation for the catchment. The costs are likely to be influenced the accessibility of the IAPs, the type of species present and the number of follow up clearings. The clearing of IAPs is considered as an ecosystem-based adaptation (EbA) strategy, which is defined as the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (DEA & SANBI, 2017). Clearing of IAPs

supports the stimulation of the rural economy through providing additional rural livelihood options, creating nodes of rural development and stimulating job creation and skills development.

The development of a groundwater network located in the Bushbuckridge Municipality shows the second highest variation, while also appearing to have the lowest minimum and maximum costs (aside from the construction of Dingleydale dam), and thus would likely be a viable scheme to implement alongside Scenario 1. According to the Mbombela Reconciliation Strategy (DWS 2020), groundwater was used prior to construction of the Inyaka Dam, so components may be reactivated or redeveloped for conjunctive use.

The development or modification of WWTW in the study area show the least variability in cost ranges, but the gains in yield would not be dispersed evenly across the system as the WWTWs are geographically dispersed. It would therefore be difficult for an economic sector to utilize the available yield. The potential negative effects this intervention may have on downstream water quality also needs to be considered, as poor management of these WWTWs could have severe consequences. As stated in the Reconciliation Strategy (DWS 2020), further feasibility on this scenario would need to be investigated.

The final scenario, the construction of the Dingleydale Dam, would be the most expensive, but would also provide the largest available yield. It is worth noting that, given the site of this dam, this yield would only be directly available in the Sand River sub-catchment, unlike the other interventions contained in this analysis.

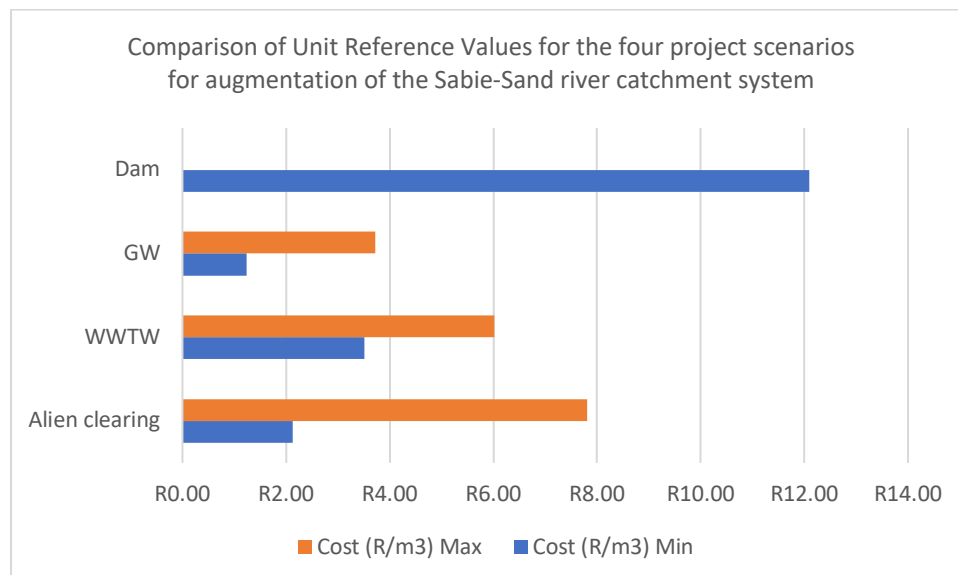


Figure 0-1. Comparison of unit reference values for the four project scenarios for augmentation of the Sabie-Sand Catchment

### Economic Benefits of Scenarios

The different scenarios will have a positive development impact on the economy of the Sabie-Sand catchment. This impact includes a positive impact on the catchment economy in terms of attracting investment and job creation

The table below summarises the macro-economic indicators for the economic effect from the increased water flow and the investment costs for each scenario for the Sabie-Sand catchment economy. The GVA is an economic productivity metric that measures the contribution by the different scenarios to the economy of the catchment. The impact of each of the four different scenarios on the Sabie Sand Catchment economy is estimated to be between R107 million (Scenario 1) and R788 million (Scenario 4) as indicated by the GVA values in the table. Scenarios 2 and 3 will have an estimated impact of R285 million and R487 million on the catchment economy respectively.

A significant number of direct and indirect jobs would be created per annum in each of the different scenarios. The number of direct and indirect jobs that will be created per year varies between the different scenarios, with the highest number of jobs being created in Scenario 4 and the lowest number of jobs would be created in scenario 1. More than 600 jobs would be created in each of the Scenarios 1 and 2.

*Table 0-1. Macro-economic indicators estimated for Sabie Sand catchment scenarios (considering increased water flow and capital investments)*

Macro-economic impacts	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4
GVA	Million R	107	285	487	788
Compensation of employees	Million R	60	152	281	419
Number of jobs		710	680	1,250	1,860
GVA per single job	R/year	150 704	419 118	389 600	423 656

## Recommendations

The major recommendations of the study are:

1. Develop a Stewardship Strategy for the headwater of the X3 catchment which includes the Mpumalanga Drakensberg SWSA. The Stewardship Strategy should include an Ecosystem-based Adaptation (EbA) component which would provide adaptation strategies for communities at risk from climate change and who rely on water resources. The target region represents an area of approximately 180 000 ha. Landscapes for stewardship implementation within the region comprises approximately 58 000 ha untransformed, natural and degraded land and 80 000 ha of plantations (Figure 0.3). The area identified in the Figure below provides an ideal starting point for stewardship activities.

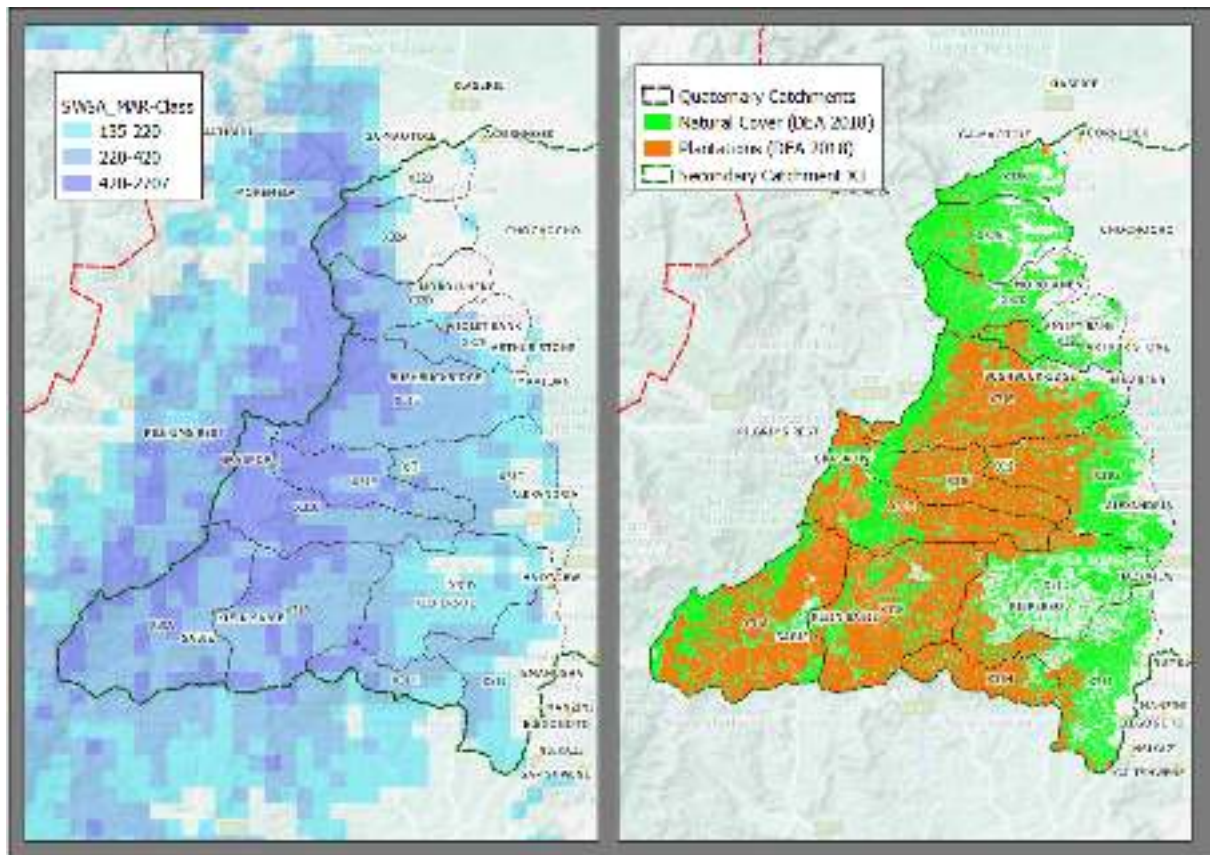


Figure 0-2: Focus area of stewardship implementation and target landscapes in the X3 catchment

2. Implement a focused IAP clearing programme in the headwaters of the Inyaka Dam in the X31E quaternary catchment.
  - Working for Water (WfW), K2C, WWF and SANParks have the necessary experience to develop a targeted IAP clearing strategy.
3. Undertake a feasibility study for the implementation of the findings and recommendations of the Mbombela Reconciliation Strategy (DWS 2020).
4. Finalise the Validation and Verification actions within the Mbombela Reconciliation Strategy (DWS 2020). Particularly around diffuse water use.
5. Implementation of scenarios needs to be in a phased approach with Biodiversity and Water Stewardship playing a central role in yield augmentation.

## Acronyms

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CRA	Comparative Risk Assessment
DWS	Department of Water and Sanitation
EbA	Ecosystem-based Adaptation
EI	Ecological Infrastructure
EWR	Ecological Water Requirements
GVA	Gross Value Added
IAP	Invasive Alien Plants
IEM	Integrated Economic Model
IUCMA	Inkomati-Usuthu Catchment Management Agency
IUWMA	Inkomati-Usuthu Water Management Area
K2C	Kruger2Canyons
LM	Local Municipality
MAR	Mean Annual Runoff
PSC	Project Steering Committee
SAM	Social Accounting Matrix
SANParks	South African National Parks
SWSA	Strategic Water Source Areas
TEEB	The Economic of Ecosystems and Biodiversity
URV	Unit Reference Value
WfW	Working for Water
WSA	Water Source Area
WWF	World Wide Fund for Nature
WWTW	Waste Water Treatment Works

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## 1. Introduction

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### 1.1. The Sabie River Catchment

The study area is focussed on the Sabie River Catchment situated in the Inkomati-Usuthu Water Management Area (WMA). The catchment falls within drainage region X31 and has a total area of 7096 km<sup>2</sup>. The study site is primarily located within the Mbombela Local Municipality (LM), but the catchment also falls within the Thaba Chweu and Bushbuckridge LMs. The LMs form part of the larger Ehlanzeni District Municipality (DM). A major tributary of the Sabie River is the Sand River, which has its origins on the border of the Thaba Chweu and Bushbuckridge LMs and the Marite River, which is regulated by releases from the Inyaka Dam (DWS, 2018). The Sabie River flows through the Kruger National Park (KNP) and impounds the Corumana Dam in Mozambique. It then discharges into the Indian Ocean as the Inkomati River to the north of Maputo in Mozambique (DWS 2018).

The main towns and urban centres in the study site include, Hazyview, Marite, Hoxani, Thulamahashe and Acornhoek (Figure 1-1). Approximately 40% of the allocation of available water within the catchment is for the agro-forestry sector followed by bulk water abstraction for domestic water supply. Bulk water abstraction takes place at the Hoxani Water Treatment Works between Hazyview and Mkhulu (Riddell *et al.* 2018).

In December 2016 the Minister of Water and Sanitation gazetted the Sabie Catchment as a Management Class 1 catchment with an A/B Recommended Ecological Category (REC), affording it a high level of protection through a large proportion of the mean annual runoff (MAR) allocated to ecological water requirements (EWR) and stringent resource quality objectives (RQOs) for water quality (Riddell *et al.* 2018).

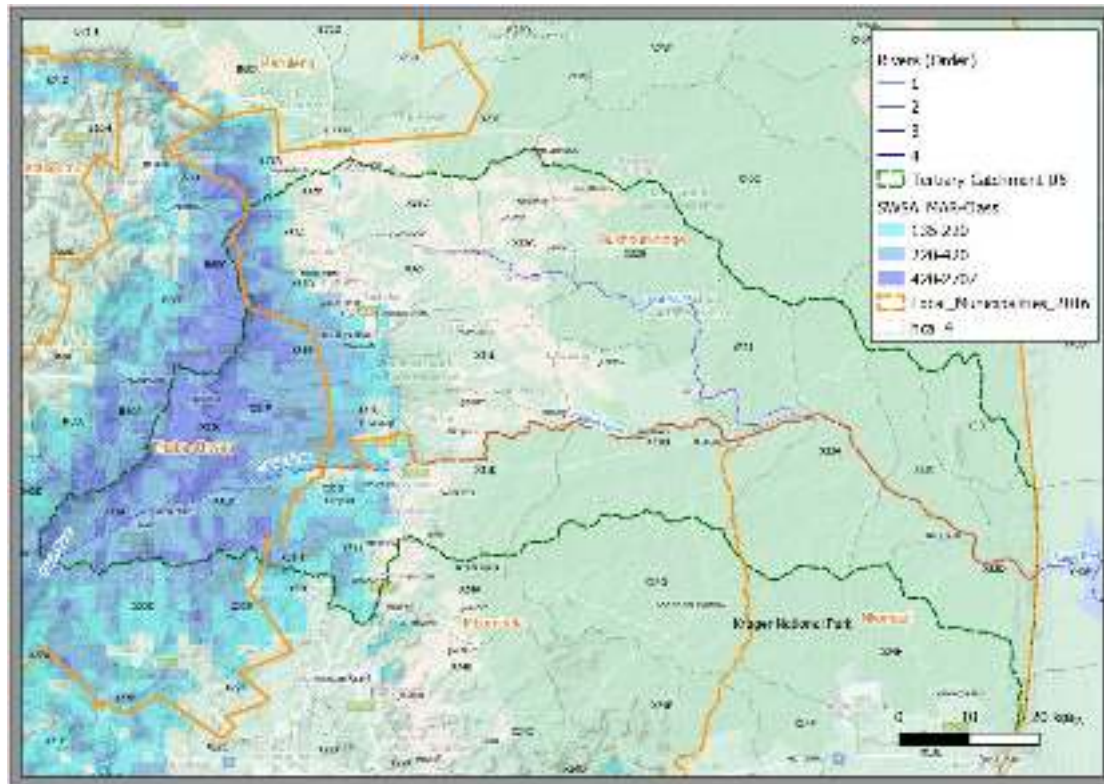


Figure 1-1. Map of Sabie Sand Catchment including a portion of the Mpumalanga Drakensberg Strategic Water Source Area. Mean annual runoff (MAR) is given as  $Mm^3/annum$

## 1.2. Strategic Water Source Areas

Water source areas (WSAs) are used to describe mountain areas that supply disproportionate runoff compared to adjacent lowland areas (WWF, 2013). Strategic water source areas (SWSAs) are areas of land that either:

- a. Supply a disproportionate amount of mean annual surface runoff in relation to their size and are considered nationally important; or
- b. Have high groundwater recharge and are locations where the groundwater forms a nationally important resource; or
- c. Are areas that meet both criteria (a) and (b) (Le Maitre, *et al.* 2018).

South Africa has 22 WSAs situated in five provinces. The total volume of water supplied by these areas per year is approximately 2 457 million cubic meters (CER, 2020). Within the Sabie River Catchment, the Mpumalanga Drakensberg water source area supplies water to parts of Mpumalanga including eMalahleni, Middleburg and Nelspruit as well as Phalaborwa in Limpopo. The Olifants, Sabie, Elands and Crocodile rivers flow from the SWSA. According to the CER (2020, major threats to the Mpumalanga Drakensberg WSA include coal and gold mining, land degradation and large-scale plantations. With regards to forma protection, only 9% of the SWSA is formally protected which includes ten provincial

reserves, twelve forest protected areas and two local nature reserves. The Kruger National Park (KNP) is downstream from the WSA (CER 2020). Figure 1-1 below show the location of South Africa’s SWSAs as well as the approximate location of the Mpumalanga Drakensberg WSA.

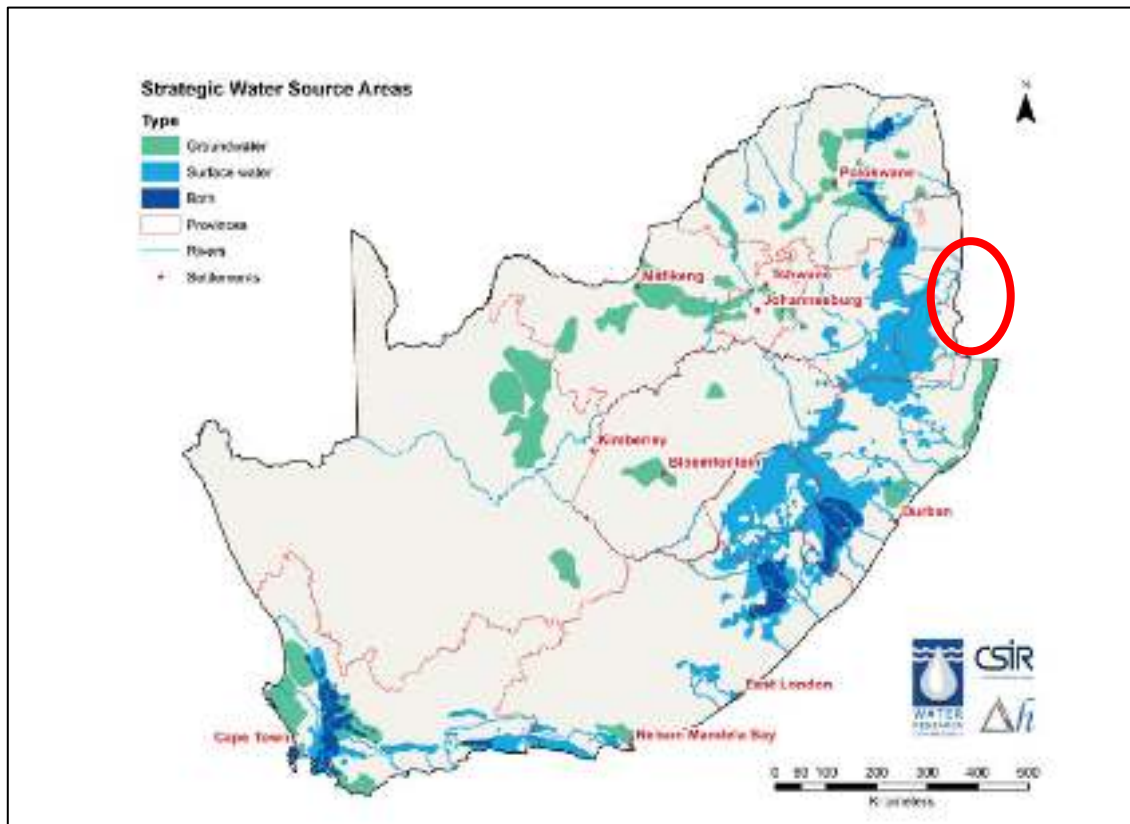


Figure 1-2. Map showing the strategic water source areas within South Africa. The approximate location of the Mpumalanga Drakensberg WSA is circled in red

### 1.3. Problem Statement

The Sabie Catchment is a diverse system which provides water to a number of different sectors, communities, the environment and directly to Mozambique. Most of the allocatable water is sourced from the Inyaka Dam and several users abstract directly from the Sabie and Sand Rivers for a number of uses.

The current water balance presented in Figure 1-3 shows the system in deficit, both with and without releases for the Ecological Water Requirement (EWR). The EWR refers to the quality, quantity and timing of freshwater inflows reserved to support ecosystem function. Under the condition of no EWR releases, the urban water requirements already exceed the available resources at a 98% assurance of supply level. When the irrigation allocations are added to the urban requirements, the resources are insufficient for both the requirements with and without EWR releases options. Figure 1-3 shows that the existing balance is in severe deficit if the EWR releases are made prior to an intervention option.

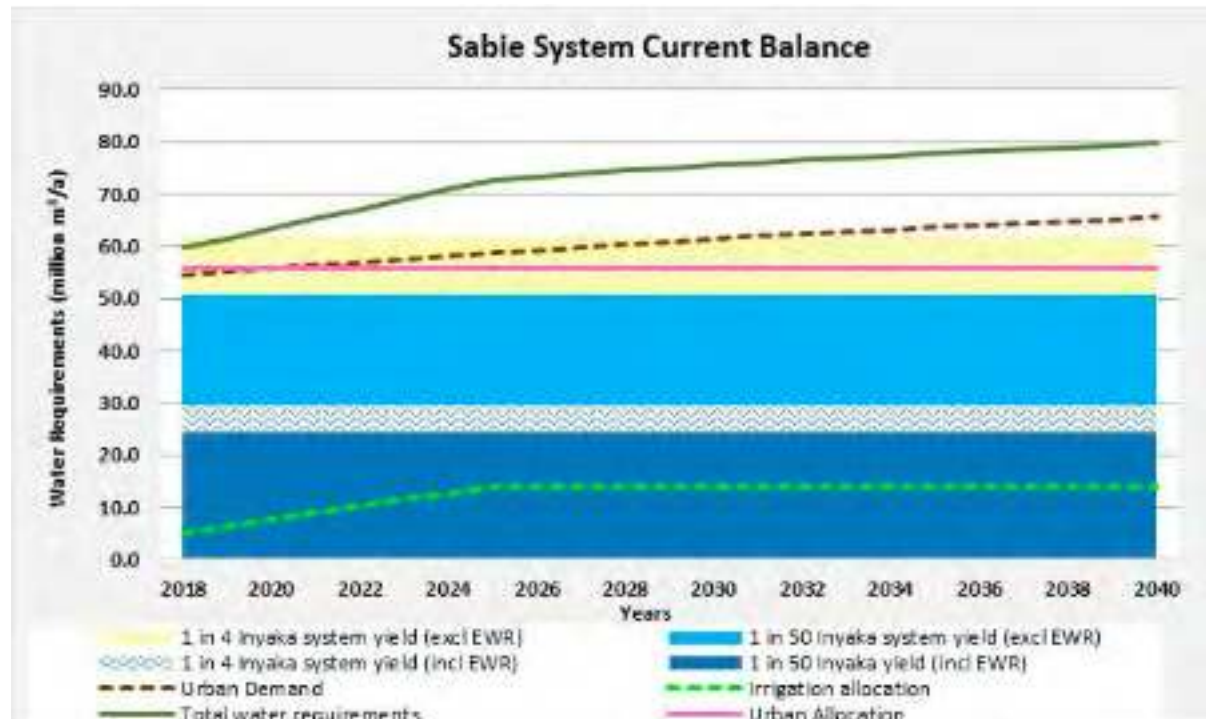


Figure 1-3. The current Sabie system water balance (DWS, 2020)

Taking this deficit into consideration, one of the key objectives of this study is to assess development scenarios listed in the Draft Mbombela Reconciliation Strategy (DWS, 2020) by using estimated water requirements. In addition, as the headwaters of the catchment falls within the Mpumalanga Drakensberg WSA, it is important to understand how developmental scenarios as well as sustainable land use practices may impact on water yield of these areas.

#### 1.4. Aim and Objectives of the Study

The aim of the study is to determine the impacts of water allocation in the Sabie River catchment in the context of source water protection through a desktop analytical assessment of current drivers of consumptive demands, including the impact of transformative policies (equitable water access and socio-economic development). Furthermore, the objectives of the study are:

- Determine the current drivers of consumptive demands, including the impact of transformative policies;
- Identify and evaluate the drivers of future consumptive demands to understand trade-offs and options of mitigating impacts through Source Water Protection mechanisms; and
- Assess development scenarios using estimated water requirements (Verified existing water use; current water use; future water use).

The project is aligned with several other initiatives in the Sabie River Catchment. Of particular importance is the WWF-SA Nedbank Green Trust Project GT5650 which is co-managed by K2C, South

African National Parks (SANParks) and the Inkomati-Usuthu Catchment Management Agency (IUCMA).

The aims of the project are:

- Incentivise catchment stewardship through the mid and headwaters of the Sabie Catchment. This is to ensure the water supply at a higher level of assurance to users downstream and therefore minimizing the pressure on water supply from the Inyaka Dam; and
- Promotion of water security at the catchment scale by ensuring that the Mpumalanga Drakensberg SWSA is well managed.

### **1.5. Structure of the Report**

The report is structured as follows:

- Section 1 provides a formal overview of the Study Area, this strategy and the purpose and structure of this report.
- Section 2 presents an overview of the methodology of the study.
- Section 3 provides a summary of the water use of the study area.
- Section 4 provides the social context of the study area.
- Section 5 provides the economic profile of the study area.
- Section 6 provides an ecological profile of the study area.
- Section 7 presents the water augmentation scenarios and their cost implications.
- Section 8 provides an overview of the socio-economic benefits of the various water augmentation scenarios.
- Section 9 presents the conclusions and recommendations for further work specifically around stewardship.
- Section 10 indicates the study references.

## 2. Methodology

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The assignment is aimed at assessing the feasibility of management scenarios for future water resource management. The scenarios focus on the management of ecological and aquatic resources which in turn have a cause-and-effect relationship with drivers of the system and eventually beneficiaries within the system.

The approach taken is one of defining linkages of causality between the implementation of a scenario, or combination of scenarios, and the resulting impacts on socio-ecological and economic systems. These linkages are defined through an ecosystem services approach whereby various best-use econometric tools such as natural capital accounting, resource economic analysis, ecosystem service mapping and quantification and Comparative Risk Assessments (CRA) are being utilised. The methodology referred to in Figure 2-1 has been described in a WRC study from 2018 that reviewed the Socio-Economic Guidelines for Water Resource Classification and Development of an Improved Decision Support Tool (Naidoo *et al.* 2018).

The broad approach taken to defining these linkages provided in Figure 2-1. Key inputs, components and outputs of the process include the following:

1. The drivers of change. This represents the various scenarios which drive changes in the relationships between components.
2. The ecological responses to change in scenario. This is defined through understanding the physical impacts that the scenario will have on supporting ecological processes, or in other words, regulating services. This includes impacts on water quantity regulation and stream augmentation, water quality regulation, erosion regulation and flood regulation. These are measured by changes in flow and water quality. This impact is typically termed the “environmental hazard” in the traditional WRCS, however in this study the scenarios include positive impacts and therefore will be termed the “Ecological Response”.
3. The classification of socio, ecological and economic characteristics within the Sabie catchment linked to the ecological responses as a result of changing scenarios. The classification process is done through the use of three modular tools (described below), which are typically packaged as an Integrated Economic Model (IEM). The IEM, through the use of ecosystem service frameworks, link the ecological responses (change in flow or quality) with a socio-economic response (change in economic productivity). The typical IEM used in the WRCS process is not appropriate here and a simplified IEM will be developed in the case of the Sabie catchment. The modular tools will nonetheless provide the framework from where linkages will be quantified and defined. For this assignment these include the following:

- a. The Water Balance Module aims to identify and estimate the use of water in the catchment by various users. The module defines the magnitude of water used, and by extension, estimates the relative reliance a specific beneficiary has on the water resources in the catchment.
  - b. The Socio-economic Module aims to estimate magnitude of the macro-economic indicators of the target economy (Sabie catchment). This classifies the current size of economic sectors which will be used to measure impacts on the economy due to ecological responses to scenarios.
  - c. The Ecosystem Services Module approach aims to link the ecological response to key beneficiaries of the range of ecosystem services through the use of ecosystem services frameworks. This will be done by identifying ecosystem services at risk of change (either positive or negative) and link them to the current beneficiaries.
4. The socio-economic response to change in development scenario, which will be, as far as logically possible, presented through key economic indicators. These indicators may include changes in GVA, jobs and value of ecosystem services.

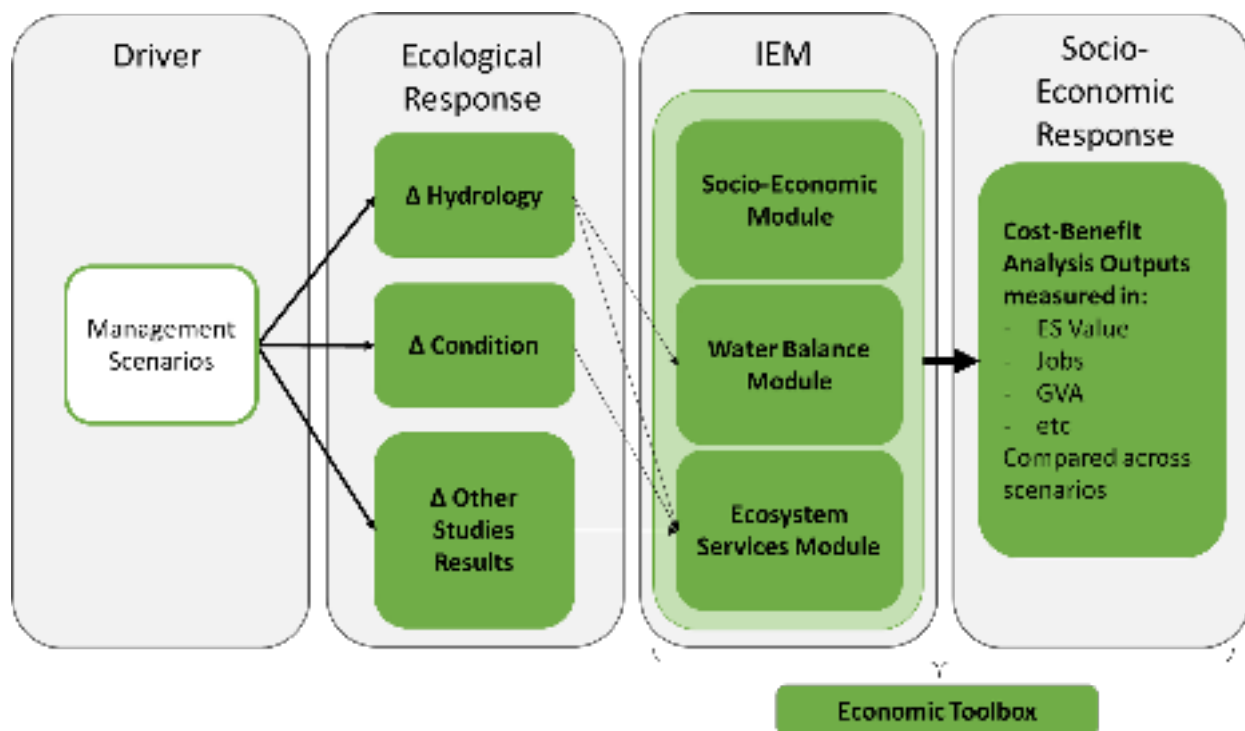


Figure 2-1: Framework to the development of the simplified Integrated Economic Model that will utilise estimated ecological response indicators as inputs to identify changes to key components necessary to effectively assess socio-economic impacts of management scenarios in the Sabie Catchment (Arrows indicate flow of data from input to output). The approach taken for the development of the IEM is described in WRD Report K5/2465 in Naidoo et al. 2018)

Please note: this process focusses on identifying the costs and benefits of varying scenarios on ecological systems. The financial costs required to implement scenarios are therefore not included here

and will be incorporated in steps to follow towards assessing the feasibility of varying scenarios or combinations of scenarios.

### 3. Water Use

#### 3.1. Overview

The total 2018 water requirement for the Sabie Sand Catchment was 334 million m<sup>3</sup> which includes urban-industrial, irrigation, afforestation, the ecological water requirement (EWR) and invasive alien species (IAP). Water use in these sectors are described in more detail below.

#### 3.2. Urban Industrial Water Requirements

Table 3-1 below provides a summary of the domestic and industrial requirements of users located in the study area. Groundwater requirements in the study area are 2.61 million m<sup>3</sup>/annum. The Sabie urban area makes use of groundwater resources which are estimated to yield 2.05 million m<sup>3</sup>/annum, while the current requirement is 1.78 million m<sup>3</sup>/annum (Table 3-1). The Graskop urban area makes use of groundwater resources which are estimated to yield 1.31 million m<sup>3</sup>/annum, while the current requirement is 0.83 million m<sup>3</sup>/annum (Table 3-1).

The surface water requirements from urban areas in the Sabie catchment (that have access to the Inyaka dam) is estimated to be 63.25 million m<sup>3</sup>/annum. The system transfers 10.44 million m<sup>3</sup>/annum to Nsikazi North in the Crocodile (East) Sub-Catchment.

Table 3-1: Urban and industrial projected water requirements per year indicated

Requirement (million m <sup>3</sup> /annum)					
Demand centre	2018	2025	2030	2035	2040
Sabie	1.78	1.78	1.78	1.79	1.79
Graskop	0.83	0.91	0.97	1.04	1.10
<b>Sub-total (Sabie Groundwater)</b>	<b>2.61</b>	<b>2.69</b>	<b>2.75</b>	<b>2.83</b>	<b>2.89</b>
Hazyview	1.61	2.09	2.47	2.70	2.84
Hoxani	14.20	16.00	17.20	18.20	19.20
Marite	3.40	3.90	4.30	4.60	4.80
Acornhoek (own resources)	5.15	7.15	7.85	9.95	10.95
Thulamahashe (own resources)	3.45	4.65	5.45	6.05	6.65
Bushbuckridge Transfer pipeline to Acornhoek and Thulamahashe	25.0	25.0	25.0	25.0	25.0
Nsikazi North (transfer)	10.44	11.63	2.75	2.83	2.89
<b>Sub-total Inyaka Dam</b>	<b>63.25</b>	<b>70.42</b>	<b>74.78</b>	<b>79.63</b>	<b>83.19</b>

### 3.3. Irrigation Water Requirements

There is an irrigation allocation of 14.1 million m<sup>3</sup>/annum from Inyaka Dam in the Sabie catchment which is expected to be utilised optimally by 2025. Irrigation boards in the area make use of the Sabie River canal and the Da Gama Dam.

There are four irrigation boards in the Sabie catchment:

- Sabie River Irrigation Board (formed in 1953);
- White Waters Main Irrigation Board (formed in 1965);
- Burgers Hall Irrigation Board (established 1954); and
- De Rust Irrigation Board (established in 1961).

A summary of irrigation requirements in the Sabie River catchment is provided in Table 3-2.

Table 3-2: Summary of irrigation requirements in the Sabie Sand Catchment

Type	Area (km <sup>2</sup> )	Volume (million m <sup>3</sup> /annum)
Sabie Irrigation Board	20.63	10.9
White Waters Irrigation Board	27.84	15.6
Diffuse <sup>1</sup> (Sabie)	79.1	63.1
Diffuse <sup>1</sup> (Sand)	24.65	17.06
<b>Total</b>	<b>152.2</b>	<b>106.7</b>

<sup>1</sup> Irrigation taking place outside a formal irrigation board, normally on tributaries, is referred to as diffuse irrigation.

### 3.4. Afforestation and Alien Vegetation

There are large areas of forestry within Sabie River catchment including exotic plantations such as Pine, Eucalyptus and Wattle which reduce the amount of water that would otherwise flow in the rivers in the catchments where the plantations are located. The information available for the afforestation and the alien vegetation streamflow reduction is sourced from the IWAAS (DWAF, 2009) (Table 3-3).

Table 3-3: Streamflow reduction activities in the Sabie Sand catchment (DWAF, 2009)

Afforestation			Alien vegetation	
Tertiary	Area (km <sup>2</sup> )	Streamflow reduction (million m <sup>3</sup> /a)	Area (km <sup>2</sup> )	Streamflow reduction (million m <sup>3</sup> /a)

X31	797	85.8	182.6	29.9
X32	56	3.9	33.1	1.7
X33	0	0	0	0.0

### 3.5. Ecological Water Requirements

The EWR for the Sabie River catchment has been determined and Gazetted as part of the water resource classification process (DWS, 2014). EWR structures are based on the cumulative natural flow that occurs from the catchments upstream of the EWR site (Table 3-4).

Table 3-4. Ecological water requirements for the Sabie Sand Catchment

EWR	Site Name	Category	MAR upstream of EWR site (million m <sup>3</sup> /annum)	Ecological Reserve (% of NMAR)
EWR1	Upper Sabie	B/C	132.0	35.8
EWR2	Aan de Vliet	C	261.7	27.3
EWR3	Kidney	A/B	493.7	30.8
EWR4	Mac Mac	B	65.8	45.4
EWR5	Marite	B/C	156.4	21.7
EWR6	Mutlumuvi	C	45.0	26.0
EWR7	Upper Sand	C	28.9	20.4
EWR8	Lower Sand	B	133.6	18.5

### 3.6. Water Resource Availability

Surface water runoff is the main source of water for users within the Sabie catchment. The total surface water runoff under natural conditions for the tertiary catchments is summarised in Table 3-5.

Table 3-5: Surface water runoff per tertiary catchment

Major River	Tertiary Catchment	IWAAS (maint.) MAR (million m <sup>3</sup> /annum)
Sand	X32	135.96
Sabie	X31	526.68
Sabie	X33	12.51

Under the condition of no EWR releases, the urban water requirements already exceeds the available resources at a 98% assurance of supply level. When the irrigation allocations are added to the urban requirements, the resources are insufficient for both the requirements with and without EWR releases options. The existing balance will be in severe deficit if the EWR releases are made prior to any intervention option.

### 3.7. Regulating Storage Structures

Three large dams are situated within the catchment including the Inyaka (largest) on the Marite River, Da Gama on White Waters River and Acornhoek on Motlamogatsana River (in Acornhoek) Figure 3-1. Numerous smaller dams are scattered over the study area, most of which supply water for irrigation and domestic use. The total storage of these small dams adds up to a volume of 20.9 million m<sup>3</sup> (Table 3-6).

Table 3-6: Minor dams located in the Study Area

Major River	Quaternary Catchment	Reservoir	Full Supply Capacity (million m <sup>3</sup> )	Users Supplied
Sabie	X31E	Maritsane Dam	2.0	Domestic
Sabie	X31H	Da Gama Dam	13.6	Irrigation
Sand	X32C	Acornhoek Dam	0.1	Irrigation/ Domestic
Sand	X32C	Edinburgh Dam	3.3	Irrigation/ Domestic
Sand	X32F	Orinoco Dam	1.9	Irrigation

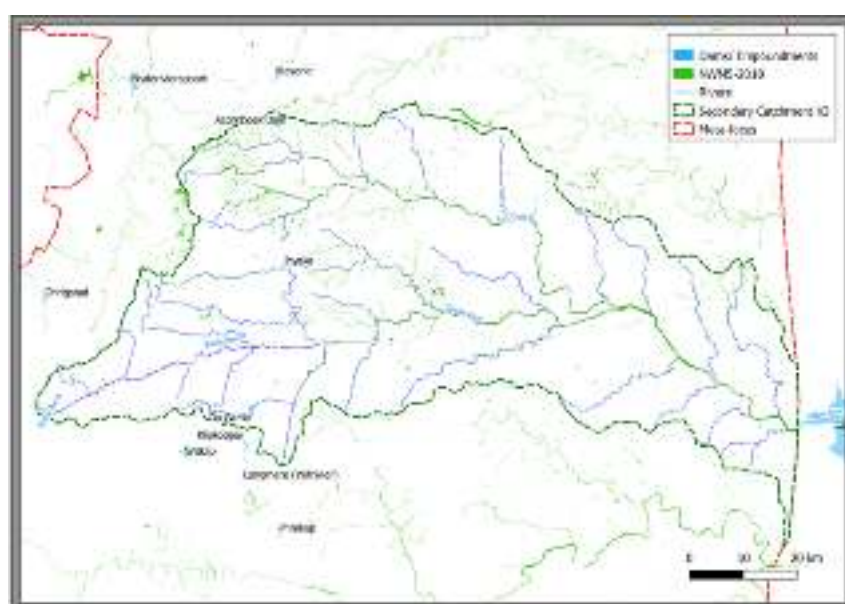


Figure 3-1: Water resources in the Sabie Sand Catchment

### 3.8. Summary of Water Use

A summary of the water use in the catchment is given in Table 3-7 below.

Table 3-7. Summary of water use in the Sabie Sand Catchment

Water users	Water balance (million m <sup>3</sup> /a)
Sabie-Sand urban demand-surface water	63.25
Sabie urban demand -Groundwater	2.61
Irrigation (including diffuse irrigation)	106.7
Invasive Alien Plants	31.6
<b>Total water demand (urban and irrigation)</b>	<b>204.16</b>

## 4. Social Context

### 4.1. Land Ownership

Within the catchment, the largest category of land ownership is state owned land (Figure 4-1). This is due to the presence of the Kruger National Park (KNP) in the eastern portion of the catchment, but it is also evident across the whole of the catchment (DRDLR 2015). Privately owned land is the next largest category and is distributed mainly in the urban areas around the main towns such as Sabie, Hazyview, Graskop, Acornhoek, Mkhuhlu and Thulamahashe. In addition, significant private land is found along the western border of the KNP and includes several privately owned game lodges predominately found within the Sabi-Sabi Game Reserve. Other categories of land ownership include communal lands, traditional lands and provincial lands (Figure 4-1).

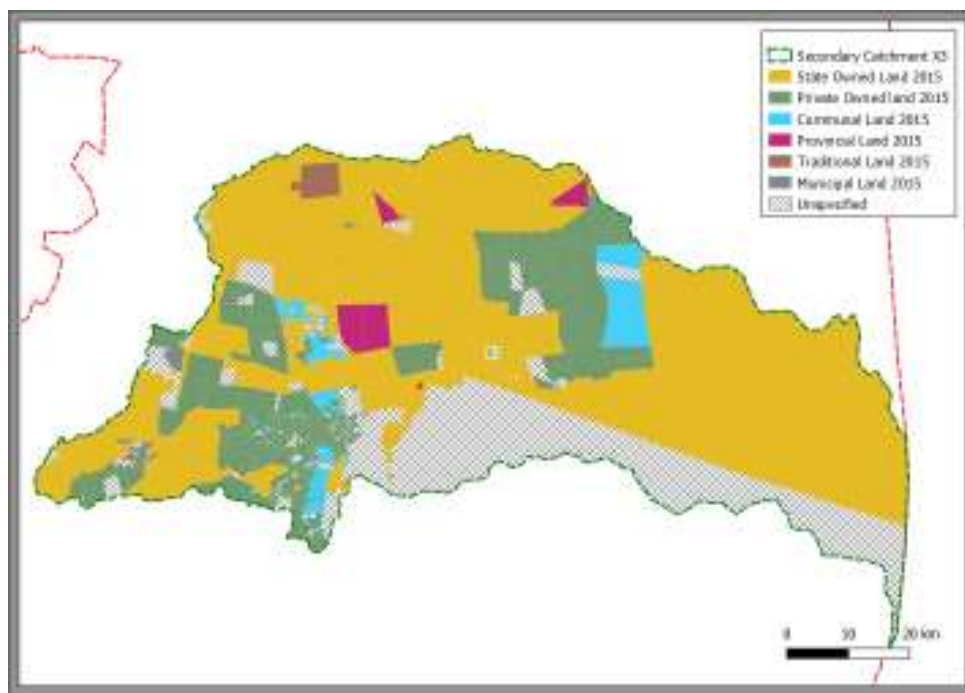


Figure 4-1: Land ownership classification in the Sabie Sand Catchment (DRDLR 2015)

### 4.2. Land Cover

Land cover within the catchment is characterised by predominately woodland, which is due primarily to the presence of the KNP in the eastern section of the catchment (Figure 4-2). The land cover map shows that much of the western portion of the catchment is dominated by plantations situated along the escarpment. The location of these plantations overlaps on a large portion of the Mpumalanga Drakensberg SWSA which is where the Sabie River and many of the tributaries arise. In addition, urban land cover is significant and stretches from Acornhoek in the north western regions in a southern direction down to Hazyview. Cultivated fields are also a significant category and are concentrated

predominately in the Kiepersol/Hazyview area. Crops in this area consist of bananas, citrus and more recently, ginger and macadamia nut trees (Figure 4-2). Landcover is based on the national Land Cover 2018 dataset (DEFF 2018) and amended based on local knowledge of land use activities in the catchment (Figure 4-2).

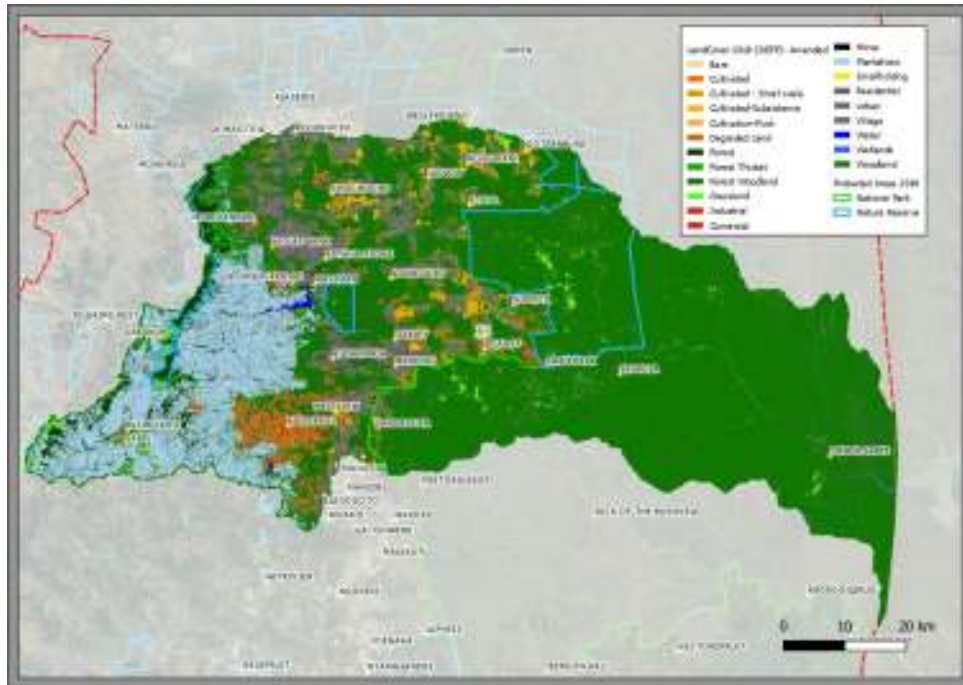


Figure 4-2. Land cover in the Sabie Sand Catchment (DEA, 2018)

### 4.3. Demographics and Socio-Economic Profile

#### 4.3.1. Population Density

The X3 secondary catchment has a total population of approximately 564 853 with approximately 146 398 households (Census 2011). The population density is higher in the central regions of the catchment compared to the Western and Eastern regions. This trend tends away from protected areas in the East and mountainous regions in the west (Figure 4-3Error! Reference source not found.). The predominant language spoken in the catchment is Xitsonga (47%), followed by Sepedi (20%) and Siswati (20%) and Sesotho (5%)

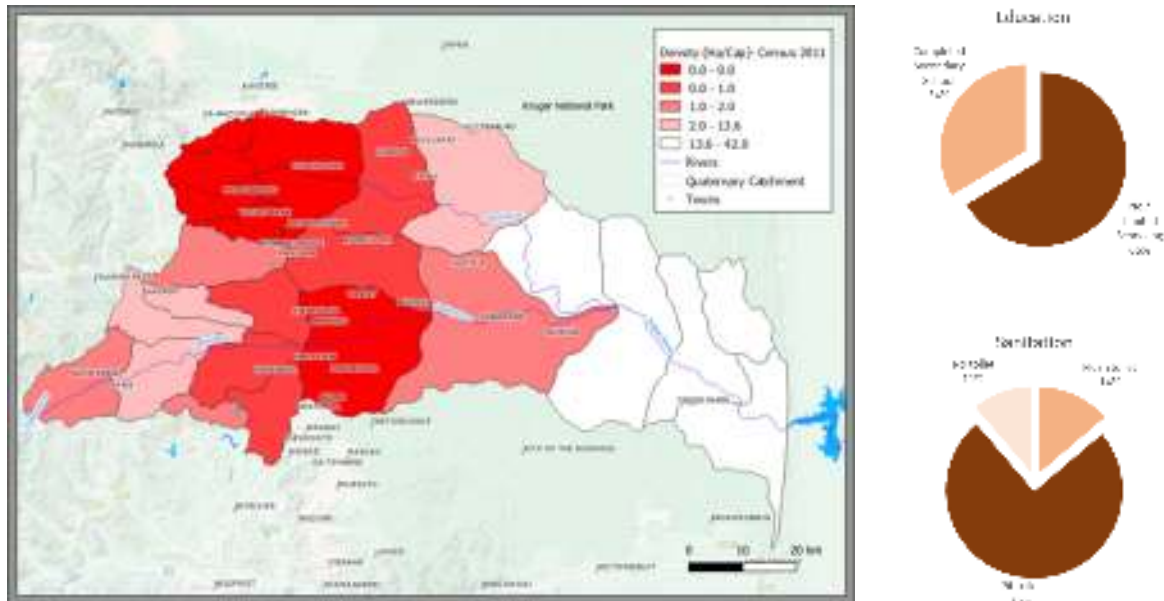


Figure 4-3: Population density (Ha/Cap) within the Sabie Sand Catchment (Census 2011)

#### 4.3.2. Access to Services

The access to services varies greatly across the catchment and between the rural and urban communities. Access to services is commonly used to indicate levels of wellbeing of the population in this catchment. A large proportion of the population in the central parts of the catchment rely on rivers, streams and dams (impoundments) as their primary source of water (Figure 4-4). In the catchment as a whole there are as many as 16% of the households that rely on the rivers, streams and dams as their primary source of water (Approx. 23 000 households), and a large 37% of the total population have limited or no access to piped water services.

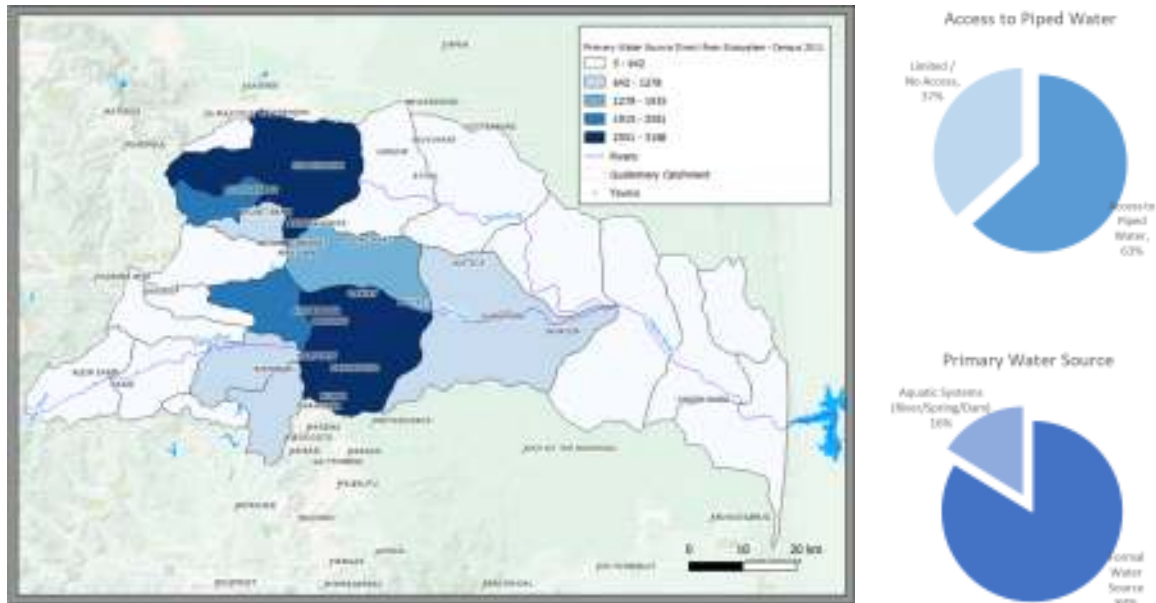


Figure 4-4: Reliance on rivers, streams and dams (impoundments) as the primary source of water in the Sabie Sand Catchment

### 4.3.3. Employment

Employment levels vary across the catchment with the highest percentage employment per capita in the western (escarpment) and eastern (protected areas) regions (Figure 4-5). More than half of the catchment are classified as discouraged workseekers (55%), 20% unemployment and 25% employed.

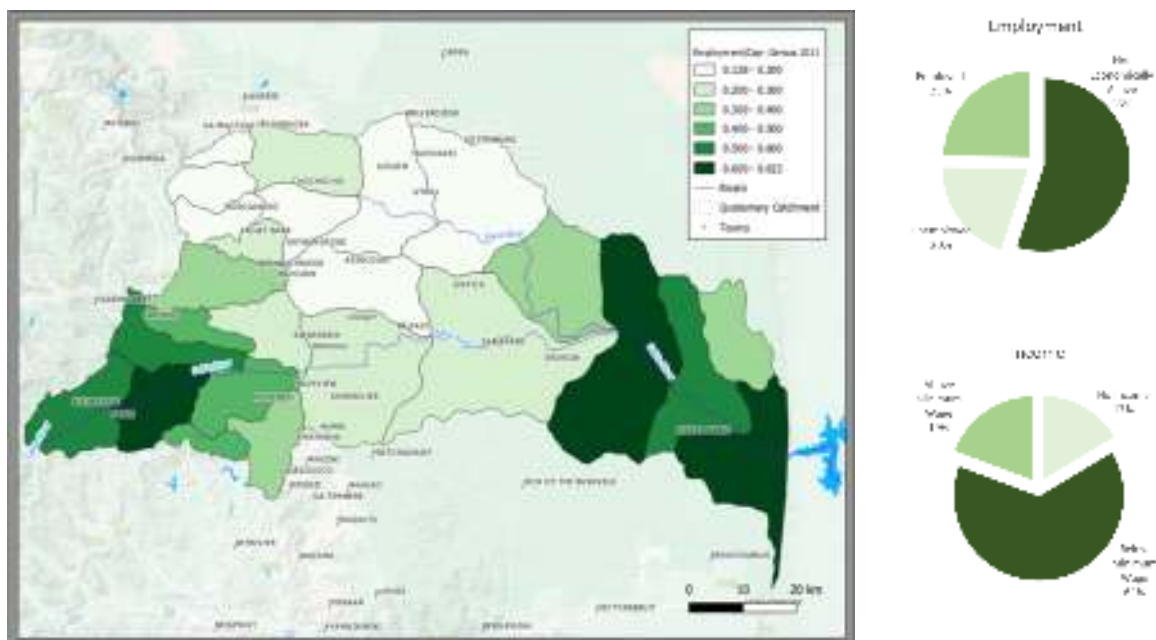


Figure 4-5: Employment per capita (%) across the Sabie Sand Catchment

### 4.4. Poverty Index

The Integrated Spatial Prioritization for the Greater KNP Buffer (K2C 2017) conducted an assessment to develop a Poverty Index for the greater Kruger region. The Poverty Index is based on proportions of households which meet specific poverty criteria. These criteria include the following (See K2C 2017 for additional details):

- Low-income households (<R9600/year/HH) (Census 2011)
- Dependency ratio (Ratio of employed to unemployed). This measures how dependent the population is on employed people (Census 2011)
- Access to services (electricity, decent sanitation, water supplies and refuse collection) (Census 2011)
- Consumption. Identified through the proportion of goods owned (as per Census 2011) by the total goods possible to be owned (Census 2011)

The Poverty Index indicates households experiencing significantly higher levels of poverty in the north-central region of the catchment (Figure 4-6). These regions display characteristics of undeveloped, rural landscapes including limited formal economic development, smallholdings, and subsistence agriculture.

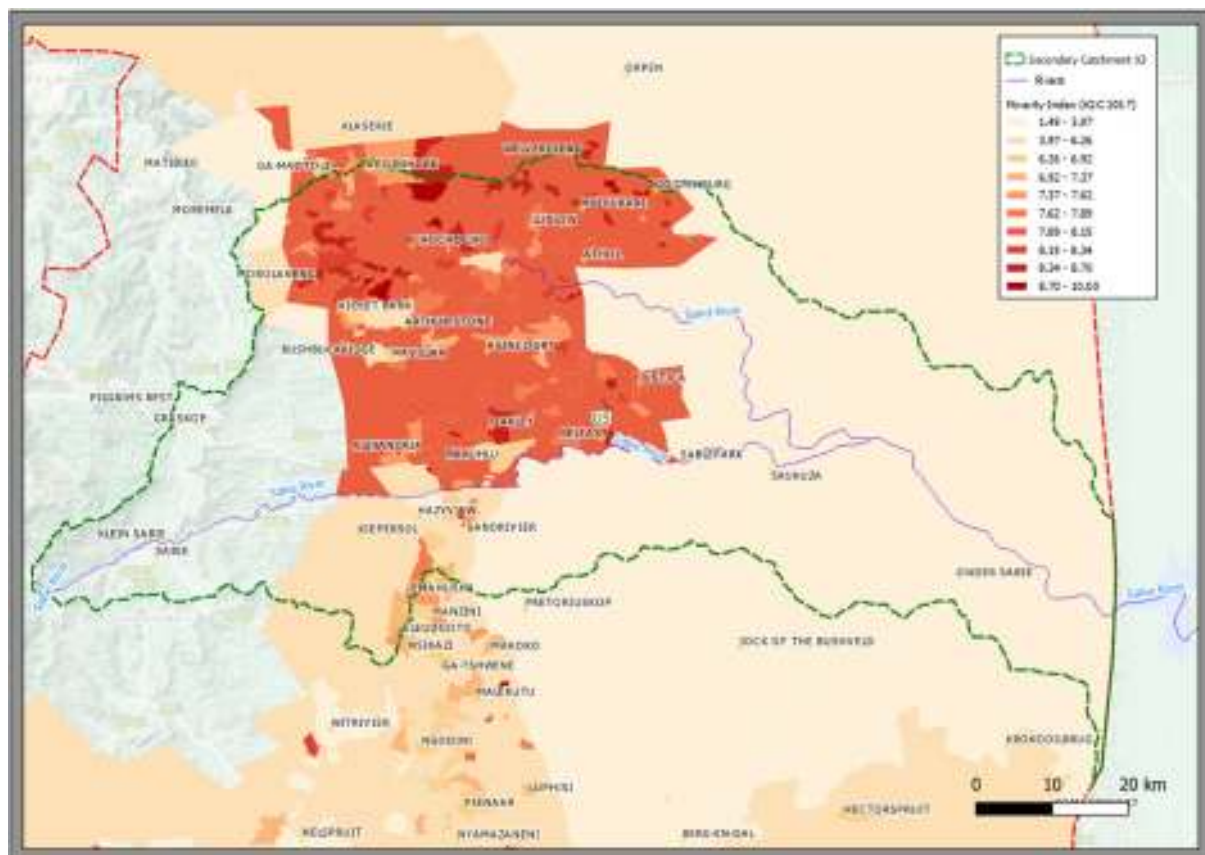


Figure 4-6: Poverty Index in the Sabie Sand Catchment

#### 4.5. Resource Dependency

The Integrated Spatial Prioritization for the Greater KNP Buffer (K2C 2017) furthermore conducted an assessment to develop a Direct Resource Dependency Index for the greater Kruger region. Direct Resource Dependency Index (DNRI) was calculated by identifying households which are directly dependent on the environment for traditional building materials, for wood for cooking, for wood for heating, and for the direct supply of water (primary source of water being something other than easily accessible piped water) (K2C 2017). The criteria specifically included the following:

- Supply of building materials (Traditional dwellings)
- Use wood for cooking
- Use wood for heating
- Supply of water from environment

The DSRI indicates high dependency on natural resources to be concentrated within sub-places (small regional centers) that fall outside protected environments (Figure 4-7). Due to their dependencies, the populations in these regions will be more vulnerable to changes in the ecological status quo. Similarly, it is likely that the ecosystems in these regions are under increased pressure due to their use by local populations.

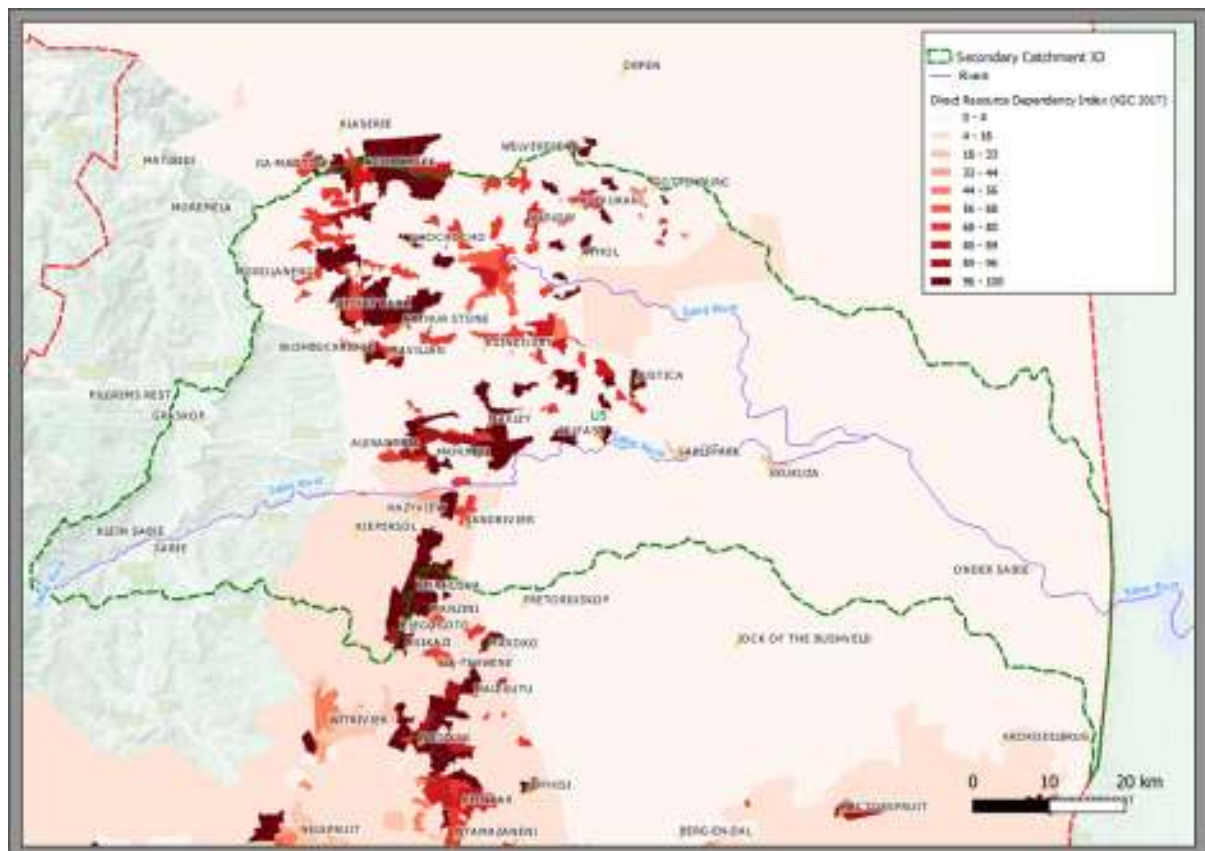


Figure 4-7: Direct Resource Dependency Index in the Sabie River Sand Catchment

## 5. Economic Profile

### 5.1. Gross Value Add

The economic status of the Sabie River Catchment (for the year 2019) was assessed by illustrating the status of the Gross Value Added (GVA) of the area, the employment conditions and the salaries paid. Gross Value Added is an economic productivity metric that measures the contribution of a corporate subsidiary, company or municipality to an economy, producer, sector or region. Gross Value Added provides a monetary value for the amount of goods and services that have been produced in a country, minus the cost of all inputs and raw materials that are directly attributable to that production. The GVA of the catchment amounted to R15.6 billion in 2019 after growing an estimated 0.8% from 2018. This is the growth associated with the entire Mpumalanga Province. The general economic growth dropped from 2.6% in 2014 (assuming similar growth as the province). Table 5-1 illustrates the GVA of the area per part of the municipality falling within the catchment.

Table 5-1 indicates that Bushbuckridge was the highest contributor to the catchment at 49%. The portion of Mbombela LM included in the Sabie River Catchment contributes 42% of GVA in the catchment, this is the second highest contribution followed by Thaba Chweu LM at 9% contribution to the catchment.

Table 5-1: GVA contribution per municipality falling within the Sabie River Catchment

Area	GVA 2011 (R millions at 2010 prices)	GVA estimate 2019 (R millions)	Contribution to catchment (%)	Population (Wards in and overlapping X3)	GVA per capita
Mbombela LM	5 744	6 599	42	196 617	33 561
Bushbuckridge LM	6 598	7 579	49	541 246	14 002
Thaba Chweu LM	1 199	1 378	9	36 044	38 218
Total	13 541	15 555	100	773 907	20 099

### 5.2. Contribution by Sector

The highest contributing economic sector in the catchment is social and government services at 26% (R4. 1 billion) contribution to the catchment's GVA (Table 5-2 and Figure 5-1). Retail trade (excluding tourism transactions) contributed 12% to the GVA. Businesses services contributed 18%. Agriculture (excluding forestry) employed an estimated 25 300 people in 2019 (Table 5-3 and Figure 5-2) making up 6% of the workforce, its GVA contribution was only 2% of the catchment due to low wages in the sector.

Agroforestry and forestry related products in the Mpumalanga province contribute 2.5% (1.4% general forestry and 1.1% forestry products) of the provincial GDP (DAFF, 2005) (Mpumalanga government, 2011) from its 35 000ha of natural forest and 624 000ha of plantations (DAFF, 2014). In the Sabie River Catchment, this translates to R389 million (2.5%) of the Sabie River Catchment GVA. This accounts for the entire value chain which is processed in the catchment. For example, this also includes all wood products which are produced in the catchment.

Tourism contributed R1.4 billion which is approximately 9% of the total GVA in 2019. The calculation of the tourism contribution can be complicated, as tourism activities are included in a number of economic sectors including the retail trade, business services and transport, but for this deliverable, it was feasible to calculate as part of retail trade only. The tourism sector will be investigated further in this study. The tourism sector of the Mpumalanga Province contributes about 9% to production and this was used to deduce the tourism contribution of the catchment.

Table 5-2: The GVA contribution by economic sector in the Sabie River Catchment

Economic sector	GVA 2019	GVA contribution to catchment (%)
Social and government services	4 098	26
Retail trade (excluding tourism)	1 822	12
Tourism	1 400	9
Business services	2 839	18
Manufacturing	2 046	13
Transport	1 182	8
Agriculture (excluding agro-forestry)	172	1
Agro-forestry	389	2.5
Construction	495	3
Utilities	466	3
Mining and mining related services	646	4
<b>Total</b>	<b>15 555</b>	<b>100</b>

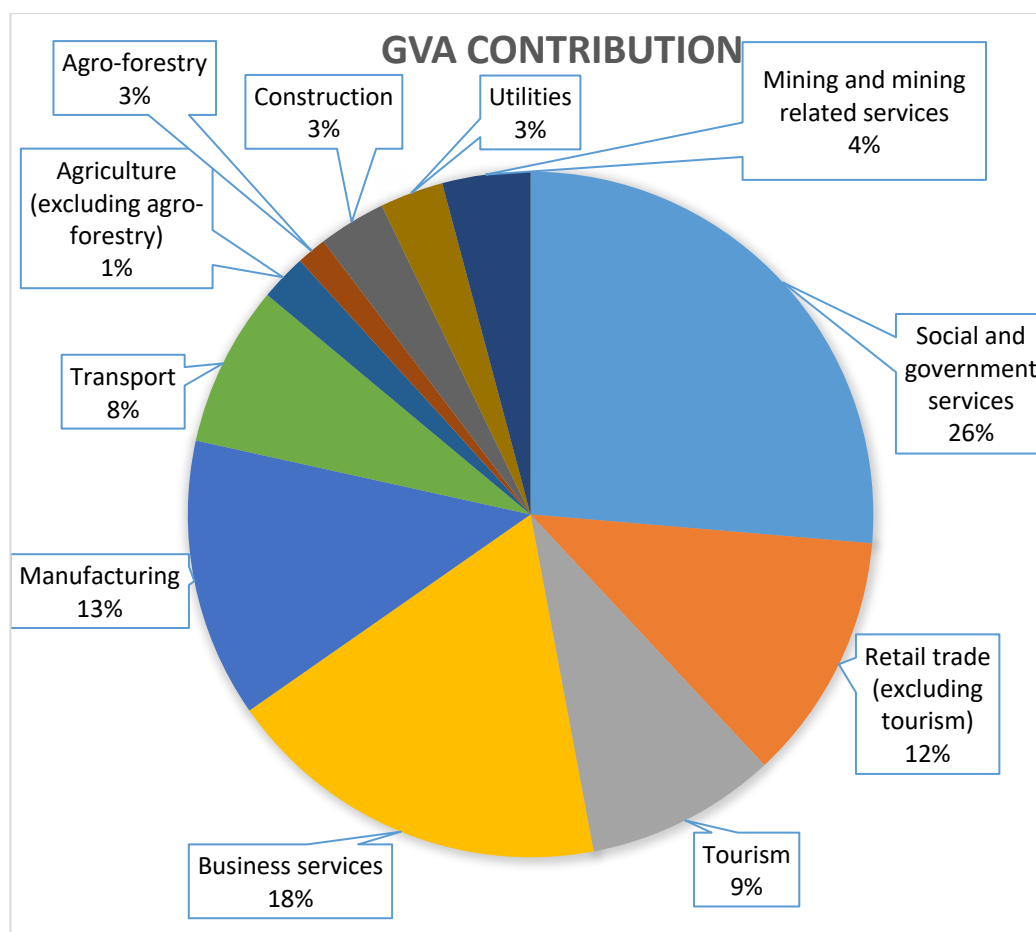


Figure 5-1: GVA contribution per economic sector

### 5.3. Employment

The majority of employees are employed in the government and social services sector (116 000 people) making up 28% of the work force in 2019 (Table 5-3). The second highest employer was the retail and trade sector (excluding tourism) which employed 13% of the workforce. The agriculture sector (excluding agro-forestry) employs 6%. Agroforestry employed 7% of the workforce and business employed 12% and tourism employed 10% of the workforce (these included tourism related businesses). Mining and related services only employed only 1% of the workforce.

Table 5-3: Employment by sector in the Sabie River Catchment

Economic sector	Number of people employed in 2016	Number of people employed in 2019 (estimate)	Percentage employed per sector
Social and government services	116 462	118 092	28
Retail trade (excluding tourism)	54 432	55 194	13

Tourism	40 824	41 396	10
Agriculture (excll. agro-forestry)	25 041	25 392	6
Agro-forestry	30 482	30 909	7
Business services	50 628	51 337	12
Construction	37 138	37 658	9
Manufacturing	29 282	29 692	7
Transport	18 046	18 298	4
Mining and mining related services	4 965	5 035	1
Utilities	2 292	2 324	1
<b>Total</b>	<b>409 594</b>	<b>415 328</b>	<b>100</b>

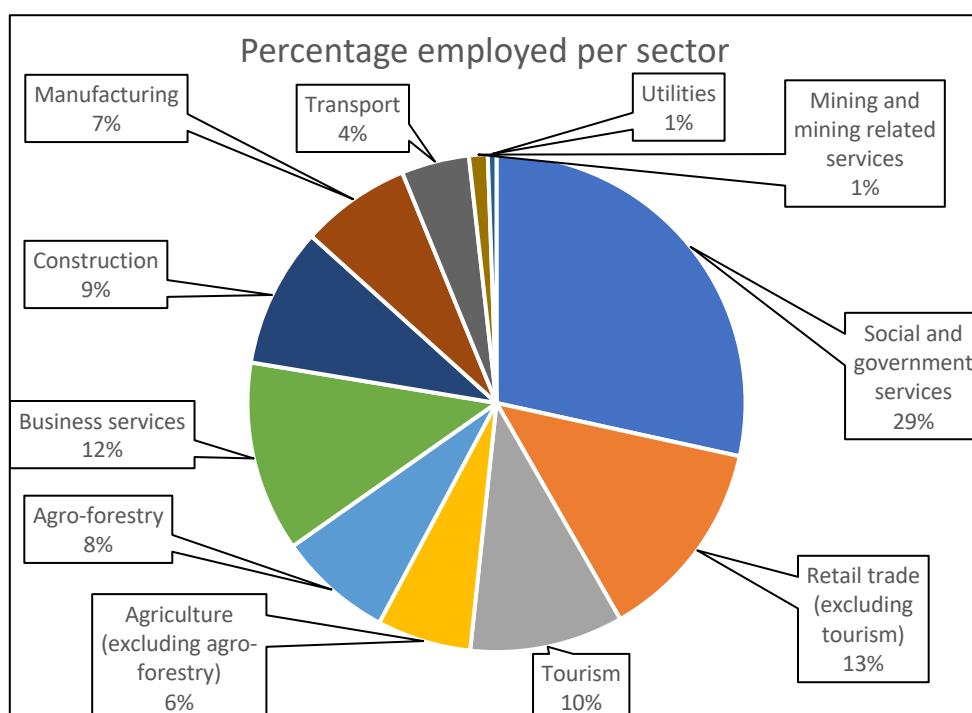


Figure 5-2: The employment per economic sector by percentage

One other good measure of economic performance is the amount of money paid as salaries to the employees. Table 5-4 illustrates the compensation to employment per economic sector. A total of about R80.4 billion is paid to employees of the sectors annually.

Table 5-4: Salaries and wages paid to employees in the catchment

Economic sector	Annual salaries paid in 2019 (R millions)	Average salary per capita per month (R)
Agriculture (excluding agro-forestry)	1 232	4 043
Agro-forestry	1 500	4 043
Mining and mining related services	1 329	22 000
Manufacturing	6 564	18 423
Utilities	837	30 000
Construction	7 882	17 442
Retail trade (excluding tourism)	9 071	13 696
Tourism	6 804	13 696
Transport	3 294	15 000
Business services	13 553	22 000
Social and government services	28 342	20 000
<b>Total</b>	<b>80 408</b>	

## 6. Ecological Profile

### 6.1. Protected Areas

More than half of the catchment falls within protected areas with the KNP representing the greatest extent of land classification in the catchment (Figure 6-1). Other significant protected areas include the Sabi Sands Private Nature Reserve, Bosbokrand Nature Reserve, Mac Mac Reserve and the Hartbeesvlakte Forest Reserve (Figure 6-1). The northern part of the catchment also includes the southern portion of the K2C biosphere reserve.

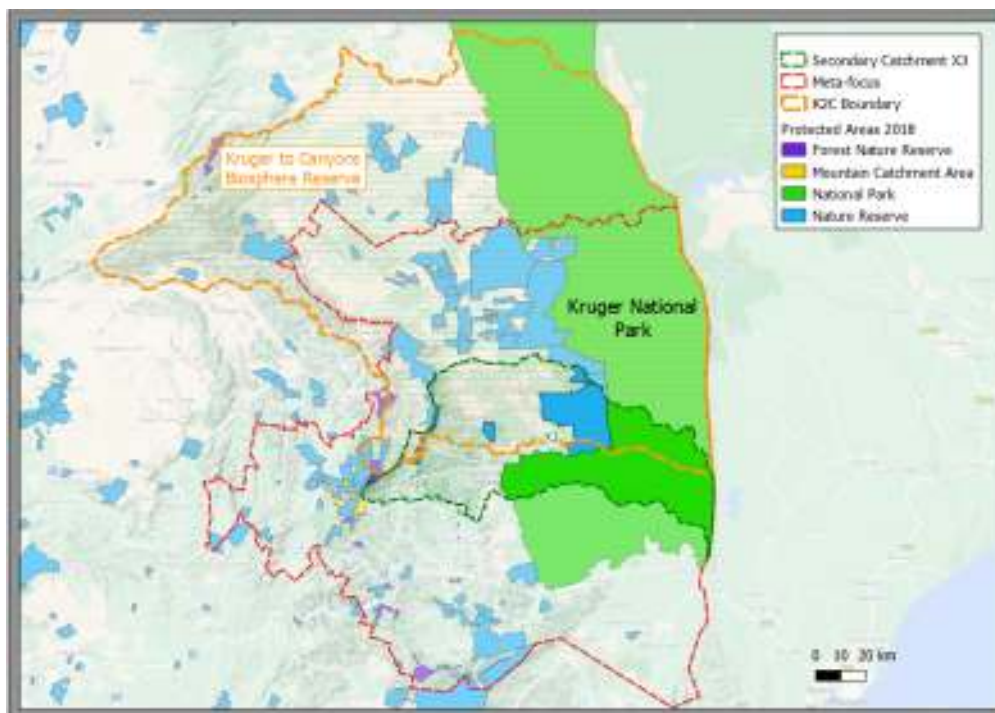


Figure 6-1: Protected areas in the Sabie River Catchment (DEFF 2018)

### 6.2. Ecological Infrastructure

The X3 catchment extends from a maximum elevation of 2 154m in the far western escarpment, to a minimum of 135m where the Sabie River leaves South Africa and flows into Mozambique (Figure 6-2). Key water resources in the catchment include various large wetland systems, rivers, dams and impoundments. Largest rivers include the Sabie and the Sand with smaller tributaries of the Mante, Nwaswitshaka and Matsavana draining into them (Figure 6-2). The headwaters of the Sand and Sabie Rivers are established in the escarpment

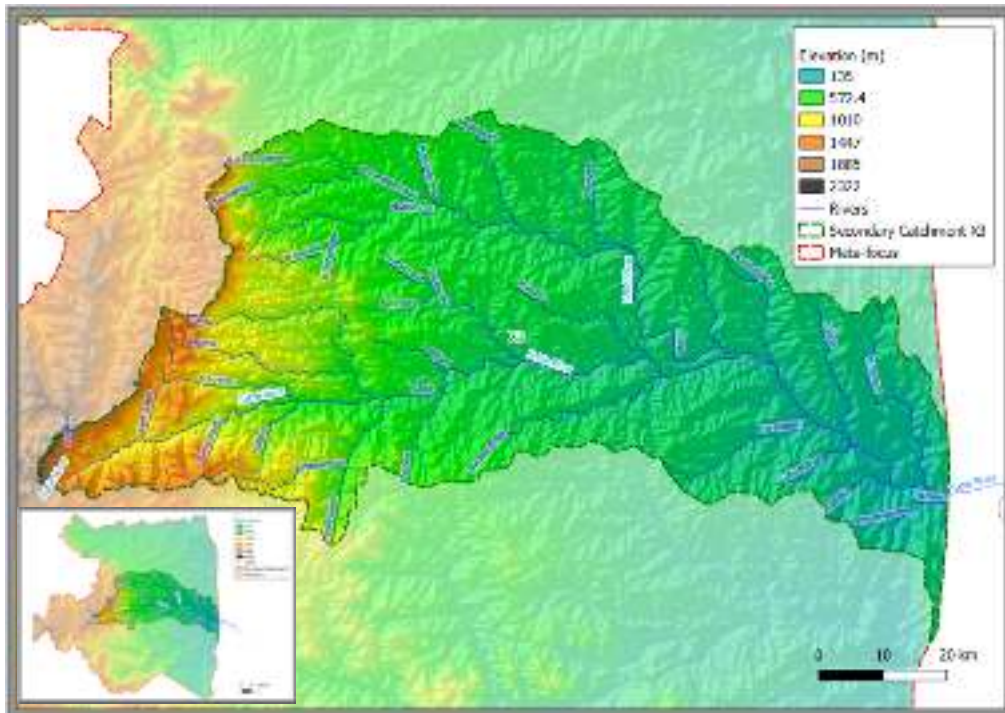


Figure 6-2: Elevation of the Sabie River Catchment

The national Strategic Water Source Area (SWSA) extends from the Drakensberg in Eastern Cape through Eswatini northward along the upper X3 catchment towards Tzaneen and Thohoyandou. The upper X3 catchment represents a significant region for capturing precipitation on a national scale (Figure 6-3)

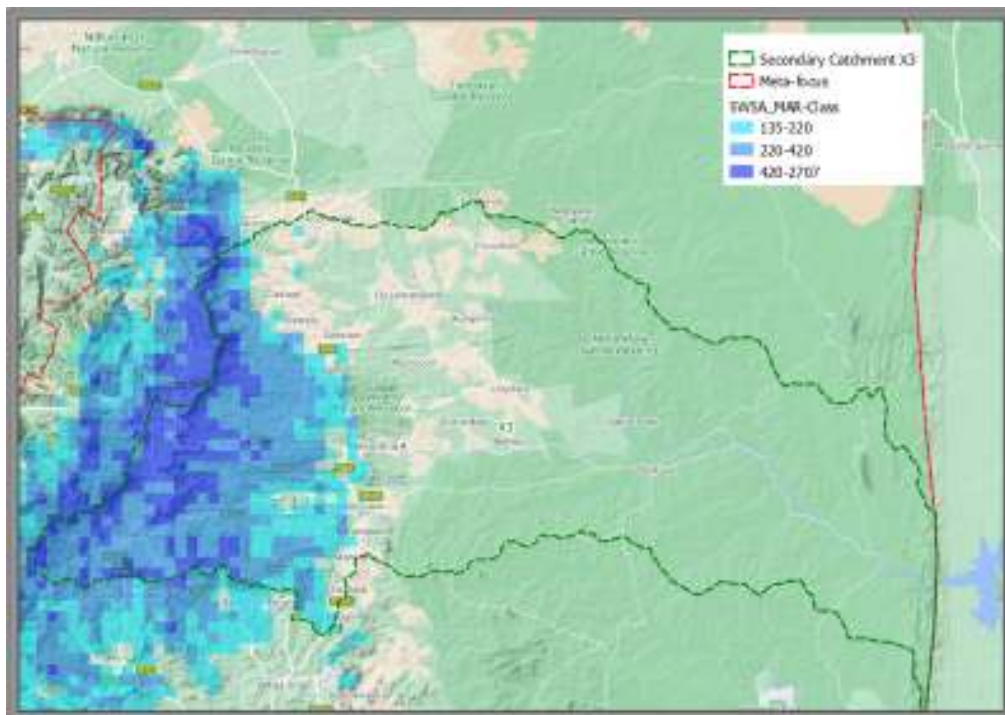


Figure 6-3: Strategic Water Source Areas associated with the Sabie River Catchment

The Integrated Spatial Prioritization for the Greater KNP Buffer (K2C 2017) identified the general extent and locality of key ecosystem services, based on the presence and condition of associated aquatic ecological infrastructure, across the buffer region of the KNP.

The process prioritised four regulating ecosystem service flows which are important in the water economy of a catchment. These included water quality regulation, water production and stream flow regulation, flood attenuation and erosion regulation. The distribution and relative flow of these services were demonstrated through the identifying the presence and condition of ecological infrastructure (EI) important for providing these services.

The following databases were used in this process:

- Rivers (NFEPA 2011)
- Streams (perennial and non-perennial) (Surveys and Mapping 1:50 000 river data)
- Wetlands (NFEPA 2011 and WRC 2014)
- Gullies (Mararakanye and Le Roux 2012)
- Runoff (Nel et al 2013)
- Strategic Water Source Areas (Nel 2013)
- Condition as per land cover classification (DEA 2014)

Please note: The spatial limits in the K2C report as pertaining to this report (i.e., inclusion of Thaba Chewu Local Municipality) were filled using similar techniques to illustrate the patterns of water related EI in the region. Although the alignment is not perfect, the exercise effectively illustrates spatial extent of valuable water related ecological infrastructure throughout the Sabie catchment.

### **6.2.1. Water Production and Stream Flow Regulation**

The distribution of water production and stream flow augmentation services were indicated through the locality of wetlands (specific to water quantity regulation) and river features. The extent of distribution (utilizing buffers) varied with classifications of water yields, size of the feature, wetland type and condition. The results, as per Figure 6-4, indicate the upper catchment to represent the greatest potential for water production with high presence of key ecological infrastructure however, due to land transformation, flow has likely been impacted through transformed EI. Moving out of the SWSA, the service is reduced significantly however the extensive network of waterways and wetlands provide a valuable service. Impacts on this flow are evident around development centers but are reduced moving downstream into the protected areas.

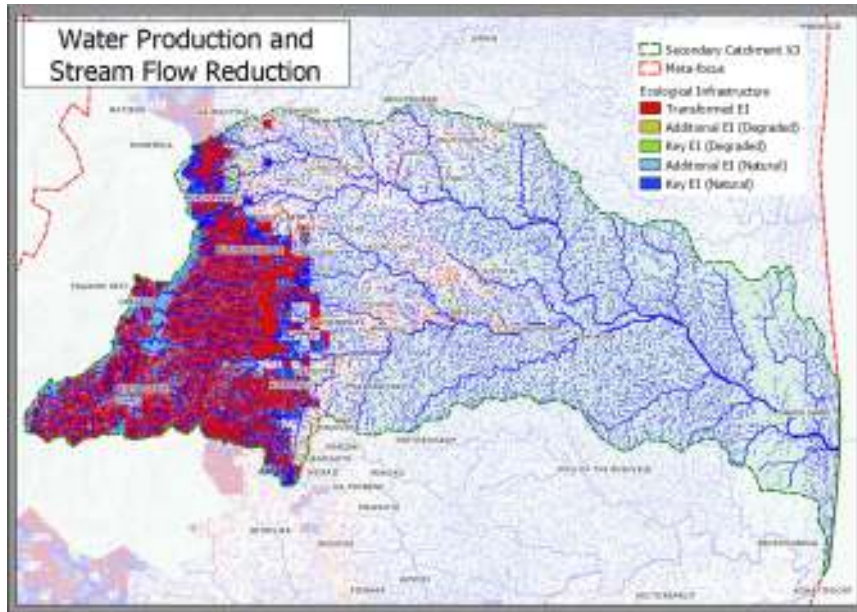


Figure 6-4: Distribution of ecological infrastructure important for water production and stream flow regulation in the Sabie River Catchment (K2C 2017)

### 6.2.2. Water Quality Regulation

The distribution of water quality regulation services (water quality enhancement or maintenance) was indicated through the locality of wetlands (specific to water quality regulation) and river features. The extent of distribution (utilizing buffers) varied with the size, type and condition. The results (Figure 6-5) indicate a relatively homogenous pattern of key ecological infrastructure important for water quality regulation. The condition of these features improving with decreasing land use intensity towards the protected areas.

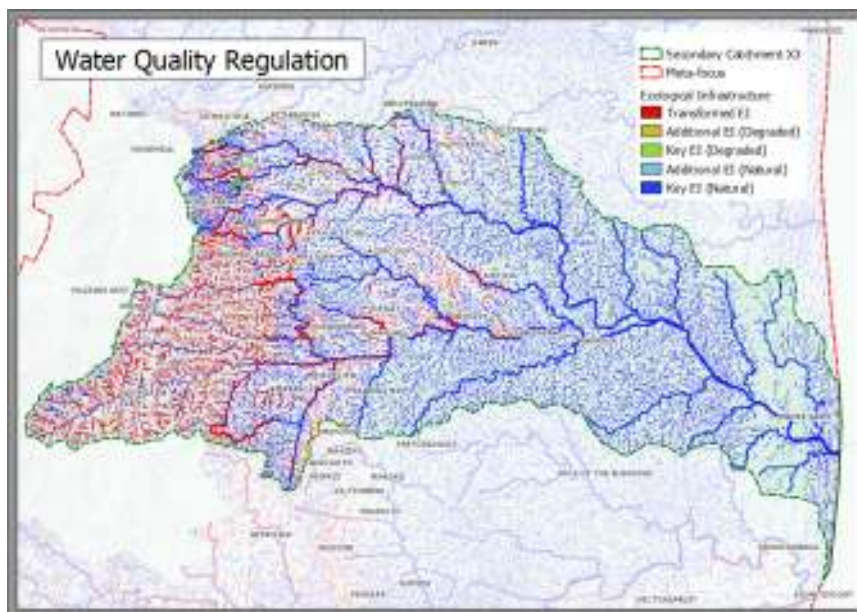


Figure 6-5: Distribution of ecological infrastructure important for water quality regulation in the Sabie River Catchment (K2C 2017)

### 6.2.3. Flood Attenuation

The distribution of flood attenuation services was indicated through the locality of wetland types known to delay flood peaks and reduce intensity of floods and river features. The extent of distribution (utilizing buffers) varied with the type and condition of the feature. The results (Figure 6-6) indicate a comparatively limited extent of EI key for providing this service and a larger extent of secondary EI. The characteristic pattern of land use in the catchment can similarly be seen by the impact on the EI.

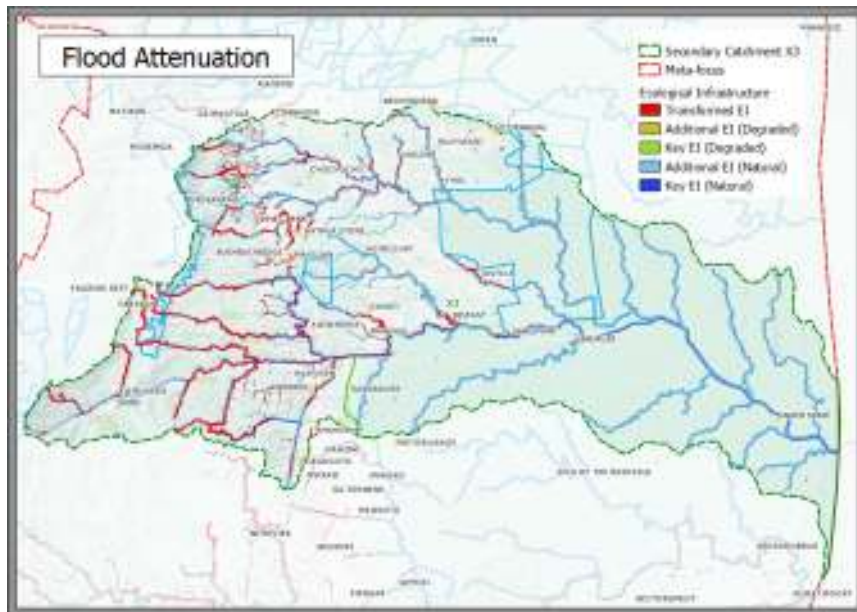


Figure 6-6: Distribution of ecological infrastructure important for flood attenuation in the Sabie River Catchment (K2C 2017)

### 6.2.4. Erosion Regulation

The distribution of erosion regulation services was indicated through the locality of erosion prone areas indicated by national gully erosion maps, wetlands and riparian buffers which were identified to be important for erosion regulation. The extent of distribution varied with the type and condition of the feature. The results show key ecological infrastructure in the upper (northern Morolaneng) and lower catchment (KNP). Similarly, to other services the likely flow of this service is reduced through impacted or transformed ecological infrastructure.

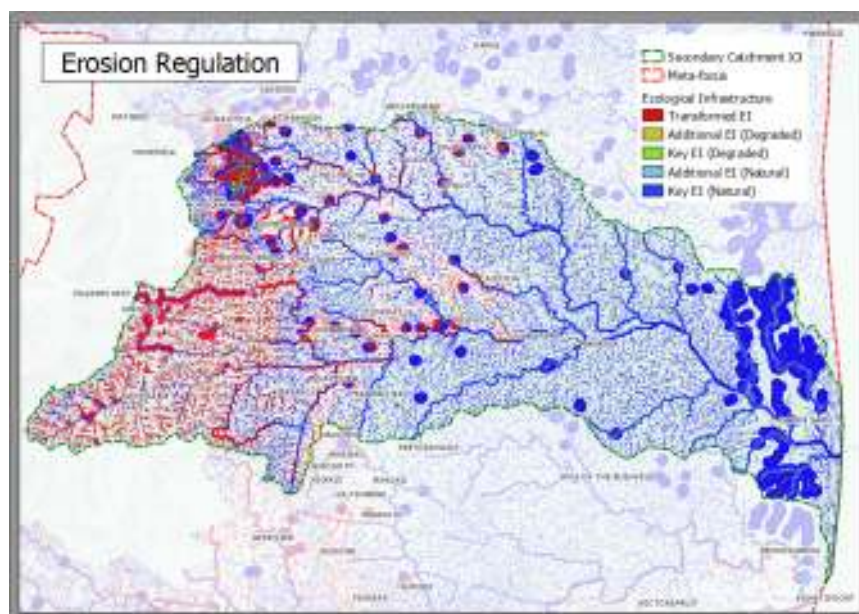


Figure 6-7: Distribution of ecological infrastructure important for erosion regulation in the Sabie River Catchment (K2C 2017)

### 6.2.5. Combined Ecological Infrastructure

The four outputs were combined into a consolidated map indicating the distribution of ecological infrastructure important for providing water regulating services to the catchment (Figure 6-8).

A series of observations can be from these results:

- 1) Water related ecosystem services can generally be found throughout the catchment.
- 2) Ecosystem services hotspots are identified in the upper and lower catchment
  - a. This is largely due to the locality of the SWSA, flood attenuating wetlands and other key EI in the KNP.
- 3) Transformed ecological infrastructure is generally situated in the upper reaches of the catchment and scattered occurrences throughout the catchment.
  - a. Transformation is observed due to land use transformation associated with settlements. The upper reaches transformation of the SWSA is due to extensive plantations in the region.
  - b. Protection status of land in the lower reaches are the likely driver of untransformed EI.
- 4) High impact regions for restoring water related ecosystem services can be found within SWSA in the upper catchment.

Please note the K2C 2017 study did not include the remainder upstream region of the X3 catchment. As such, due to the relatively homogenous land use (plantations) and presence of the SWSA, the pattern of ecological infrastructure, land use and related ecosystem services (seen to abruptly stop in Figure 6-8) is assumed to extend to the upper reaches of the catchment.

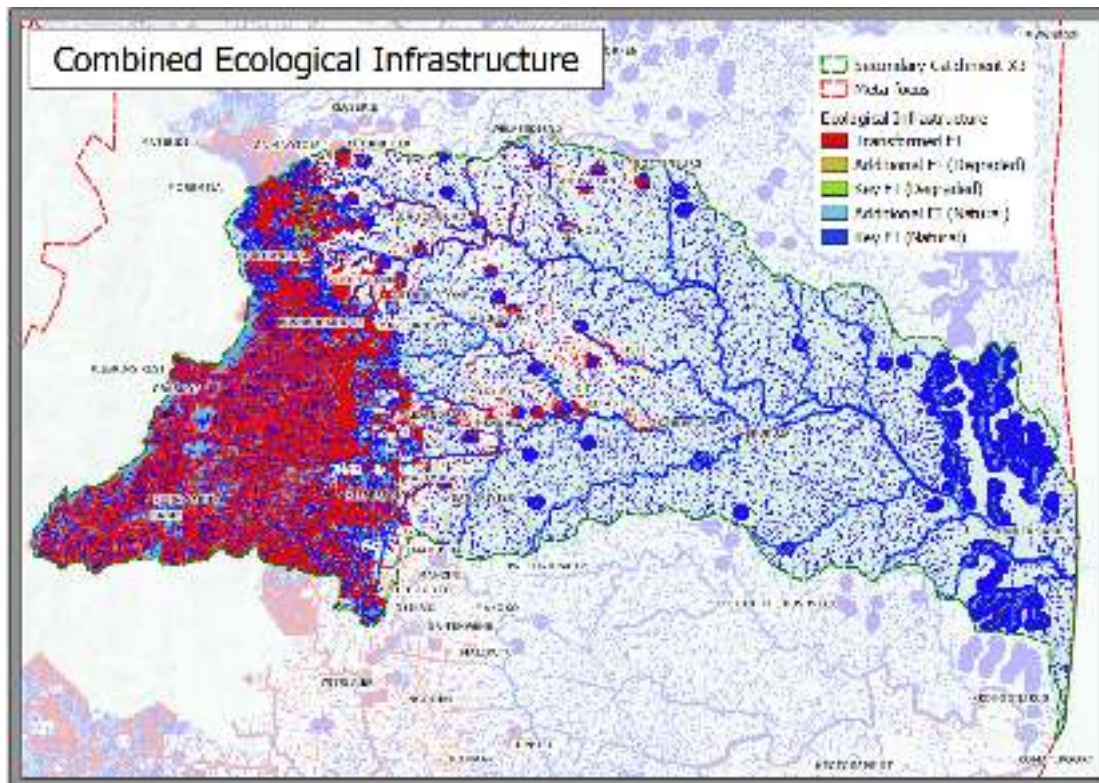


Figure 6-8: Combined water related ecological infrastructure important for water regulation ecosystem services in the Sabie River Catchment (K2C 2017)

## 7. Water Augmentation Scenarios

Based on discussions with the PSC and the options proposed in the Mbombela Reconciliation Strategy (DWS, 2020), four scenarios were selected for analysis. Changes in yield will have an impact on the delivery of ecosystem services and on socio-economic parameters. Scenario 1 can be considered as the ecological scenario, while scenarios 2, 3 and 4 can be considered developmental scenarios, where hard infrastructure will need to be put in place.

Scenario Number	Scenario Name	Description	Additional Yield <sup>3</sup> (Mm /annum)
SC1	Ecological Scenario	The removal of alien invasive species within the upper reaches of the X31E catchment could lead to an increase in yield for the Inyaka Dam. Additionally, the implementation of sustainable land management (SLM) practices and stewardship incentives with private and government landowners of primarily forestry land in the upper reaches of the X31E catchment would also lead to an increase in yield for the Inyaka Dam.	3
SC2	Increased return flows from wastewater treatment works (WWTW)	The conversion of the oxidation ponds to treated effluent WTW could result in additional return flows.	6
SC3	Development of groundwater resources	Sustainable development of groundwater resources in the Bushbuckridge LM.	10,5
SC4	Construction of a new dam.	Construction of the new Dingleydale Dam in the Sand River Catchment.	20,6

### 7.1. Scenario 1: Ecological Scenario

The socio-economic nature of the catchment has resulted in impacts to ecological systems. These impacts provide an opportunity for ecological restoration of which result in the reclamation of ecological wealth through naturally derived socio-economic benefits. The flow of benefits is reliant on

the ability (presence and condition) of ecosystems to supply services to beneficiaries that have a demand for such services.

The ecological scenario envisages the restoration of ecological systems or/and the halting of ongoing degradation in the upper X31 and X32 catchments towards securing or returning lost ecosystem services. This scenario aims to ensure at minimum no additional loss but rather a gain in ecological wealth through improved ecosystem functioning. This is proposed through implementation of the following interventions:

- 1) Prevention of further degradation through appropriate protection of landscapes which could range through the following:
  - a) Formal protection under NEM:BA and NEM:PA
  - b) Stewardship programs
- 2) Restoration of functionality of natural ecosystems through soft and/or hard interventions including improved landscape management and rehabilitation:
  - i) Softer interventions include improved landscape management including fire, grazing, soil or water resource management.
  - ii) Hard or physical rehabilitation include interventions such as alien vegetation removal or wetland rehabilitation.

The feasibility of implementing Scenario 1 is explored here through assessing the costs of implementation against the likely ecological benefits received through local ecological restoration. The desktop approach utilizes the latest available data to demonstrate, per intervention, the likely chain of causality between ecological restoration and benefits to the catchment. Two intervention components, including alien plant removal and biodiversity stewardship, are envisaged for scenario 1.

#### 7.1.1. Removal and Management of Alien Plant Species

The current extent of stands of alien species are provided in Table 7-1 and illustrated in Figure 7-1.

Table 7-1: Extent of alien species stands in the X31 and X32 catchments (DWS 2020)

Catchment	Total Alien Extent Ha	Reference
X31E-Upstream of Nyaka Dam	1 832	Mbombela Reconciliation Strategy (DWS 2020)- Assume stand density is equal to that seen in X31
X31	18 260	Mbombela Reconciliation Strategy (DWS 2020)
X32	3 310	Mbombela Reconciliation Strategy (DWS 2020)

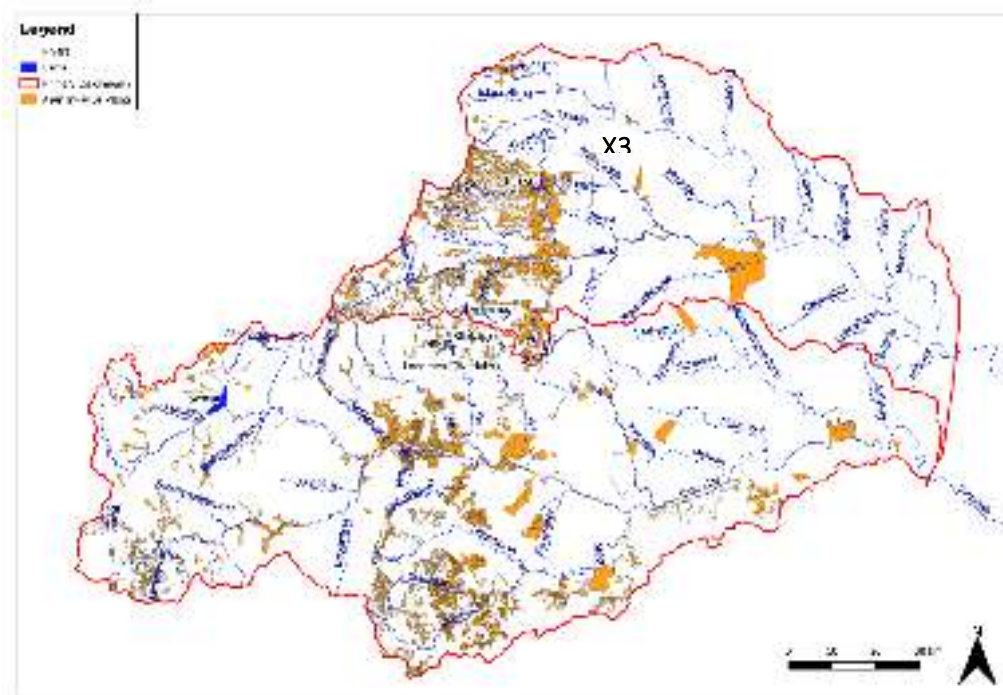


Figure 7-1: Extent of alien plant species in the X31 and X32 tertiary catchments (SANBI 2014)

### 7.1.2. Costs

The costs of alien clearing have a high variation depending on the topography, target species, species age, density and distance from processing facility. Removal of alien stands in the target regions (including removal, chipping and transport) range between R30 000 and R110 000 per Ha (corrected to 2021 value at 6% inflation) for high density stands (Mugido et al. 2014). The perceived cost ranges of alien removal for the target region are presented in

Table 7-2.

Table 7-2: Estimated cost range for alien removal in the study area

Catchment	Total cost of Removal (mil ZAR)	
	Minimum	Maximum
X31E-Upstream of Nyaka Dam	55	200
X31	548	2000
X32	100	365

While this scenario would probably be the quickest and easiest to implement, it is also likely that it would be an ongoing process to cover all the relevant encroached areas, and ensure that cleared areas are kept clear, allowing for natural vegetation to take hold. For this reason, and for uniformity with the other scenarios, the total costs of implementing this intervention were spread over a period of 20 years,

with a discount rate of 6% applied to estimate the Unit Reference Values (URV) for the minimum and maximum discounted costs. This is summarised in Table 7-3 below.

Table 7-3: Summary of Unit Reference Value for the clearing of invasive alien species.

Cost scenario	Total discounted costs (Rands)	Estimated yield (million m <sup>3</sup> /annum)	URV (R/m <sup>3</sup> )
Minimum	R31 500 000	3	R2.10
Maximum	R115 600 000		R7.80

### 7.1.3. Biodiversity Stewardship

The biodiversity stewardship component of Scenario 1 aims to see ecological systems (both natural, degraded or unnatural) being managed towards maximizing, securing and/or restoring ecological functionality to the region.

Biodiversity Stewardship is defined by SANBI (2015) as:

“an approach to entering into agreements with private and communal landowners to protect and manage land in biodiversity priority areas, led by conservation authorities in South Africa. It recognises landowners as the custodians of biodiversity on their land. Biodiversity stewardship is based on voluntary commitments from landowners, with a range of different types of biodiversity stewardship agreements available to support conservation and sustainable resource use. Some types of biodiversity stewardship agreements are formally declared as protected areas in terms of the Protected Areas Act, providing long-term security for the sites involved (SANBI 2015)”

The headwaters of the X3 catchment represents a Strategic Water Source Areas (SWSA) and therefore fall within 10% of land that produce 50% of total national runoff. This provides a valuable opportunity, within this highly significant water resource area, to facilitate sustainable management of these systems, in line with the principles of biodiversity maintenance and ecological functionality.

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The target region represents a total area of approximately 180 000 ha (including the X31A, X31B, X31C, X31D, X31E, X31F, X31G, X31H, X31J, X32A, X32B, X32D and X32E quaternary catchments-see Figure 7-2).

Landscapes available for stewardship implementation within the region comprises approximately 138 000ha (58 000 ha untransformed, natural and degraded land and 80 000 ha of plantations) (Figure 7-2).

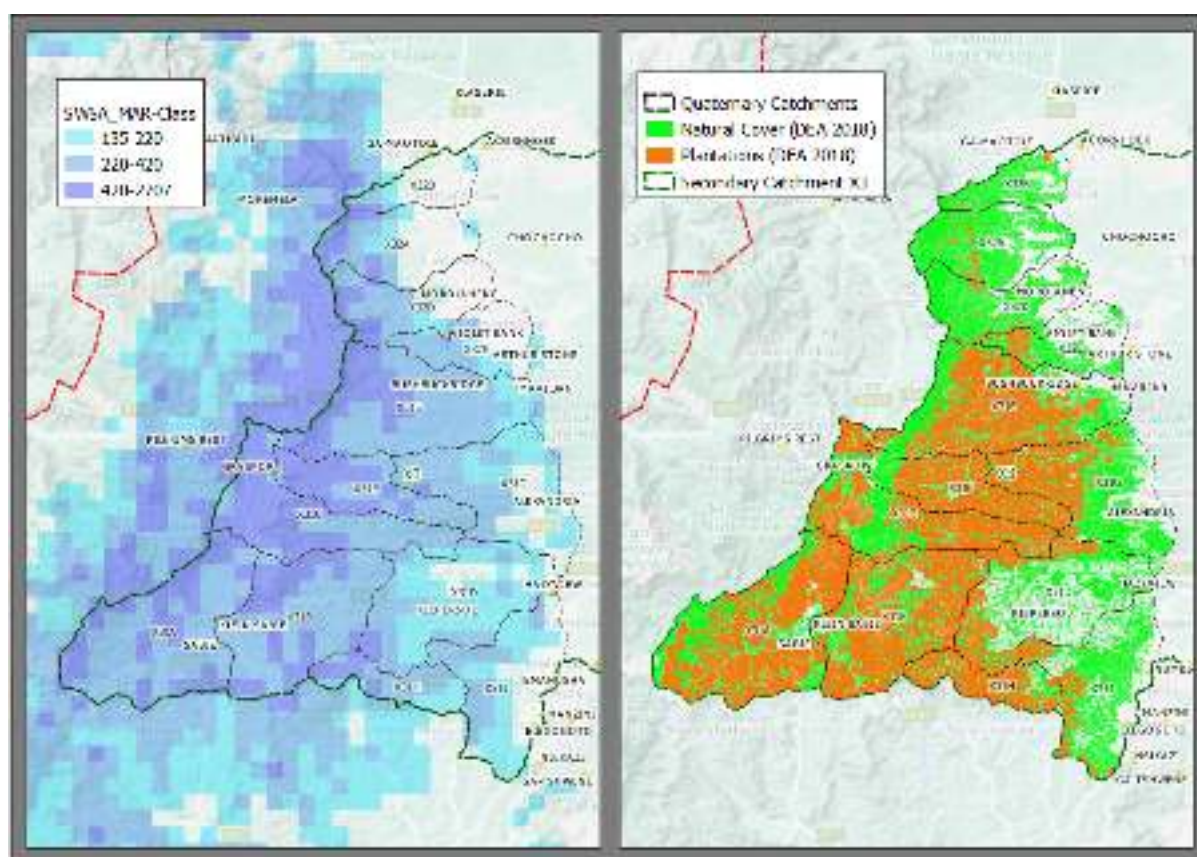


Figure 7-2: Focus area of stewardship implementation and target landscapes in the X3 catchment

Based on the SWSA classification of the region (Nel *et al.* 2013), these landscapes available for stewardship, under a predevelopment scenario, would produce cumulative mean annual runoff of between 0.37 and 1,5 billion m<sup>3</sup> per year (Table 7-4). Due to land transformation and impacts on ecosystem health, this MAR range is currently not being achieved. The volume, however, represents what could be achieved if the focal catchments are restored to natural conditions.

Table 7-4: Total natural MAR per year for land under specific land type classification (at predevelopment). This volume per year is the product of area of untransformed, natural and degraded land and plantations (i.e., all excluding agricultural and urban developed areas) under each target quaternary catchment and the associated SWSA MAR class (Nel *et al.* 2013).

Land Use Type	Area (Ha)	MAR (under predevelopment scenario) (billion m <sup>3</sup> /a)	
		Minimum	Maximum
Untransformed, natural and degraded land	58 000	0.15	0.6

Plantations	80 000	0.23	0.94
Total	138 000	0.37	1.54

Variations in land conditions and land use changes from natural conditions (predevelopment or impact) influences both the magnitude and reliability of these flows as is currently seen throughout the catchment. As an example, degraded land would result in increased runoff in wet seasons however due to reduced infiltration during these periods would have reduced baseflows and even zero flows in dry seasons (hydrograph would be extreme). Inversely a healthy ecosystem would generally absorb high flows and maintain baseflows in the dry season. The natural cumulative mean annual runoff therefore represents an opportunity substantial contribution to the socio-economic wellbeing of the catchment and downstream social, economic and ecological beneficiaries.

Although the presence of plantations throughout this region, has resulted in a reduction in natural MAR (due to the increased evapotranspiration compared to native vegetation (Le Maitre *et al.* 2018)) the focus of stewardship in these areas will be on improvement of operational management of water resources. In a badly managed plantation, operational characteristics may result in alternative impacts on ecosystems including:

- Sedimentation from harvesting or planting related activities;
- Sedimentation from poorly designed and maintained road networks;
- Stream flow reduction and lowering of water courses;
- Invasion of plantation species of neighbouring areas; and
- Herbicides and pesticides introduced into water cycle (Le Maitre *et al.* 2018).

The WWF works with diverse water users through their Water Stewardship Programme to drive the sustainable management of water resources. The focus is on intensive water users including agriculture and forestry sectors. The WWF water stewardship model takes a risk-based approach and aims to work with landowners to improve water management on their land. Specific interventions would vary depending on the landowner and characteristics of the plantation. Table 7-5 and Figure 7-3 outline key characteristics of the plantations within the SWSA in the catchment.

Table 7-5: Area of plantations within SWSA classes in the headwaters of the X3 catchment by ownership type (Ownership from DALRRD 2015; Land Cover from DEFF 2018)

SWSA Class (MAR)	Area of plantation under ownership type (Ha)			
	State Owned	Private Owned	Unknown Ownership	Total
1 (420-2700)	14 077	10 494	2 147	26 719
2 (220-420)	23 159	21 358	4 369	48 886

SWSA Class (MAR)	Area of plantation under ownership type (Ha)			
	State Owned	Private Owned	Unknown Ownership	Total
3 (135-220)	1 090	2 210	1 262	4 562
<b>Total</b>	<b>38 326</b>	<b>34 062</b>	<b>7 778</b>	<b>80 167</b>

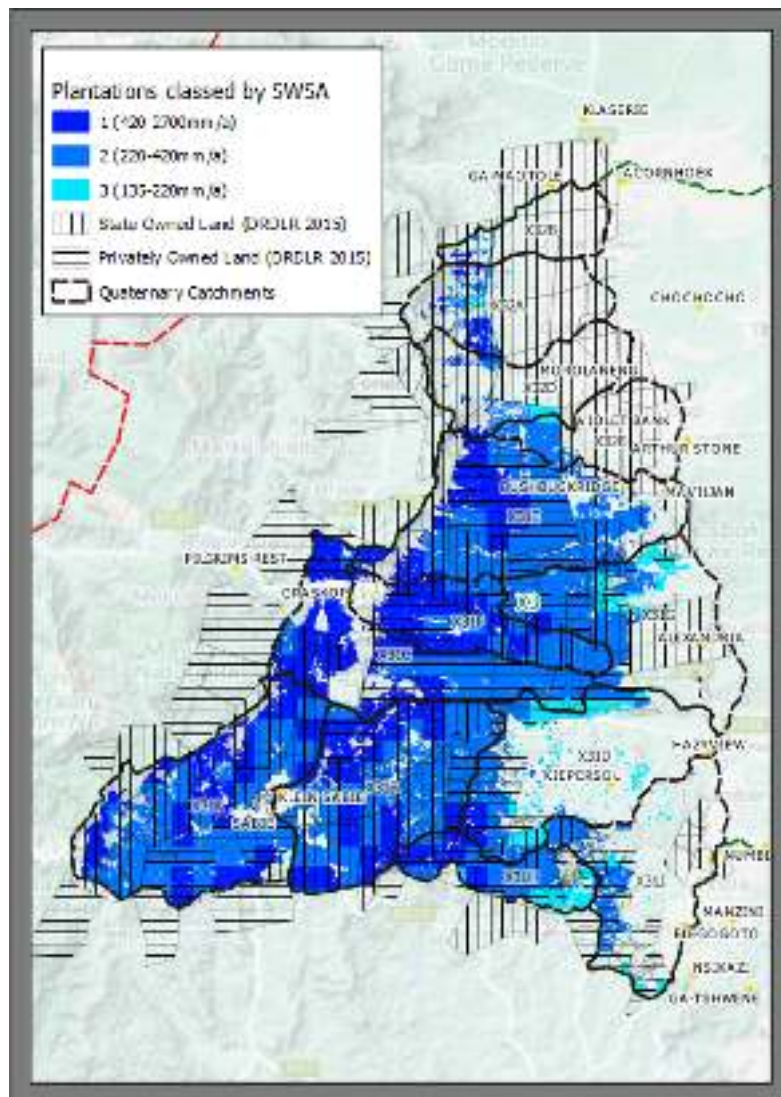


Figure 7-3: Locality of land under plantations within SWSA classes in the headwaters of the X3 catchment by ownership type (Ownership from DALRRD 2015; Land Cover from DEFF 2018)

The catchment is representative of scattered natural regions which are associated with the fringes of plantations, valleys and ravines and along the escarpment. Variations in ecological condition, impacts from land uses and improper land management, on these areas, are expected to have impacted on the reliability of flows and water regulation in the sub-catchment.

Stewardship of untransformed land focuses on the restoration of native condition through implementation of the following interventions (which would likely vary depending on nature and position of ecosystem):

- Fire management;
- Grazing Management;
- Reseeding of bare areas;
- Formal protection (secure condition into the future);
- Rehabilitation; and
- Alien removal and management (described above)

The stewardship approach to untransformed natural and degraded land will focus on land rehabilitation, management and, where possible, protection, to secure and maintain the condition of native vegetation and ecosystems present.

Table 7-6 and Figure 7-4 outline the extent, SWSA significance and ownership of untransformed land within the SWSA in the catchment.

*Table 7-6: Area of untransformed land within SWSA classes in the headwaters of the X3 catchment by ownership type (Ownership from DALRRD 2015; Land Cover from DEFF 2018)*

Land Cover Type	SWSA Class (MAR)	Area of untransformed land under ownership type (Ha)			
		State Owned	Private Owned	Unknown Ownership	Total
Degraded Land	1 (420-2700)	7	4	6	18
	2 (220-420)	160	47	290	496
	3 (135-220)	256	401	638	1 295
Forest/ Thicket/ Woodland	1 (420-2700)	8 917	2 446	2 293	13 656
	2 (220-420)	11 820	3 949	4 428	20 197
	3 (135-220)	3 902	1 893	7 704	13 499
Grassland	1 (420-2700)	1 629	244	1 152	3 024
	2 (220-420)	1 012	515	796	2 324
	3 (135-220)	172	121	288	580
Wetlands	1 (420-2700)	193	158	91	441
	2 (220-420)	305	266	156	727
	3 (135-220)	164	39	166	369
Total	Grand Total	28 829	10 275	18 715	57 819

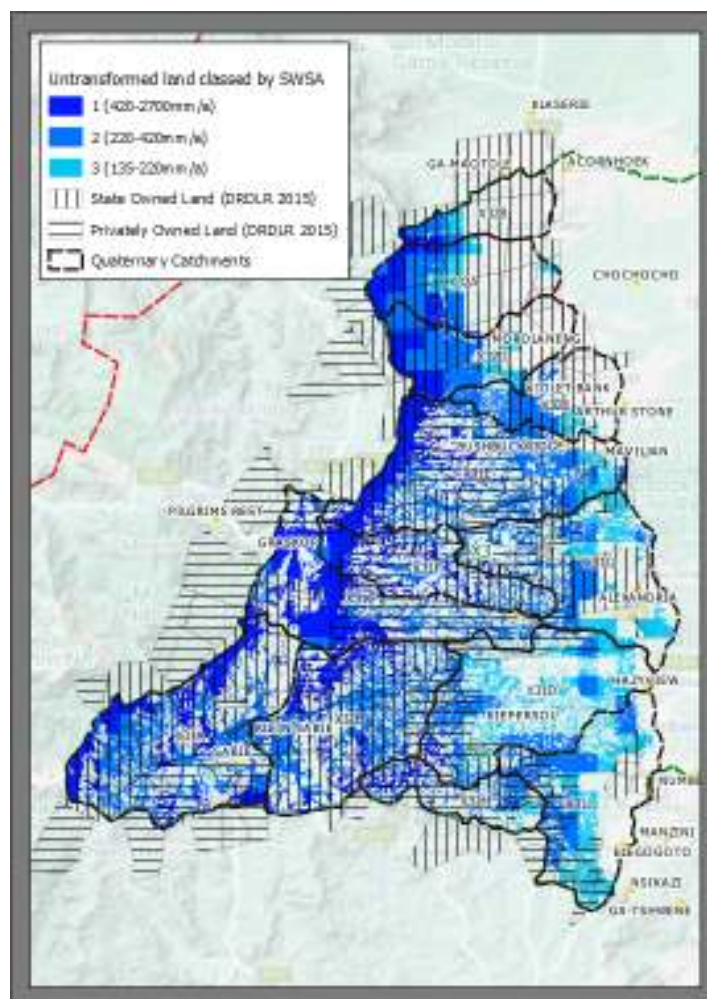


Figure 7-4: Locality of untransformed land within SWSA classes in the headwaters of the X3 catchment by ownership type (Ownership from DALRRD 2015; Land Cover from DEFF 2018)

#### 7.1.4. Costs

The costs for implementing water stewardship in plantations are not included here however would likely be absorbed into the operational costs of sustainable management.

For the sake of a costing demonstration, likely interventions proposed under stewardship (excluding alien vegetation removal) for untransformed land include fire and grazing management. The indicative costs are provided in Table 7-7.

Table 7-7: Cost estimates for fire and grazing management of untransformed land within the SWSA in the headwaters of the X3 catchment (Cost estimates sourced from Blignaut et al. 2010 and corrected for 2021). Land cover classes were delineated based on the 2018 LandCover database (DEFF 2018) with Degraded land (Collating Bare, Degraded, Fallow Land & old fields classification); Forest/Thicket/Woodland (Collating contiguous forest, low forest and thicket, dense forest and woodland, open woodland classification); Grassland (including natural grassland classification only); Wetland (including currently and previously mapped wetland classification).

Land Cover Class	Area (ha)	Total Cost (ZAR/a)
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		Fire Management (@ 20 ZAR/ha)	Grazing Operations and Management (@ 30 ZAR/ha)	Total
Degraded Land	1 800	40 000	60 000	100 000
Forest/ Thicket/ Woodland	47 000	950 000	1 560 000	2 510 000
Grassland	6 000	120 000	200 000	320 000
Wetlands	1 500	30 000	50 000	80 000

Class 1 SWSA regions should be prioritised for stewardship implementation. Depending on the implementer, the land-owner type should be considered to ensure maximised ease of implementation. Please note, the analysis above provides spatial opportunities for improved ecosystem health across the region and is not limited to stewardship only. The analysis can be used at a broader scale to identify opportunities for ad hoc interventions towards improving ecosystem health and support the flow of ecosystem services.

## 7.2. Scenario 2: Increased Return Flows from Wastewater Treatment Works (WWTW)

### 7.2.1. Scenario Description

Within the study area, there is scope for adding to the water balance if reuse from wastewater is considered. Currently, the majority of schemes in the Sabie and Sand River catchment (Figure 7-5) do not have formal wastewater treatment works and the majority of wastewater is managed through oxidation ponds. The water stays in the ponds after treatment, evaporates and only limited volumes are returned to the river system for potential downstream use. The location of the oxidation ponds, particularly in the Sand catchment, indicates that downstream users, including the EWR, could benefit from return flows of treated effluent into the system.

The conversion of the oxidation ponds to treated effluent within the system could result in return flows of an additional **8 Mm<sup>3</sup>/annum**. This increase in yield would be spread throughout the system and would not impact on the yield of the Inyaka Dam.



Figure 7-5. Location of wastewater treatment works in the Sabie-Sand River Catchment

Table 7-8: Location and operational flow of WWTWs taken into consideration.

WSA Name	Name	Owner Type	Main Process	Operational Flow (Ml/d; 2021)
Bushbuckridge	Bushbuckridge Police Station STW	Private	No Information	0.5*
Bushbuckridge	Dwarsloop	Public - Municipal	Biofilter & Humus settling tank	2.49
Thaba Chweu	Graskop	Public - Municipal	Activated Sludge	1.00
Mbombela	Hazyview	Public - Municipal	Activated Sludge	1.06
Mbombela	Lower Sabie WWTW	Private		0.5*
Bushbuckridge	Manghwazi WWTW (bio disc)	Public - Municipal	No Information	0.08
Bushbuckridge	Maviljan	Public - Municipal	Oxidation Ponds	0.53
Bushbuckridge	Mkhuhlu	Public - Municipal	Oxidation Ponds	4.62
Thaba Chweu	Sabie	Public - Municipal	Activated Sludge	1.58
Bushbuckridge	Thulamahashe	Public - Municipal	Biofilter & Humus settling tank	3.17
Bushbuckridge	Thulamahashe STW	Private	No Information	0.5*

### 7.2.2. Costs

The cost of developing wastewater treatment works capable of supplying treated effluent back into the surface water system was calculated using the expected operational flows noted in Table 7-8, along with DWS sanitation costing (2019), which can be seen in Table 7-9. Expected operational flows were calculated from DWS flow data for 2018, with an assumed annual increase of 5.5% (Danida, 2020). Two types of system were considered: Activated Sludge and Rotating Biological Contactors (RBC). For the cost calculations, it was assumed that the treatment plants would be constructed in full during 2021. The capital costs were discounted over an assumed useful life of 20 years, with a discount rate of 6% applied. A summary of the resulting unit reference values is provided in Table 7-10.

Table 7-9: Indicative costs of Activated Sludge and RCB wastewater treatment systems (DWS, 2018)

Sanitation System (off-site component)		Typical Cost per Ml/d
		2019/2020
Activated sludge	< 0.5 Ml/d	R 14 854 895
	1 Ml/d	R 14 234 419
	6 Ml/d	R 12 774 479
	> 10 Ml/d	R 11 989 761
RBCs	< 0.5 Ml/d	R 15 329 375
	1 Ml/d	R 14 234 419
	6 Ml/d	R 12 021 319
	> 10 Ml/d	R 10 227 092

Table 7-10: Summary of Unit Reference Values for the development of WWTWs in the Sabie-Sand catchment

Treatment Option	Total discounted costs (Rands)	Expected yield (million m <sup>3</sup> /a)	URV (R/m <sup>3</sup> )
Activated Sludge	R90 500 000	5.85	R3.50
RCB	R155 000 000	5.85	R6.00

## 7.3. Scenario 3: Development of Groundwater Resources

### 7.3.1. Scenario Description

The availability of groundwater in the Sabie River catchment provides for the potential conjunctive use of groundwater and surface water resources in the future as the water requirements increase. Groundwater is currently not being used conjunctively with the surface water supplies in the

municipality and the boreholes that were drilled before the construction of Inyaka Dam have been decommissioned. An assessment of the groundwater potential in Bushbuckridge LM indicated that there is approximately **10.5 million m<sup>3</sup>/annum** of exploitable groundwater in the area (DWS, 2016). While this potential development falls primarily in the Sand River Catchment and is unlikely to provide utilisable yield to the Sabie, it will however take further investigation of the groundwater potential in the upper reaches of the X3 catchment would be required. Utilisation of groundwater resources in this area could alleviate pressure on the Inyaka Dam by providing additional utilisable yield for allocation to other users.

### 7.3.2. Borehole Yield

The yield from boreholes exhibits a considerable variation, even in a relatively small geographical area. Often multiple drilling operations are required before a viable well is achieved.

This number does not take into account the quality of the water which may be abstracted, however the upper range of costs used for the analysis is inclusive of basic treatment.

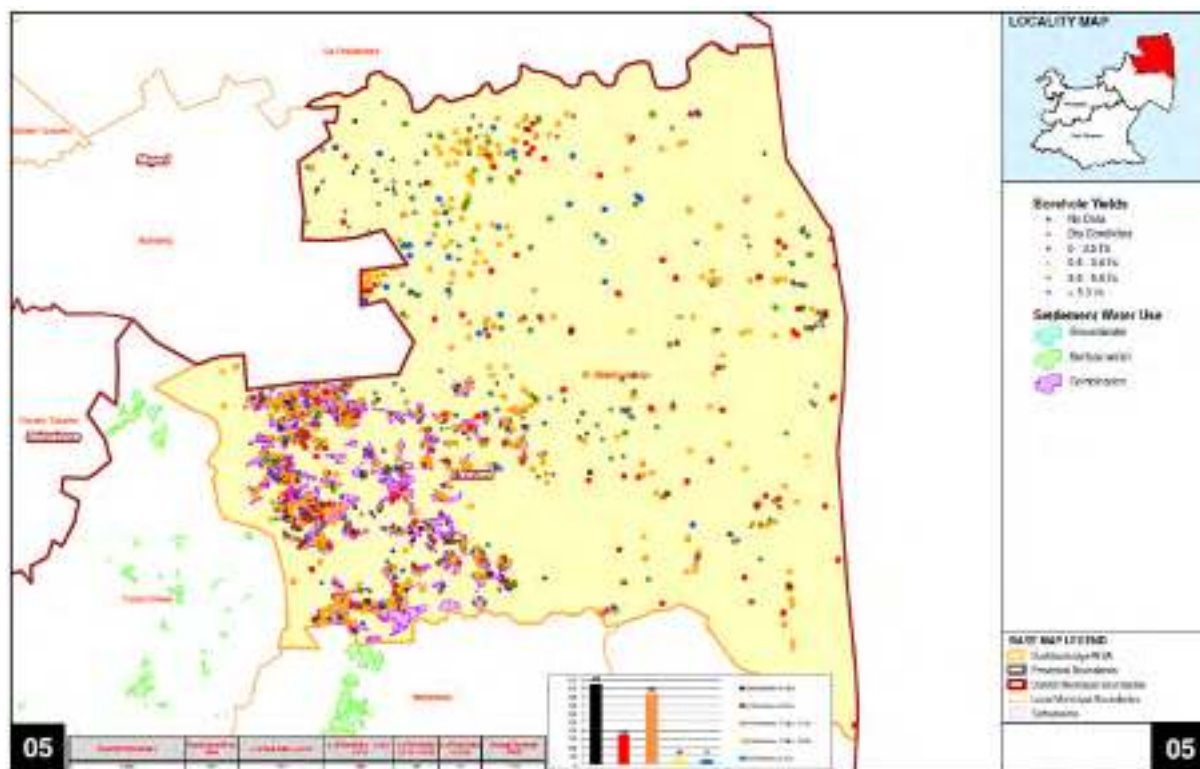


Figure 7-6 provides an indication of the borehole yields of Bushbuckridge LM. From this it was estimated that the yield of a borehole in this region would likely range between 1 and 3 liters per second, which equates to around 86 to 259 kiloliters per day. At this rate of yield, it was calculated that anywhere from 110 to 330 boreholes would be required to provide the targeted volume of 10.5 million m<sup>3</sup> per annum. This number does not take into account the quality of the water which may be abstracted, however the upper range of costs used for the analysis is inclusive of basic treatment. This number does

not take into account the quality of the water which may be abstracted, however the upper range of costs used for the analysis is inclusive of basic treatment.

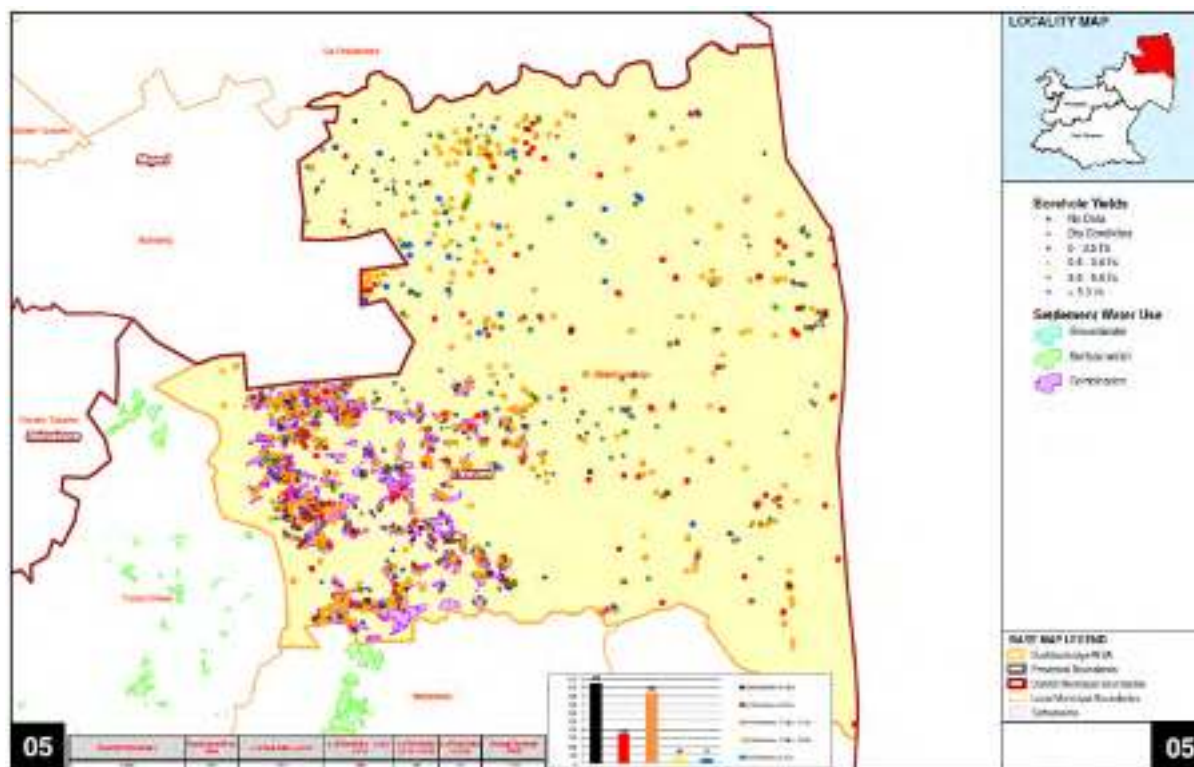


Figure 7-6: Borehole yields for the Bushbuckridge LM (DWS, 2018).

### 7.3.3. Costs

Similar to yields, the cost of developing groundwater resources varies significantly depending on, among other things, siting of boreholes, required output, and network connection costs. Through a review of budgeted costs for groundwater development in Mpumalanga (DWS, 2020), it was estimated that the installation cost of a borehole could range between R400,000 for a basic installation for onsite usage, to R870,000, inclusive of associated costs for storage, network connection, and some basic treatment. As with scenarios 1 and 3, the costs were spread out over a 20-year period, with a discount rate of 6% applied. A summary of the resulting unit reference values is provided in Table 7-11 below.

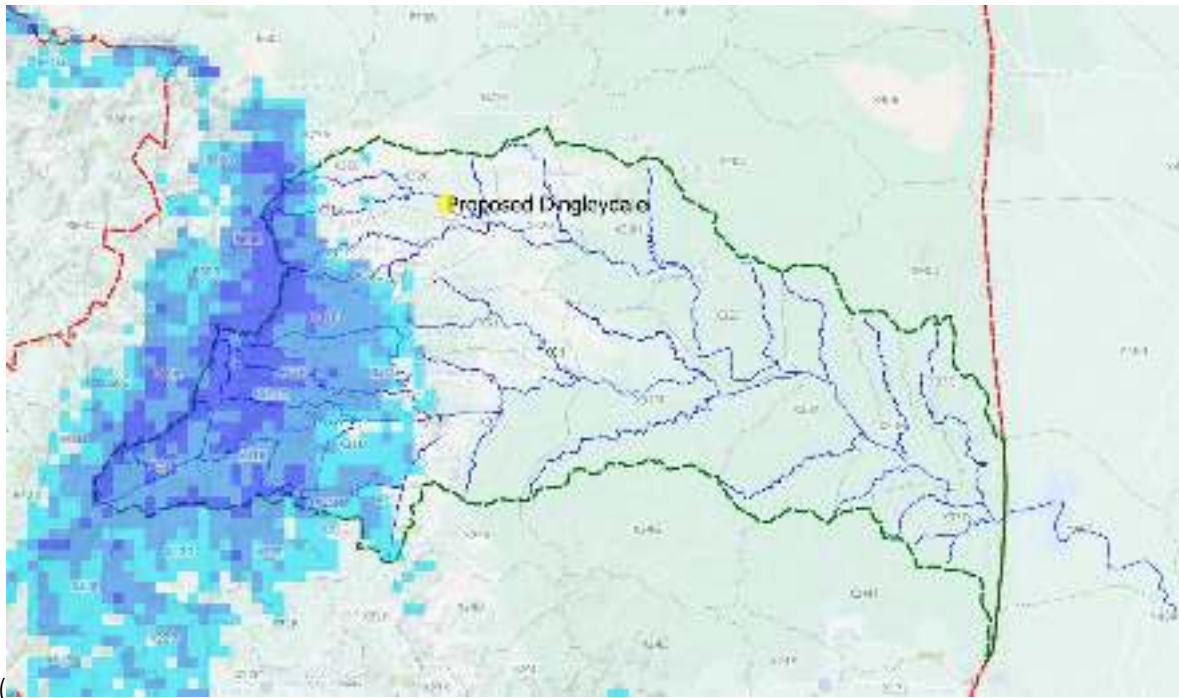
Table 7-11: Summary of Unit Reference Values for the development of groundwater infrastructure within the Sabie-Sand catchment

Yield Cost Scenario	Total discounted costs (Rands)	Expected yield (million m <sup>3</sup> /a)	URV (R/m <sup>3</sup> )
High yield / low cost	R58 000 000	10,5	R1.20
Low yield / high cost	R174 000 000		R3.70

### 7.4. Scenario 4: Construction of a New Dam

### 7.4.1. Scenario Description

Largescale water storage infrastructure in the form of a dam generally provides the largest possible addition to a water system. However, this is contingent on the ability of the system to allow for it. The assessment of a number of potential dam construction projects by the DWS (2014) have indicated that the most feasible option would likely be the Dingleydale Dam, sighted in the Sand River catchment X32



(Figure 7-7). It is estimated that this dam could potentially supply up to 20.6 million m<sup>3</sup> per annum, providing water for urban use, irrigation, and the EWR.

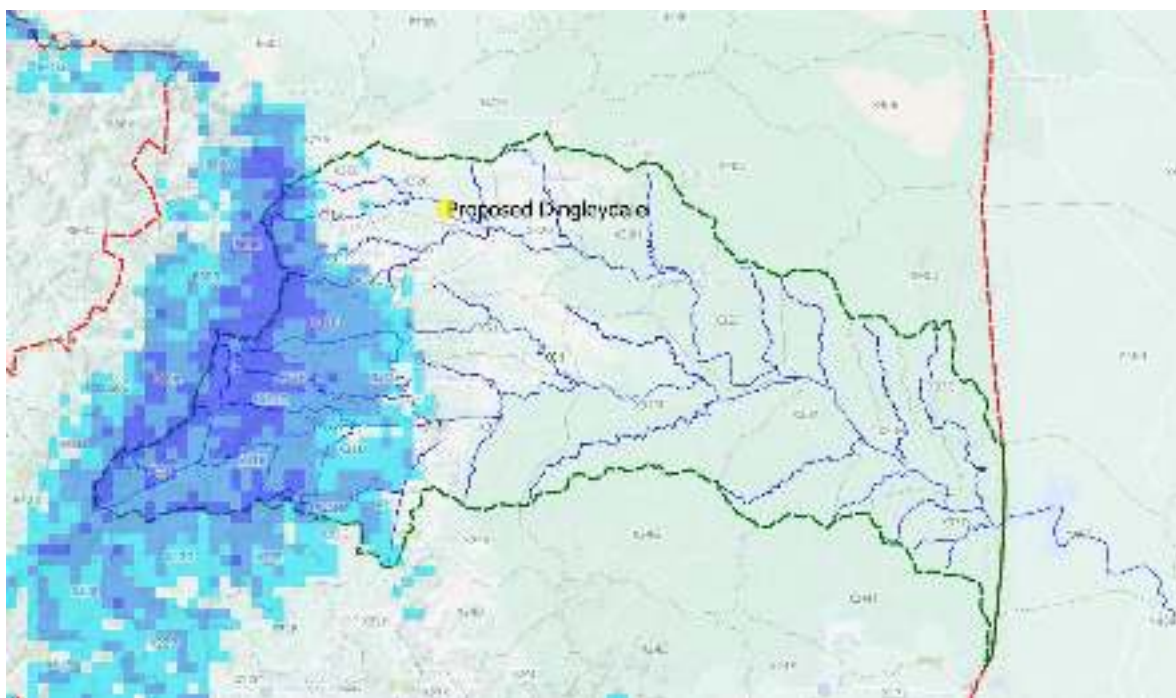


Figure 7-7: Proposed sight of the Dingleydale Dam (DWS, 2020).

#### 7.4.2. Costs

The Dingleydale Dam would require not only the construction of the dam itself, but also the development of downstream infrastructure in order to deliver the necessary water resources to users. This downstream infrastructure includes water treatment works, a pump station, and both rising and gravity mains. The total cost of this project, including the downstream infrastructure, is estimated to be around R3 billion. The unit reference values for the evaluation of this project were estimated by assuming a 45-year economic lifespan, with a discount rate of 6%. Key figures are summarized in Table 7-12 below.

Table 7-12. Summary of the Unit Reference Value for the Dingleydale Dam project

Project Name	Total discounted costs (Rands)	Expected yield (million m <sup>3</sup> /a)	URV (R/m <sup>3</sup> )
Dingleydale Dam	R2 561 650 000	20.6	R12.10

#### 7.5. Summary of Costs

The summary of the scenario URVs are given in Figure 7-8 below. For all scenarios, barring the Dingleydale Dam construction, for which the figures presented in the Mbombela Reconciliation Strategy (DWS, 2020) were used, a maximum and minimum value was calculated from available literature and data sourced from the strategy). The clearing of invasive alien vegetation exhibits the greatest variation in costs (Figure 7-8) but would appear to be a logical first step in the process of water augmentation for the catchment. The costs are likely to be influenced by the accessibility of the IAPs, the type of species present and the number of follow up clearings. The clearing of IAPs is considered as an ecosystem-based adaptation (EbA) strategy, which is defined as the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (DEA & SANBI, 2017). Clearing of IAPs supports the stimulation of the rural economy through providing additional rural livelihood options, creating nodes of rural development and stimulating job creation and skills development.

The development of a groundwater network located in the Bushbuckridge Municipality shows the second highest variation, while also appearing to have the lowest minimum and maximum costs (aside from the construction of Dingleydale dam), and thus would likely be a viable scheme to implement alongside Scenario 1. According to the Mbombela Reconciliation Strategy (DWS 2020), groundwater was used prior to construction of the Inyaka Dam, so components may be reactivated or redeveloped for conjunctive use.

The development or modification of WWTW in the study area show the least variability in cost ranges, but the gains in yield would not be dispersed evenly across the system as the WWTWs are geographically dispersed. It would therefore be difficult for an economic sector to utilize the available yield. The potential negative effects this intervention may have on downstream water quality also needs to be considered, as poor management of these WWTWs could have severe consequences. As stated in the Reconciliation Strategy (DWS 2020), further feasibility on this scenario would need to be investigated.

The final scenario, the construction of the Dingleydale Dam, would be the most expensive, but would also provide the largest available yield. It is worth noting that, given the site of this dam, this yield would only be directly available in the Sand River sub-catchment, unlike the other interventions contained in this analysis.

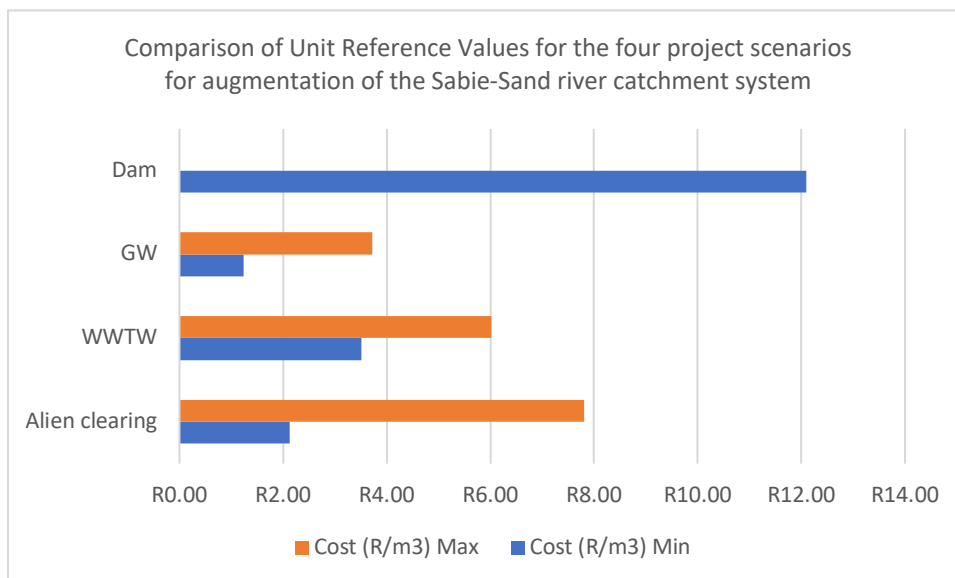


Figure 7-8. Comparison of unit reference values for the four project scenarios for augmentation of the Sabie-Sand Catchment

## 8. Socio-Economic Benefits

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### 8.1. Economic Benefits

The main objective of the economic task was to evaluate the economic impact of the additional yield for the four scenarios. The investment amount for the four scenarios has an economic impact and a more direct impact with regards to job creation. The total economic impact from the water yield and the scenario investment was calculated. The procedure followed during the modelling of the economic impact is discussed below.

To understand the economic impact of water yield for each scenario; the water volume yield was converted to economic final demand for the Sabie-Sand River catchment's economy. This was done per economic sector existing in the catchment. The resulting final demand was run through a social accounting matrix (SAM) to estimate the gross value add (GVA) and employment compensation. The economic impact of each scenario investment was directly added into the relevant economic sectors in the SAM.

The proportion used to split the water use within the catchment was constructed in three ways, the household, agriculture was adopted from (Pollard & du Toit, 2011), the tourism percentage was estimated based on the GVA percentage contribution from the Systems Description Report (Deliverable 2) and lastly the manufacturing and other industry sectors was estimated from the balance that remained (Table 8-1).

*Table 8-1. The percentage split of the water yield per sector*

Economic Sector	Proportion split %
Household	21
Agriculture	25
Forestry	23
Manufacturing and industry	22
Tourism	9

The economic sectors modelled in the SAM and how the water volumes were split for each economic sector based on the estimated water use, are shown in

Table 8-2 below:

*Table 8-2. The volume split for water yield per scenario*

Water final demand by industry	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	R million/year			
Social and government services	28.23	75.47	213.53	193.85
Agriculture (excl agro-forestry)	0.82	2.20	6.21	5.64
Agro-forestry and forest products	0.00	0.01	-	0.03
Manufacturing	29.15	77.93	-	200.16
Construction	11.09	29.64	-	76.13
Mining and mining related services	13.00	34.75	-	89.25
Utilities	0.07	0.18	-	0.45
Transport	2.19	5.85	-	15.03
Business services	4.49	12.00	-	30.83
Tourism	0.38	1.02	193.85	2.61

### 8.1.1. Economic Impact of the Scenarios

The different scenarios will have a positive development impact on the economy of the Sabie-Sand catchment. This impact includes a positive impact on the catchment economy in terms of attracting investment and job creation.

Table 8-3 below summarises the macro-economic indicators for the economic effect from the increased water flow and the investment costs for each scenario for the Sabie-Sand catchment economy. The GVA is an economic productivity metric that measures the contribution by the different scenarios to the economy of the catchment. The impact of each of the four different scenarios on the Sabie Sand Catchment economy is estimated to be between R107 million (Scenario 1) and R788 million (Scenario 4) as indicated by the GVA values in the table. Scenarios 2 and 3 will have an estimated impact of R285 million and R487 million on the catchment economy respectively.

A significant number of direct and indirect jobs would be created per annum in each of the different scenarios. The number of direct and indirect jobs that will be created per year varies between the different scenarios, with the highest number of jobs being created in Scenario 4 and the lowest number of jobs would be created in scenario 1. More than 600 jobs would be created in each of the Scenarios 1 and 2.

Table 8-3. Macro-economic indicators estimated for Sabie Sand catchment scenarios (considering increased water flow and capital investments)

Macro-economic impacts	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4
------------------------	------	------------	------------	------------	------------

GVA	Million R	107	285	487	788
Compensation of employees	Million R	60	152	281	419
Number of jobs		710	680	1,250	1,860
GVA per single job	R/year	150 704	419 118	389 600	423 656

For Scenario 1, alien plant clearing programmes and the subsequent required ongoing land rehabilitation supports the stimulation of the rural economy through providing additional rural livelihood options, creating nodes of rural development and stimulating job creation and skills development. Jobs are created directly on alien infested sites through land management and restoration, as well as commercial activities such as processing of biomass and transportation that are complementary to ecological restoration. Through job creation the local economy is indirectly stimulated through the flow of financial remuneration.

The average person days per ha varies between 20 and 36 (WCG 2018) for the first year of removal. Please note the alien removal process requires ongoing management of the removal site to ensure regrowth is managed. This does not account for follow up rehabilitation and management of the removal site and therefore job creation will be higher.

### 8.1.2. Gross Value Add Contribution

The current economic contribution of the Sabie-Sand catchment to the national economy is indicated below. This information was used to estimate the Sabie River catchment economic impact from the National SAM.

Table 8-4. The GVA contribution of the Sabie-Sand catchment to national GDP

Indicator	GVA estimate 2019 (R millions)
Sabie River GVA	15 555
National GVA	4 173 328
Percentage GVP of National	0.37%

The GVA effect from the increased water flow and the investment costs for each scenario for the Sabie River catchment economy for each of the different economic sectors is given in Table 8-4 below.

Table 8-5 The GVA contribution by economic sector in the Sabie Sand Catchment for each scenario compared to the base value.

Economic sector	GVA 2019	GVA contribution to catchment (%)	Sc 1	Sc 2	Sc 3	Sc 4
Social and government services	4 098	26	28	74	127	205
Retail trade (excluding tourism)	1 822	12	13	34	58	95
Tourism	1 400	9	10	26	44	71
Business services	2 839	18	19	51	88	142
Manufacturing	2 046	13	14	37	63	102
Transport	1 182	8	9	23	39	63
Agriculture (excluding agro-forestry)	172	1	1	3	5	8
Agro-forestry and forest products	389	2.5	3	7	12	20
Construction	495	3	3	9	15	24
Utilities	466	3	3	9	15	24
Mining and mining related services	646	4	4	11	19	32
<b>Total</b>	<b>15 555</b>	<b>100%</b>	<b>107</b>	<b>283</b>	<b>485</b>	<b>784</b>

## 8.2. Ecosystem Service Benefits through Stewardship

All scenarios will contribute additional yield to the system and therefore we can assume an increase in ecosystem services if that yield is allocated to the EWR. However, it is Scenario 1 where we should see a tangible increase in ecosystem services. The benefits of implementing water and biodiversity stewardship accrue in the form of improved condition of ecosystems and the associated improvement in flow of ecosystem services. Given the significance of the target landscapes in line with SWSA, an improved natural condition of ecosystems would support improved regulation and reliability of water flows throughout the year.

Although on average, improved reliability of water flows would not necessarily accrue to increased available yield (to be made available to catchment demands), improved regulation of flows would support the maintenance of ecosystems and their services throughout the year.

Improved plantation management, though would not restore native MAR in these regions, would reduce impacts on downstream water resources through improved soil stability and runoff management. This would support the integrity of adjacent ecosystems and reduce additional impacts.

The stewardship approaches described for plantations and untransformed land would support the maintenance of healthy ecosystems and restore and secure the flow of ecosystem services from the

headwaters through the rest of the catchment. The socio-economic analysis of the catchment classified a range of both formal and informal beneficiaries of these ecosystem services. Key to the stewardship approach is the maintenance and securing of the following ecosystem services:

Regulating services (as per TEEB 2013 classification) are intermediary or supporting services which are especially significant in the headwaters of the catchment including:

- Flow regulation (i.e., maintenance of base flows in the dry season and absorption of excess water in the wet seasons);
- Erosion regulation (i.e., Retention of sediments especially during extreme events);
- Water quality amelioration (i.e., the regulation of water quality as water moves slowly through ecosystems);
- Climate change regulation (i.e., carbon storage and sequestration)

Provisioning and cultural services are underpinned by the regulating services and represent final ecosystem services as utilised directly by catchment beneficiaries. A summary of the CRA process linking impacts of the scenario on key provisioning and cultural ecosystem services to catchment beneficiaries is described below:

Ecosystem Service	Impacts of Biodiversity Stewardship in the Headwaters of the catchment
Food Provisioning	The high densities of informal communities with associated subsistence livelihoods in the catchment will benefit from the food provisioning services (e.g., livestock grazing, food collections, fishing) that would be promoted through improved flow regulation and associated regulating services.
Fresh Water (Natural Sources)	The expected increase in availability of surface water throughout the year would directly support the 16% of households in the catchment, who rely directly on rivers and streams as their primary source of water. The expected regulation of water availability would likely not have major benefits for other raw water abstractors (this is not the case for alien plant removal)
Raw materials / Fibre	The characteristic high densities of informal communities within the catchment, with associated subsistence livelihoods, would benefit from improved reliability of raw material provisioning services (collection of fuel and building materials) that are associated with increased primary productivity associated with healthy ecosystems.
Medicinal Resources	No clear evidence of this provisioning service, however due to the nature of populations in the catchment it is likely there is a flow of services. Regardless, no negative impacts are foreseen on this service due to the implementation of the scenario.
Habitats for species	Increased primary productivity and condition of ecosystems would support habitats and therefore biodiversity value in natural and untransformed areas. This is especially significant due to the presence of the extensive protected area network in the downstream region of the catchment.
Ecotourism & recreation	The upper catchment has a relatively well-developed ecotourism industry, with Graskop and Sabie representing a bespoke destination known for its ecological character including activities such as fishing, tubing, river rafting, kayaking, views capes etc. The greater Sabie catchment is significant as an

Ecosystem Service	Impacts of Biodiversity Stewardship in the Headwaters of the catchment
	<p>ecotourism destination with internationally significant protected areas and wildlife offerings and associated activities.</p> <p>Improved regulation of aquatic ecosystems would drive improved condition of ecosystems and primary productivity which would likely support if not stimulate the existing ecotourism industry.</p>
Landscape, Inspiration and Amenity Value	<p>The well-established ecotourism industry within, and downstream, of the catchment is expected to be linked to the demand for rentals or property and therefore real estate prices associated with the natural resources. The stimulation of the industry will likely have a direct impact on the demand and therefore drive increased property prices in appropriate hotspots within the catchment. These hotspots would likely be centred around existing ecotourism hotspots in the towns of Sabie and Graskop and private protected areas.</p> <p>Inspirational values are closely linked with regions that attract visitors.</p>
Educational	<p>Although no direct evidence of this service within the upper catchment is available, the Kruger National Park downstream of the catchment represents an internationally significant resource for extensive research and training of which improved regulation of ecosystems would support.</p>

Through improving the condition of native vegetation within the SWSA region, the natural reliability of ecosystem service flows would be supported and, in the case of protection and continued management under stewardship, these flows would be secured into the future.

## 9. Conclusions and Recommendations

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### 9.1. Conclusion

The following are the main points of the analyses:

- According to the Mbombela Reconciliation Strategy (DWS, 2020), the current water balance for both the Sabie and Crocodile systems indicates severe deficits. The Strategy proposes a number of interventions in order to obtain a positive water balance. The analysis shows that the implementation of the four scenarios within the Sabie Sand Catchment will result in additional yield throughout the system. The costs and benefits of these interventions are discussed in this report.
- For the scenarios analysed, two distinct groupings can be distinguished: 1) Scenario 1: The ecological scenario which comprises IAP removal and stewardship and 2) Scenarios 2-4, which include the development of hard infrastructure including groundwater schemes, WWTW conversion and the construction of a new dam.
- In terms of gross value add (GVA) to the Sabie-Sand Catchment, the construction of the Dingleydale Dam will result in the addition of R784 million as well as the addition of 1 680 jobs. While the development of a groundwater network in the Bushbuckridge LM will result in the addition of R485 million to in GVA and 1 250 jobs. While these scenarios offer obvious economic benefits, it is likely that the delivery of ecosystem services will be impacted, especially with the construction and operation of a new dam. Additionally, the impact of climate change is likely to impact groundwater resources and the dam capacity though reduced precipitation and increased evapotranspiration (ET). In the case of the groundwater development scheme, reduced precipitation and increased ET represent increasingly significant risks to long term groundwater storage, especially when combined with increased abstraction.
- While Scenario 1 provides lower economic metrics when compared to the other scenarios with a contribution of R107 million to the GVA of the catchment and 710 jobs created, there are several benefits in the delivery of ecosystem benefits as well as potential for implementing ecosystem-based adaptation (EbA) activities through IAP removal and stewardship in the upper reaches of the catchment which would lead to the conservation of the SWSA.

### 9.2. Recommendations

The major recommendations of the study are:

6. Develop a Stewardship Strategy for the headwater of the X3 catchment which includes the Mpumalanga Drakensberg SWSA. The Stewardship Strategy should include an EbA component which would provide adaptation strategies for communities at risk from climate change and who rely on water resources. The target region represents an area of approximately 180 000 ha. Landscapes for stewardship implementation within the region comprises approximately 58 000 ha untransformed, natural and degraded land and 80 000 ha of plantations (Figure 9-1). The area identified in the Figure below provides an ideal starting point for stewardship activities.

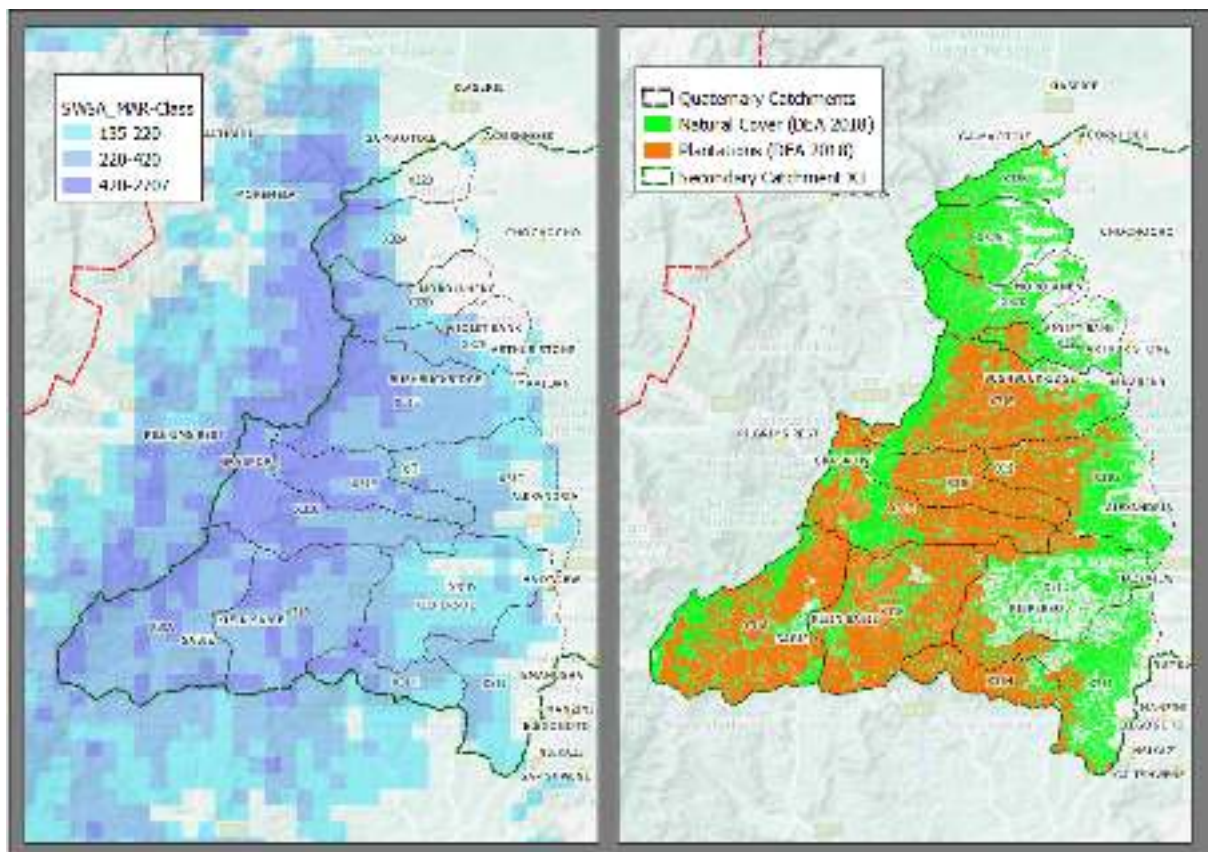


Figure 9-1: Focus area of stewardship implementation and target landscapes in the X3 catchment

7. Implement a focused IAP clearing programme in the headwaters of the Inyaka Dam in the X31E quaternary catchment.
  - Working for Water (WfW), K2C, WWF and SANParks have the necessary experience to develop a targeted IAP clearing strategy.
8. Undertake a feasibility study for the implementation of the findings and recommendations of the Mbombela Reconciliation Strategy (DWS 2020).
9. Finalise the Validation and Verification actions within the Mbombela Reconciliation Strategy (DWS 2020). Particularly around diffuse water use.

10. Implementation of scenarios needs to be in a phased approach with Biodiversity and Water Stewardship playing a central role in yield augmentation.

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