REVIEW OF SOCIO-ECONOMIC GUIDELINES FOR WATER RESOURCE CLASSIFICATION AND DEVELOPMENT OF AN IMPROVED DECISION SUPPORT TOOL

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Report to the
Water Research Commission

by

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EXECUTIVE SUMMARY

The Water Resource Classification System (WRCS) is used to determine the management class of catchments. It lays out a set of procedures grouped together in 7 steps, that when applied to a specific catchment will result in the determination of a Management Class (MC). This process, which evaluates the trade-offs associated with utilisation versus protection of a water resource, is assessed, taking into account the social, economic and ecological context.

To date, numerous Water Management Areas (WMAs) have been classified by different private service providers (PSPs) on behalf of the Department of Water and Sanitation (DWS) at considerable expense. However, in the socio-economic component of the classification process there have been several concerns raised over the consistency of methodologies, unclear linkages between ecosystem services and the economy, repetition between steps, confusion amongst stakeholders, evidence availability and legal defensibility.

As risk to the various dimensions of water security increases in future, resulting from increased pressure on water resources, one would expect a higher likelihood of contentious matters arising from WRCS studies, requiring increasingly evidence-based assessment of WRCS scenarios and its implications.

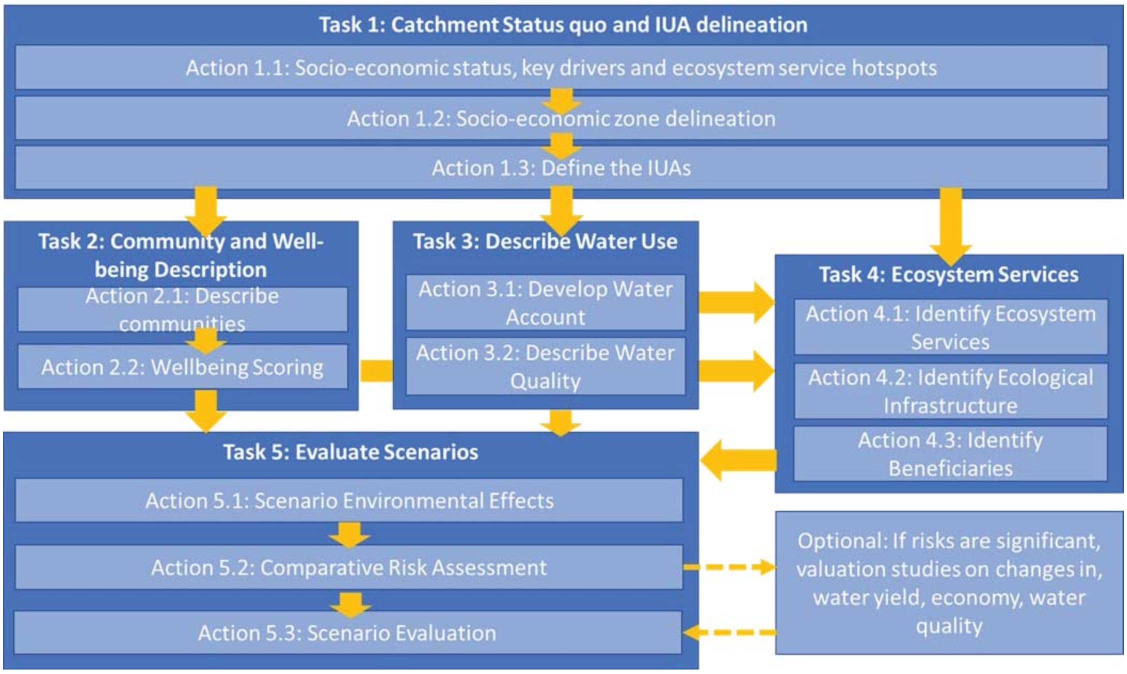
The main aim of the project was to revise and update the current WRCS Socio-Economic Guideline. To achieve this, intermediary aims included the investigation and recording of successes and failures of the current WRCS and Resource Quality Objectives (RQO) socio-economic studies in a gap analysis, and address the gaps identified through the recommendation of standardised data sources, economic indicators used, analysis approaches and methodologies and reporting outputs.

In order to achieve these aims, the project began with a gap analysis on WMA classifications to identify weak points that contributed to these shortcomings. Completed classification projects were evaluated accordingly and several successes and challenges emerged. The various WRCS projects conducted to date have experienced different and unique, location-specific challenges. In some cases, the methodologies used were sufficient to deal with challenges and in other cases they were not.

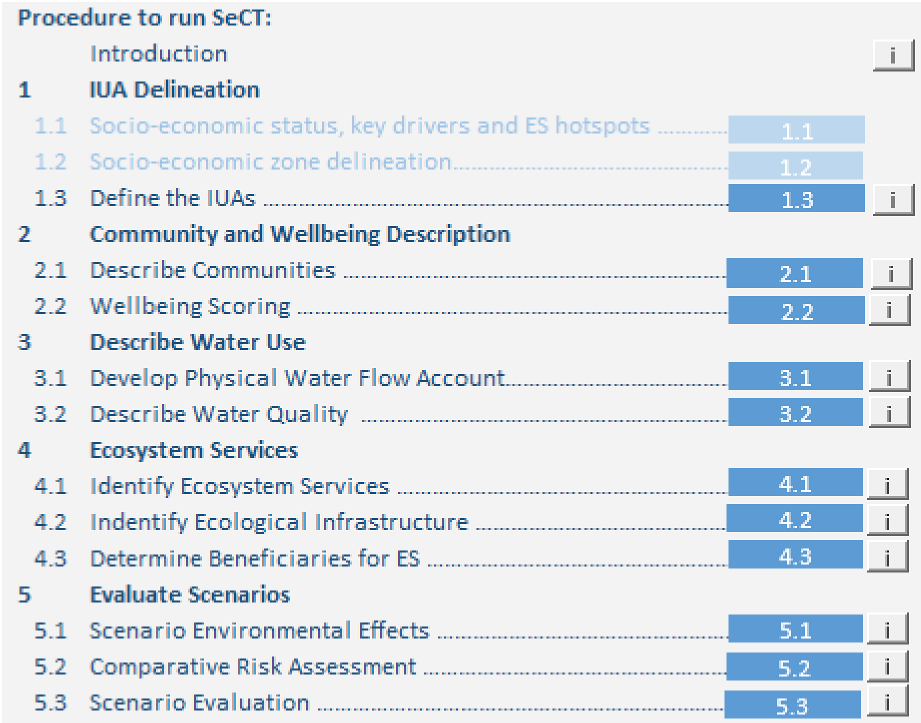
The main challenges identified were:

- Inconsistent methodology: The guidelines have not been able to specify a suitable set of socio-economic approaches and methodologies that would enable a common understanding of analyses and results. This has resulted in difficulty in comparing the results of classifications, and in some cases, huge omissions.
- Inadequate linkage between ecosystems and the economy: The current guidelines are not clear on how the economic analysis should link to and integrate with the other components of the WRCS process.
- Logical order of methodological steps: The order of evaluation tasks proposed by the 2007 Guideline is highly problematic. The existing guideline required onerous work at the start of the process, that may be premature if the information is not required later in the process.
- Confusion among stakeholders: The varying approaches and outputs used by different PSPs have caused confusion among some stakeholders, especially in adjacent WMAs where stakeholders have been involved in more than one Classification/RQO process.
- Legal defensibility: There have been stakeholder challenges to the WRCS process, especially in the Olifants and the Mvoti-Umzumkulu studies. Inconsistent methodology and low transparency are key drivers of legal challenges.

In consultation with DWS and PSPs, recommendations were made to address these issues. The recommendations included simplifying the process to improve transparency, reordering the stepwise process, and leveraging existing data sources to make more efficient use of resources. Standardised methodologies were also required to improve legal defensibility, comparison between classifications, and improve the linking of ecosystems to the economy. These recommendations were used to improve the process workflow in the figure below and update the socio-economic guidelines (Section 3), to aid PSPs and the DWS in future classifications. The revised guideline follows a logical approach with step-wise Tasks and intermediate Actions to be followed, the framework of which is presented in the figure below.



While this framework represents a significant simplification of the process, it is still complex, and requires transdisciplinary collaboration. Thus, to operationalise the guideline and aid PSPs in adopting the updated guidelines, a decision support tool was developed to complement the guidelines (Section 4), called the Socio-economic Classification Tool (SeCT).



The SeCT is a Microsoft Excel-based tool that ensures standardised inputs and outputs to simplify the process and ensure that classifications are transparent and comparable in the figure above. This user-friendly model allows the socio-economic practitioners to systematically work through the framework and input data from other classification processes into a format suitable for further analysis. In this manner the SeCT also serves a repository for information improving transparency and legal defensibility. The analysis culminates in a comparative risk assessment to evaluate scenarios and inform the larger classification process.

Lastly, a case study (Appendix 1) was performed to test the updated guidelines and decision support system in a WMA. The Olifants WMA was selected and valuated using the tool to ultimately develop a socio-economic evaluation of three hypothetical scenarios using data available to PSPs. The analysis demonstrated that the tool and updated guidelines resulted in time savings and standardised outputs. In collaboration with DWS, a few issues identified were the need for further simplification, clarification and standardisation. The model was then demonstrated to various PSPs to test its user-friendliness and functionality. The input from the various PSPs were used to further improve the model.

In general, the revised guideline and complementary tool was found to significantly simplify the socio-economic component of the classification system. This leads to the process being faster and therefore less resource intensive, less confusing to stakeholders, more legally defensible, and avoids duplicating work. The process also allows for linking ecosystem services to the economy through a modular approach to valuation. While the aims and objectives of the project have been fulfilled, there are opportunities for further research and optimisation of the process. It is recommended that future projects seek to standardise how water quality and social well-being scoring are better integrated into the process.

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The Department of Water and Sanitation played a pivotal role in this project, led by Lebogang Matlala. The team directing the project included

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Kate Pringle (INR).

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Abbreviations and Acronyms

AMD	Acid Mine Drainage
CBA	Cost Benefit Analysis
CMA	Catchment Management Area
CRA	Comparative Risk Assessment
CWMMM	Crocodile West/Marico Water Management Area and the Mokolo and Matlabas catchments
DEA	Department of Environmental Affairs
DBSA	Development Bank of Southern Africa
DWS[1]	Department of Water and Sanitation
EEA	Environmental Economics Account
EGSA	Ecosystem Goods, Services and Attributes
EI	Ecological Infrastructure
ERA	Ecological Risk Assessment
ERE	Environmental and Resource Economics
ES	Ecosystem Services
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
IUA	Integrated Unit of Analysis
IVRS	Integrated Vaal River System
IWRM	Integrated Water Resource Management
LSS	Large Sample Survey
MC	Management Class
MEA	Millennium Ecosystem Assessment
NFCM	Non-Financial Census of Municipality
NWPR	National Water Policy Review
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objective
SAM	Social Accounting Matrix
SANBI	South African National Biodiversity Institute
SASQAF	South African Statistical Quality Assessment Framework
SECT	Socio-Economic Classification Tool
SEZ	Socio Economic Zone
StatsSA	Statistics South Africa

[1] Department of Water and Sanitation (DWS) was known as Department of Water Affairs (DWA) until 2014. Therefore, many publications still use DWA as their reference. We will, for simplicity's sake, consistently use DWS when referring to this department.

SUT	Supply Use Table
TEEB	The Economics of Ecosystems and Biodiversity
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WQM	Water Quality Model
WRC	Water Research Commission
WRCS	Water Resource Classification System
WWTW	Wastewater Treatment Works

1 BACKGROUND

1.1 Introduction

The Water Resource Classification System (WRCS) is a very important water policy instrument that seeks to enable the protection of water resources[2]. The WRCS is established through the National Water Act (NWA) (DWS[3], 1998). The WRCS is a set of guidelines and procedures that, when applied to a specific catchment, will ultimately assist in the process of maintaining a balance between protecting our national water resources and using them to meet economic and social goals. The procedures are to be applied as part of a consultative classification process, the final outcome of which is a decision about the set of desired characteristics for each of the water resources in each catchment (DWS 2007a).

Although the focus of this study is on the WRCS, the WRCS is nevertheless intimately related to the other measures, and therefore it is important to briefly note their definitions and intentions.

The Reserve comprises firstly a basic human needs reserve provides for the essential needs of individuals served by the water resource (specifically water for drinking, for food preparation and for personal hygiene; and secondly an ecological reserve that relates to the water required to protect the aquatic ecosystems of the water resource. The Reserve refers to both the quantity and quality of the water in the resource.

The overall purpose of the WRCS is the setting of the Management Class (MC), the Reserve and the Resource Quality Objectives (RQOs) by the Minister or delegated authority for each significant water resource i.e. watercourse, surface water, estuary, and aquifer under consideration. The MC categories range from Minimally to Heavily used and describes the desired state of the water resource and the level of utilization.

1.2 Prior Work

Chapter 3 Part 1 of the NWA (DWS, 1998) requires the Minister to prescribe, "*as soon as is reasonably practicable*" a system for classifying water resources.

The WRCS may (as the Minister considers necessary):

a) establish guidelines and procedures for determining different classes of water resources;

b) in respect of each class of water resource –

i. establish procedures for determining the Reserve;

ii. establish procedures which are designed to satisfy the water quality requirements of water users as far as is reasonably possible, without significantly altering the natural water quality characteristics of the resource;

iii. set out water uses for instream or land-based activities which activities must be regulated or prohibited in order to protect the water resource ….

Chapter 3 Part 1 of the NWA the Minister is required to use the WRCS (established in Part 1) to determine the management class (MC) and resource quality objectives (RQOs) of all or part of water resources "*considered to be significant*". The NWA does not define what is meant by the term "*significant*" in this context.

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[2] "Water resources", and all other water-related terminology used in this report, are specifically defined as per the National Water Act (NWA) (DWS, 1998). Definitions are provided in the Glossary in Appendix 1.

[3] The Department of Water and Sanitation (DWS) was previously named "Department of Water Affairs and Forestry (DWAF)" and also "Department of Water Affairs (DWA)". For simplicity and consistency, this report will use the term DWS, to refer to both DWAF and DWA.

The purpose of the RQOs are to establish “clear goals” relating to the quality of the relevant water resources. To this end, the NWA requires that the Minister uses the WRCS to determine the MC and RQO of each “significant” water resource, by notice in the Government Gazette. The RQOs are envisaged to relate to a variety of water resource quality indicators including the Reserve; instream flow; water level; the presence and concentration of particular substances in the water; the characteristics and quality of the water resource and the instream and riparian habitat; the characteristics and distribution of aquatic biota; the regulation or prohibition of instream or land-based activities which may affect the quantity of water in or quality of the water resource; and any other characteristics that may be relevant.

The NWA envisages an interrelationship between the MC and the Reserve (*“the Reserve … will vary depending on the class of the resource”*). The Reserve may be determined for “*all or part of any significant water resource*”, and the NWA specifies a procedure for Reserve determination.

Up to this point of reading the NWA, determination of MCs and RQOs appear to require methodology that is purely informed by natural sciences. However, the NWA goes on to state that the WRCS procedure may “*provide for such other matters relating to the protection, use, development, conservation, management and control of water resources … and furthermore* “*in determining resource quality objectives a balance must be sought between the need to protect and sustain water resources on the one hand, and the need to develop and use them on the other*”. Water use is broadly defined by the NWA to include “*taking and storing water, activities which reduce stream flow, waste discharges and disposals, controlled activities (activities which impact detrimentally on a water resource), altering a watercourse, removing water found underground for certain purposes, and recreation.”* It is therefore clear that, in the determination of MCs and RQOs, the WRCS has to consider the use of water by economic agents. There is therefore a clear requirement to integrate natural sciences and economic science.

A very important requirement of the NWA is for stakeholder consultation. To this end, the NWA envisages a published notice in the Government *Gazette* setting out the proposed class and proposed resource quality objectives (by geographical area); the dates from which specific objectives would apply; and the requirements for complying with the objectives. The notice serves to invite written comments on the proposed class or proposed resource quality objectives and requires the Minister to consider any further steps required. Thus, the WRCS is required to communicate with a broad stakeholder audience.

DWS published a discussion document on the development of the WRCS (DWS, 2006) that further elaborated on the importance of assessing socio-economic implications, including redress of past inequalities for previously disadvantaged communities. This document further recognised that classification had to go beyond identifying the minimum requirements for ecosystems and human needs but should determine appropriate levels of protection between a minimum and complete protection[4].

This document set the scene for drafting guidelines and procedures for determining the MC and the RQOs by providing guiding principles, specific focus on the step-wise integration of natural and economic sciences, as set out in the sub-Sections below.

The purpose of these principles was to enable transparent process, reasonably predictable outcomes and reduced levels of potential contestation. These principles also hold important considerations for the development of socio-economic evaluation methodology.

- **Principle 1: Balance and trade-off for optimal use:** the MC should balance protection of the resource with its utilisation in line with societal norms and values. Utilisation of the

[4] Department: Water Affairs and Forestry (DWAF) 2006: A draft position paper on the development of a national water resource classification system (NWRCS): Draft discussion document. Department: Water Affairs and Forestry, Pretoria, 24pp.

resource provides economic and social benefits; however, it also has the potential to compromise ecosystem integrity, which has economic and social costs. This balance will require trade-offs. The NWRCS should therefore clearly outline the implications of different MCs to facilitate informed decision-making.

- **Principle 2: Sustainability:** Water resources are to maintain ecosystem integrity at a level that ensures the continued delivery of desired ecosystem services. The NWRCS therefore needs to provide a framework to facilitate the sustainable use of water resources. It is also recognised that there is a sustainability baseline below which ecosystem services production may be jeopardised, to the detriment of economic growth, poverty alleviation and the redress of historical inequality. As there is a degree of uncertainty as to the exact position of this baseline, and as the risks exceeding the limits of sustainability are considerable, the precautionary principle should be applied.
- **Principle 3: National interest and consistency:** A MC of a resource may need to optimise both local level and national-level benefits. Catchment level decisions therefore need to be evaluated against national-level interests (and where appropriate, international-level constraints e.g. international obligations).
- **Principle 4: Transparency:** Stakeholders should be consulted both in the development of the WRCS and in the process of classifying the nation's water resources. The approach should be legitimate and transparent and ensure that the valuation method used for determining trade-offs is fair. As the MC may have considerable economic, social and ecological implications, stakeholders would have to be informed in a meaningful way of the potential impacts on and risks (and benefits) of the MC to them. Further, stakeholders will need to be informed about the level of uncertainty related to economic, social and ecological estimates and forecasts.
- **Principle 5: Implementability:** The WRCS needs to be used, at reasonable cost, by trained DWS/CMA staff at an operational level. The institutional and transactional costs associated with making a decision on the MC should be as low as possible. The WRCS should also be sufficiently robust to make a decision in the light of imperfect knowledge.
- **Principle 6: Interdependency of the hydrological cycle:** As all components of a water resource are linked, the WRCS needs to account for the interlinkages between all resources dependent on water resources.
- **Principle 7: Legally defensible and scientifically robust:** The WRCS should be legally defensible, scientifically robust, apply due diligence in the decision-making process, be legally defensible and prevent legal liability accruing to DWS and/or stakeholders. It should be based on sound socio-economic and IWRM-related ecological principles. The 2007 Guideline should indicate the best available tools and data sets to be used in the WRCS process. These are anticipated to be regularly updated to account for developments in science and technology.
- **Principle 8: Management scales:** The scale at which the WRCS process is applied should be appropriate to the problem at hand. The end result of the classification process will be the recommendation of a MC. The implications of this will need to be understood, implemented and checked at multiple scales.
- **Principle 9: Auditable and enforceable:** The WRCS process has to be auditable and enforceable to ensure that it is operationalised. Thus, DWS would need to ensure that a transparent, permanent record of the procedures, information and logic used for classifying a particular resource is created and maintained. The outcomes of the WRCS also need to be monitored and enforced.
- **Principle 10: Lowest level of contestation and the highest level of legitimacy:** This requires consultation with, and the highest level of buy-in from, DWS and external strategic stakeholders and I&APs.
- **Principle 11: Utilisation of existing tools, data and information:** The WRCS process must use existing tools, data and information wherever possible. Where applicable,

existing tools, data and information may be modified or extended to meet the requirements of the WRCS process. Unless there is an urgent need to do so, no new tools, data or information will be developed or collected.

DWS (2006) recommends a 7-step procedure for implementing the WRCS process related to determining the MC.

- **Step 1: Delineate the integrated units of analysis (IUAs) and describe the status quo of the water resource or water resources:** This includes a description of water resource infrastructure; delineation of aquifers, estuaries, rivers and wetlands and description of Present Ecological Status (PES) and reference condition; delineation and description of socio-economic communities and their use of water and aquatic ecosystem services; identification and description of sectoral use of water and aquatic ecosystem services; overlay of IUAs and mapping of the linkages between them; consolidation and definition of IUAs.
- **Step 2: Link the socio-economic and ecological value and condition of the water resource or water resources:** Link and define biophysical-socio-economic relationships between and within IUA(s).
- **Step 3: Quantify the ecological water requirements and changes in non-water quality ecosystem services:** Determine and quantify the class thresholds of the current ecological categories (A to F) to account for upstream-downstream linkages.
- **Step 4: Determine an ecologically sustainable base configuration (ESBC) scenario**: Define non-negotiable constraints (national- and regional-level constraints and second-level constraints); describe the catchment sustainability baseline configuration scenario.
- **Step 5: Evaluate scenarios within the integrated water resource management process**: Identify future pressures and priorities for water use, ecosystem use and conservation; identify feasible scenarios and selection of a subset of scenarios for detailed analysis; describe the socio-economic and ecological implications of scenarios at catchment-, regional- and national-scales.
- **Step 6: Evaluate the scenarios with stakeholders:** Evaluate scenarios generated during Steps 4 and 5. This is an iterative process of evaluating alternative scenarios, with stakeholders, to assess the economic, social and ecological trade-offs.
- **Step 7: Gazette and implement the class configuration.**

1.3 Motivation

At the root of the WRCS, is the call for efficient, equitable and sustainable use of the nation's water resources. The economic goal of efficiency is driven by maximizing the economic returns from water resources, or put more simply, achieving maximum net benefit. The social goal of equity relates to the allocation and distribution of costs and benefits in order to utile the resource fairly. The ecological goal of sustainability is to promote the use of the resource in a sustainable manner that does compromise the economic opportunities and social wellbeing of future generations (DWS 2007a).

Balancing the ecological, social and economic requirements of the resources is a potentially conflicting process and as such trade-offs are frequently required in the Classification process. A balance between unprotected resources where often there is an over allocation of water for consumptive use and overprotection of the water resource that result in a loss of economic production and societal wellbeing needs to be met. The required optimal balance needs to take into consideration the economic benefits as well as the externalities that are associated with them such as potential health risks and loss of ecosystem services. Understanding these externalities and how they contribute to human wellbeing is paramount to the Classification process and as such the continued improvement of the socio-economic framework is vital to balancing the requirements of all stakeholders.

Unlike the ecological component of the WRCS, the socio-economic framework does not draw upon 20 years of experience and as such methodologies and data availability can be considered a limiting factor when determining trade-offs. However, it is not to say that determinations cannot be made, methodologies do exist, and the field of resource economics is constantly developing new techniques.

1.4 Rationale

Since the publication of GNR 810, DWS has made rapid and tremendous progress with the implementation the classification of water resources, and the implementation of resource quality objectives (RQOs). MC and RQO determinations have been completed and/or are under way in the Olifants WMA, Vaal WMA, Olifants-Doorn WMA, Letaba WMA, Crocodile West/ Marico/ Mokolo/ Matlabas WMA, Mvoti-Umzumkulu WMA, Inkomati WMA and Breede-Gouritz WMA.

However, during these determination processes, DWS has found the "Socio-Economic Guidelines for the 7-Step Classification Procedure" to be problematic. The existing guidelines have not enabled standardised, consistent and comparable socio-economic outputs from all studies.

DWS therefore requested the WRC to significantly revise, through this study, this Guideline such that it would enable standardised, consistent and comparable socio-economic outputs from all Classification and resource quality objective (RQO) studies.

1.5 Objectives

The study aims are as follows:

1. Revise and update the current WRCS Socio-Economic Guideline document (i.e. DWS 2007c)
2. Investigate and record successes and failures of the current WRCS and Resource Quality Objectives (RQO) socio-economic studies, if any in addition to those identified as indicated under the rationale for the project
3. Address the weaknesses identified in each case
4. Undertake gap analysis of current WRCS and RQO socio-economic studies
5. Review and recommend standardisation of data sources, economic indicators used, analysis approaches and methodologies, and reporting outputs.

The expected outcome of this proposed project is very clear: a completely revised WRCS Process Socio-economic Evaluation Guideline that is explicit on methodology to be applied to support and decision making in a systematic and transparent manner, to determine appropriate protection levels of water resources using ecosystem services and socioeconomic tools.

The key and immediate impact is on the current WRCS and RQO processes, where DWS and stakeholders would see immediate benefits in evaluation outputs.

2 GAP ANALYSIS

An analysis of the socio-economic components was performed to identify gaps in the existing studies. The objective of the socio-economic and decision analysis framework is to enable the assessment of the implications of different catchment configuration scenarios at an IUA level on economic prosperity, social well-being, and ecological condition.

Investigated in the analysis were the following evaluations:

- Olifants Water Management Area
- Vaal Water Management Areas (Upper, Middle and Lower)
- Olifants Doorn Water Management Area
- Letaba Water Management Area
- Mokolo/Matlabas Catchment: Limpopo WMA and Crocodile (West) Marico WMA
- Mvoti-Umzimkulu WMA
- Inkomati Water Management Area
- Breede-Gouritz WMA and Berg Catchment

2.1 Olifants Water Management Area

The socio-economic report of the Olifants WMA was completed in 2011.

There were numerous data sources for the socio-economic component of the Olifants WRCS study and the quality varied. The report used high quality, official data such as the census 2001 that meet most of the requirements of SASQAF, except for timeliness, which the authors acknowledge. However, the authors state that other data sources such as agricultural statistics, had many discrepancies that reduce the confidence in this data source. Data on mining was initially obtained from the Department of Mineral Resources, but stakeholders did not trust this data, leading to the project team having to generate this data directly from annual reports of each mining company in the area.

The study described the GDP of the WMA as a proportion of the national GDP. Specific sectors that were further quantified were according to their contributions to the economy. These sectors included agriculture, mining, electricity, tourism, and the associated value chains. The informal sector was also addressed, primarily subsistence agriculture, craft manufacturing, trade and harvesting of natural products. These economic activities were further described per IUA.

The study used techniques based on the Millennium Ecosystem Assessment framework that modelled the production of aquatic ecosystem services. Ecosystem services evaluated included:

- Provisioning services:
  - river water for domestic use
  - livestock watering and grazing
  - sand and clay harvesting and use
  - use of plant resources
  - harvesting and use of wild food and medicinal products
  - hunting resources
  - fishing resources
- Regulating services:
  - value of flood attenuation
  - value of base flow maintenance
  - value of water purification
  - carbon sequestration values
- Cultural services:
  - value of river-based adventure tourism

  - value of recreational angling
  - ecotourism value
  - property values
  - scientific and educational value

In order to internalise the environmental costs and benefits into the production economy (and thus link the socio-economic and ecological value and condition of the relevant water resources), the relevant transactions in the study were modelled using four economic techniques that included:

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

Some of the key issues and comments stakeholders highlighted in the Issues and Responses Report (IRR) included:

- Whether future economic development was taken into consideration during the study. This point was considered, and future growth scenarios were included as part of the scenario analysis.
- The study should have also investigated what sector invested its money in the Olifants WMA, because the coal industry provided profit to investors living outside the Olifants WMA and even overseas. As a result, the study included all economic activities that took place within the study area. Their contribution to national GDP was assessed.
- The way in which the Water Discharge Charge System (WDCS) was incorporated into the economic model. This issue was clarified by explaining that the concept of cost of load reduction to an applicable resource water quality objective was used.
- Concern was raised about the process followed with respect to the economic information that was being used in the study.
- Input data or raw data used for the economic models should have been put on paper to improve understanding. More clarification with regards to the data should have been brought in before a qualified decision could be made. As a result, model outputs were made more user friendly.
- Mines were being planned outside this WMA, which would be supplied with water from inside the Olifants WMA. The economic implications were investigated and these economic consequences were hence incorporated.

No integrated model used in the economics assessment was provided. This limited the economists' ability to comment on the detailed assumptions that drove the outputs of the model. A source clarified that the Development Bank of Southern Africa's (DBSA) model was used to assess the economics of this catchment.

2.2 Vaal Water Management Area

The scenario evaluation report of the Vaal WMA classification was released in 2012. The purpose of this report was to provide the decision-maker with sufficient information to make informed decisions regarding the implications of the flow scenario and the Ecological Category (EC) which will be signed off as the Ecological Reserve.

Information on the water resource infrastructure, water requirements, ecosystem characteristics, available socio-economic data and communities are described and summarised for each of the IUAs. The data sources were described in detail in the inception report and made use of the best available information. The authors noted that the Vaal River System has been the subject of various studies in the past of which had recently been completed, including the Comprehensive Reserve Determination Study (study consisting of various separate appointments covering the surface water, groundwater, water resource system analysis as well as water quality aspects) which they considered the most important source of information for this study.

The project area includes the most important economic region of the country, data are collected and analysed in terms of the three Vaal Water Management Areas as well as the tributaries and main stem areas in the project area.

A Production Industry Model (PIM), developed by Conningarth Economists was used in this study to identify economic activity (measured as production output) for the national economy, as well as at the Magisterial District level.

The PIM captures the linkages that occur between economic sectors and households throughout the national economy and between geographical areas as represented by the Magisterial Districts As such, the forecasts produced by the PIM was described as being based on macro-economic data which provides a 'top-down' perspective on the broader national economy.

The study identified and described Ecosystem Goods, Services and Attributes (EGSA) in qualitative terms, and baseline values described for only some of these, as the information required, was not available due to resource constraints. The study team felt that the dense populated and complex array of highly disparate social groupings with low dependence on EGSAs necessitated the use of relative values. As such, changes in EGSA values relative to a reference point rather than computing a baseline value were used.

The most important goods and services associated with the overall system and likely to be impacted by changes in operational and management scenarios were determined to be the following:

- Recreational fishing;
- Subsistence fishing;
- Other recreational aspects associated with the rivers;
- Riparian vegetation usage;
- Wastewater dilutions; and
- Floodplain agricultural usage of subsistence purposes.

The Socio-Cultural Importance was also used to assess cultural and religious uses.

Due to the earlier findings of the minimal impacts of EGSA to the total socio-economy, the study mainly considered issues around the supply of water. The study was assumed that, if in a section of the main stem of the river more water is necessary to maintain or improve the status of the ecology of a specific the river section, the water will be supplied from the present available sources. In this way, the approach taken was estimation of the costs of bringing augmentation projects forward.

Protection objectives and specific water resource management variables that are relevant to the Integrated Vaal River System (IVRS) were identified as the basis for formulating alternative future management, water use and protection options (operational scenarios) for analysis in the study.

The approach was therefore to define scenarios by considering the current framework of Integrated Water Resource Management (IWRM) as the point of departure:

- Scenario 1: This scenario represents the Present Day (2011) development conditions excluding the Ecological Water Requirements (EWR).
- Scenario 2 (Scenario A): This scenario represents Present Day developments where the year 2011 water requirements and return flows as well as current infrastructure are analysed.
- Scenarios 3 and 4: These two scenarios were based on the future (2020) development conditions which include the Lesotho Highlands Future Phase (LHFP) development option which was identified as the most feasible future option to be considered for augmenting the water resources of the Vaal River System.
- Scenarios 5 and 6: These two scenarios represent the full utilisation of the available water resources. The development condition upon which these two scenarios is based, is therefore representative of a future development level that falls between the Present Day (2011) and Future (2020) development conditions (i.e. current infrastructure). Mine water is naturalised, discharged and diluted with releases from Vaal Dam.
- Scenario 7 (Scenario B): This scenario evaluates an alternative to the EWR releases from Grootdraai Dam. For all scenarios where the EWRs are included, the Grootdraai Dam compensation release rule is replaced with the EWR for EWR site 2.
- Scenario 8 (Scenario E): This scenario was a further attempt to improve the seasonal variability of flow at the EWR site on the Wilge River downstream of Sterkfontein Dam.
- Scenario 9a: This scenario includes only the Douglas EWR and was evaluated to assess the impact thereof on the yield of the Vaal River System.
- Scenario 9b (Scenario F): This scenario evaluates the implementation of an additional EWR site downstream of Douglas Weir on the Vaal River – about 15 km upstream of the confluence with the Orange River.

Some of the key issues and comments stakeholders highlighted in the Issues and Responses Report (IRR) included:

- Whether the socio-economic study looked at the cost-benefit analysis during the lifetime of the operations or the lifetime of the impacts. Usually, by the time environmental and socioeconomic consequences become noticeable, the mines (for instance) would typically close or become insolvent and thus cannot be compelled anymore to contribute to remediation, either financially or through other actions. Hence, the lifetime of impacts should be included in the cost-benefit analysis, because in most cases externalities would be ignored.
- The study seemed a little biased towards ecology making the social aspects in the scenarios unclear. However, a source explained that the social and economic aspects were included in the goods and services.
- The unlawful water use by mining companies. It was said that unlawful water use fell outside the current study but was not necessarily ignored since data from other studies was included in the classification process.

2.3 Olifants/Doorn WMA

The report was completed in February 2007 and is largely based on 1996 and 2001 Census data. The aim of this report was to provide an update of the local baseline socio-economic data for the Olifants/Doorn WMA.

The approach to the study involved:

- Review of demographic data from the 2001 Census;
- Review of relevant planning and policy frameworks for the area, specifically

Integrated Development Plans and the West Coast Socio-Economic Profile;

- Review of existing reports and documentation on the Olifants/Doorn WMA; and
- Review of the key findings of the specialist Agricultural Study.

The economic impacts considered most relevant to the study were the contribution to Gross Geographic Product (GGP), and Job creation.

Both of these measurements are linked to water use, which enabled the study to assess the potential impacts associated with alternative water resource classes. For example, in the case of the Olifants/Doorn WMA, the agricultural sector is the most important sector in terms of both GGP and employment. It is also the single largest water user.

With regards to ecosystem valuation the authors noted:

"*The proposed approach to and methods used for measuring well-being were found to be problematic in that they assume that the factors that inform and are used to measure well-being are closely linked to water and ecosystem health. However, for many of the indicators/measures it is not possible to establish a clear link between well-being and water. Changes in the water resource class are therefore likely to have little or no bearing on these indicators. Their applicability and use when considering scenarios for assessing water resource class and comparing scenarios is therefore likely to be limited*."

Some of the key issues and comments stakeholders highlighted in the Issues and Responses Report (IRR) included:

- The ranking of social, economic and ecological priorities. In other words, if all aspects (social, economic, etc.) were important, how would they be ranked? This comment was taken into consideration and explained. According to the NWA, the reserve had the first right to water. Second in line was the water user; the DWA would therefore look at strategic users like ESKOM, etc. Moreover, conservation was already identified as very important.
- When and how were the Socio and Economic scenarios incorporated into the decision making? For the purpose of this comment, calculations for the possible economic and social impacts were done based on increase and / or decrease in water use and ecosystem conditions.
- The classification guidelines were not helpful in terms of quantifying the economic value of various elements that were listed. It was explained that the guidelines were not rigid due to the fact that there were gaps identified through implementation. The gaps were addressed in the revision of the guidelines.
- Concerns were raised on the way in which towns could be included in the economic benefits as they did contribute substantially to the economic activities. It was explained that the way to answer this question was to look at economic multipliers. Although the data was not available to determine the multipliers, it could be substantial.

- Data accuracy was raised. It was clarified that the data accuracy was dependent on measurement and monitoring.

2.4 Mvoti-Umzimkulu WMA

The economic report was completed in 2014.

The economic evaluation of the impact of the different scenarios was based on the broad assumption that the utilisation of any additional or current water allocation was utilised at maximum efficiency.

The following main water users were identified in the catchment or WMA, or are dependent on the water in the river:

- Irrigation.
- Commercial forestry.
- Mining.
- Electricity generation.
- Heavy Industry.
- Urban and domestic household use.
- Light Industry and sectors not dependent on water for production purposes; and
- Tourism.

The study used two macro-economic indicators, namely Gross Domestic Product (GDP) and Employment, to describe the baseline and scenarios.

The project team used Millennium Ecosystem Assessment as a framework to evaluate ecosystem services. However, no quantitative analyses were performed; instead scores were used to value the ecosystem services. The study evaluated changes to Ecosystem Services against scenarios in expert workshop format. The specialists (biophysical) identified the potential change that each of the key ecosystem services may undergo.

The Cost benefit Analysis (CBA) method was used to provide a logical framework by means of which projects could be evaluated:

- The costs used are the cost estimates for the different proposed dams as well as the operational and management costs as sourced from the different reports made available.
- The benefits derived from the water are calculated in terms of the estimated GDP and the number of new employment opportunities that can be created. The GDP is expressed in terms of R/m^3 and the water in m^3; by multiplying the two an answer in Rand is provided. The GDP is available per catchment as it was calculated as part of the economic status quo.
- The employment is expressed in terms of Number/million m^3 and the water in m^3; by multiplying the two an answer in employment numbers is provided. The employment is available per catchment as it was calculated as part of the economic status quo.

A Multi Criteria Analysis was then used to integrate the economic, socio-economic and ecological consequences.

The following scenarios were considered in the study:

- Isithundu Dam on the Mvoti River to supply the North Coast and KwaDakuza areas.
- Raising of Hazelmere Dam on the uMdloti River.
- Mooi-Mgeni Transfer Scheme phases providing additional water into Midmar Dam.
- Development of the Smithfield Dam on the uMkhomazi River and conveyance infrastructure to augment the water supply of EThekwini.

- Ngwadini off-channel storage dam on the lower uMkhomazi River to augment water supply of the Middle South Coast Area.
- Re-use of treated wastewater in the EThekwini Municipality.
- Re-use of treated wastewater in Msunduzi Municipality (Darvill WWTW).

Some of the key issues and comments stakeholders highlighted in the Issues and Responses Report (IRR) included:

- It was not clear how the proposed social and economic goals were factored into the study, nor how the economic and social cost of reducing these goals versus the protection of the water resource were measured. Once the classification was promulgated, the detail from the study which supported that classification dictated the level and nature of development and/or the adoption of mitigation measures, albeit that these measures were unacceptable in many quarters. It was therefore essential that the results obtained from the study were of a nature and at a level of confidence that could be directly applied with some certainty, a development policy and vision which would set out development into the long term.
- The negotiated trade-offs should have been recorded somewhere in the study in order for stakeholders to be able to access information.
- If there was no water in a river, how would the economic activity benefit? There would hence be no macro-economic benefit because there was no water abstracted from the river. The economic equation would therefore be zero. This point was clarified by highlighting the fact that one needs to establish a baseline and measure the deviation from it.

2.5 Letaba Water Management Area

The ecological consequences report for the Letaba Management Area was released in 2014. The report used reliable data that was of adequate to high quality according to SASQAF guidelines.

The economic evaluation of the impact of the different scenarios as evaluated is based on the broad assumption that the utilisation of any additional or current water allocation is utilised at maximum efficiency.

An economic baseline was established and the estimated deviation from the baseline was determined with water as the main driver. Three economic activities were used in the evaluation process, namely:

- Irrigation.
- Light Industry; and
- Domestic Household Use.

They project team used Millennium Ecosystem Assessment as a framework to evaluate ecosystem services. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. Each site was evaluated under the impact against a base value of 1, representing the status quo.

Anticipated change was evaluated against the base value with a negative impact represented as a score lower than 1 and an overall positive score represented as greater than 1. The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites. Here the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role.

The model, as is currently constructed, is in the form of a dynamic computerised water entitlement model which can be used to identify and quantify the following indicators:

- Economic benefits.
- Maximum possible water reduction.

The first step is to calculate the macro-economy of each of the Economic Regions (ERs) in the project area and to identify and establish the detailed water users in terms of volume used. In the case of irrigation and commercial forestry the detailed areas in production are determined together with the different crops produced.

A Water Impact Model (WIM) was constructed for the catchment which included the identified ERs.

The model is water driven and gives the direct and indirect/induced results for the following sectors: irrigation agriculture, commercial forestry, heavy and light industries, mining, electricity generation and urban and household use and eco-tourism. Regarding agriculture the model can accommodate up to twenty different products and for forestry it makes provision for pine, gum and wattle sub-species.

The following impacts are estimated by the WIM:

- Gross Domestic Product (GDP).
- Low Income Households and Total Households.
- Employment Creation.

A group of economic multipliers was then developed for comparing different water use activities in terms of GDP (GDP/m^3), employment creation (number/million m^3) and the low-income households. As the economy entails a number of mechanisms and linkages between sectors, economic impacts were described in terms of the direct, indirect and induced effects.

A Multi Criteria Analysis using scenario scores for the four variables, ecology, ecosystem services, economy and employment was performed. The relative weight applied to each variable for calculating the overall ranking were then indicated numerically.

Three primary EWR scenarios were identified for evaluation as listed below:

- Maintain a minimum flow rate of 0.6 m^3/s in the Letaba River into the Kruger National Park (EWR 7). This represents the primary target release operation that was applied by the system operators and confirmed with the flow measurements over the past few years.
- Make releases from upstream dams to maintain the PES low flows at respective EWR sites. The rationale of this scenario is that the high flows will be satisfied from high incremental runoff and spills from the dams while the low flows are maintained through releases.
- Releases are made from upstream dams to maintain the low flows at the respective EWR sites.

2.6 Inkomati Water Management Area

Gap analysis was conducted when only the inception presentation has been released.

The project team has stated that the analysis will include a SAM.

2.7 Mokolo/Matlabas Catchment: Limpopo WMA and Crocodile (West) Marico WMA

The management class report was released in 2014. There were numerous data sources for the socio-economic component of the Olifants WRCS study and the quality varied. The report used high quality, official data such as the census 2001 that meet most of the requirements of SASQAF. Furthermore, existing specialist studies on the catchment were used.

The economic analysis of the study involved the use of a Social Accounting Matrix, to model the transactions between economic production sectors and household consumption.

Environmental Economic Accounts for Water (Water EEAs) were used to model the transactions between economic production and water resources.

The value of ecosystem services followed the Millennium Ecosystem Services framework. The estimation of the value of aquatic ecosystem services was done through environmental and resource economics (ERE) studies to value the stream of benefits delivered by the set of ecosystem services associated with an ecosystem.

The effects of water pollutants on water resources and households were simulated using the economic effects of implementing a Waste Discharge Charge System (WDCS).

Based on the scenario evaluation and consultation with the stakeholders, the following scenarios were investigated:

- Crocodile West catchment: scenarios which supply the PES ecological category, which in the context of the Crocodile West catchment is equal to the REC ecological category, and meets the future growth in water requirements (2030) in the catchment;
- Marico catchment: the scenario in the Klein Marico is the REC with present water use (2015); the scenario in the Groot Marico is the REC with present water use (2015);
- Mokolo catchment: PES with future water use (2030); and
- Matlabas, Molopo and Ngotwane: the ESBC is to be maintained.

Some of the key issues and comments stakeholders highlighted in the Issues and Responses Report (IRR) included:

- The way this study calculated the socio-economic benefits of those that use the water from the Limpopo Main Stem. It was understood that there were no agreements in place with neighbouring countries that specify the volumes of water that should reach the Limpopo River.
- Whether the life cycle costs (closure costs) of mines were also included in the GDP total for the platinum sector. It was agreed and said that this point would be added to the study at a later stage.

2.8 Breede-Gouritz WMA and Berg Catchment

No results have been released to date, however the project team has a detailed list of supporting studies that will inform the analysis.

2.9 Current Guidelines (2007)

Review of the Socio-economic guidelines for the 7-step classification procedure

DWAF. 2007. Development of the Water Resource Classification System (WRCS). Vol 3. By Chief Directorate: Resource Directed Measures

The purpose of the guidelines is to provide guidance to service providers in assessing the economic prosperity and social well-being implications of different catchment configuration scenarios while utilising the 7-step procedure. Unlike the ecological component, which had been relatively well documented, little work had been done at this stage on the value of ecosystem services (referred to ecosystem goods, services and attributes (EGSAs)) and the economic consequences of water planning scenarios and in particular, how they relate to social well-being.

The first component of the guidelines deals with the definitions and concepts central to the 7-step process. The main definition relates to the concept of EGSAs, which are broadly defined as the services that ecological systems provide directly and indirectly to human welfare that are often ignored in economic analyses. The guideline also discusses a variety of resource-economic valuation techniques, such as total economic valuation (TEV). While these definitions and explanations are not incorrect, the Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) frameworks have largely superseded many of these terms. Definitions also extend to several measures of economic formation such as household income, capital formation and job creation. Human well-being and the measurement thereof are discussed in detail and a measurement framework is proposed.

The remainder of the report is structured and aligned with the classification process and socio-economic guidelines for each of the 7 steps are presented. The proposed framework is expanded as an example with the 'proof of concept' catchment, the Olifants/Doring WMA. The report is thorough in explaining the valuation of identified EGSAs, but does not provide sufficient guidance on how to link the EGSAs to the formal economy. This issue is touched on briefly in the final chapter with reference to the use of a social accounting matrix (SAM), but further guidance would be useful if WMAs are incorporated into more than one Province.

2.10 Discussion of Gaps and Lessons Learnt

2.10.1 Overview

During the application of the case studies described above, several successes and challenges emerged. These are discussed in the Sections below.

The various WRCS projects conducted to date have experienced different and unique, location-specific challenges. In some cases, the methodologies used were sufficient to deal with challenges and in other cases they were not.

As risk to the various dimensions of water security increases in future, resulting from increased pressure on water resources, one would expect a higher likelihood of contentious matters arising from WRCS studies, requiring increasingly evidence-based assessment of WRCS scenarios and its implications.

2.10.2 Revisiting the purpose of economic studies in the WRCS

The practical challenges relating to socio-economic assessment and stakeholder participation are three-fold:

1. The analysis outputs must be correct, evidence-based and defensible and support the Minister to make the correct decisions;
2. The analysis must set out an analysis framework, baseline assessment and outputs that is acceptable and recognizable to stakeholders;
3. The work needs to communicate with a very wide range of stakeholders, ranging across a spectrum of disciples and education levels.

Thus, the assessment should address the following questions:

- Is the analysis reliable and does it inform making the correct decisions? This would be a key concern from the Minister's point of view, requiring that the analysis be reliable.
- Will any beneficiary lose water as a result of any WRCS scenarios? This is a key stakeholder concern, as the WRCS process may determine that additional water needs to be allocated to the Reserve to achieve the desired MC, either in the near term or sometime in the future. This may affect existing operations and livelihoods and/or investment decisions to be taken. Beneficiaries here would include poor communities, local government, private sector as well as government and government entities responsible for economic development initiatives resulting from the NDP.
- Will any beneficiary lose aquatic ecosystem services? Closely associated with the concerns related to possible loss of water for use, various beneficiaries may be concerned about losses of other water resources related benefits, i.e. aquatic ecosystem services. Such concerns may often relate to lower levels of MCs or the failure to implement minimum acceptable MC (Class III). In most cases, higher MC categories may be associated with higher valued aquatic ecosystem services.
- Will any of the decisions incur additional economic costs? In some instances it may be possible that stakeholders have to pay more for water, either through higher marginal cost augmentation schemes or higher costs associated with water quality mitigation, such as the WDCS. Thus, the WRCS may result in additional costs as a key stakeholder concern. This concern has become increasingly relevant since Cabinet's 2014 publication of the National Water Policy Review (NWPR) and its policy position related to economic regulation (DWS, 2014).
- Will the decision be fair? This question deals with stakeholder opinion related to the perceived fairness of the WRCS process.

Moreover, it is a reality of stakeholder consultation processes that many stakeholders have vested interests or seek to achieve specific mandates. Thus, it is not just a matter of answering the above questions, but the analysis should also be done in a manner that can withstand challenges and legal scrutiny where required.

With these questions as context, we discuss the key gap identified in the Sections below.

2.10.3 Linkage between ecosystems and the economy

All PSPs interviewed highlighted this issue as the most problematic.

The current Guidelines are not clear on how the economic analysis should link to and integrate with the other components of the WRCS process (Principles 1, 2, 6 and 11). This includes the hydrology, river category assessment and scenario planning components. Thus the Guideline is not only weak with respect to specifying data requirements and analytical methodologies, but is also silent on setting thresholds for selecting appropriate and acceptable scenarios.

Crucially, the 2007 Guideline neglected to incorporate an extremely significant international development of the United Nations (UN), the Millennium Ecosystems Assessment (MEA, 2005). The MEA, and later The Economics of Ecosystems and Biodiversity (TEEB) defined the internationally accepted concept of ecosystem services as the benefits that ecosystems provide to human well-being. This failure has two consequences.

Firstly, the 2007 Guideline (and thus also the GNR 810) erroneously introduces a concept entitled "ecosystem goods, services and attributes", also abbreviated EGSA. Not only is the EGSA concept not in line with international best practice, but it also confuses environmental stocks (i.e. ecological infrastructure) and flows (i.e. ecosystem services). The difference between EGSA and ecosystem services is more than merely semantics as EGSA combines environmental stock (attributes) and flow items (goods and services), which from an economic modelling and valuation perspective, is flawed. The problem arises because different socio-economic modelling, accounting and valuation techniques are used for ecosystem stock and flow items. This concept is therefore confusing, and no doubt underlies some of the difficulty experienced by practitioners in applying the 2007 Guideline.

Secondly, and by far the largest problem with the 2007 Guideline is the failure to recognize the role and value of a special category of ecosystem services called the regulating services. The importance of the regulating services cannot be over-emphasized – these are the key services that link water resource health to socio-economic well-being. The 2007 Guideline not once mentions the regulating services, and this is a gross error and a fundamental omission.

The matter of ecosystem services has been particularly problematic. It is clear that various PSPs have different understandings and expectations of the definitions and use of ecosystem services. In 2010, DWS published a study on ecosystem services of several catchments, but this study did not prove to be helpful in resolving ecosystem service related issues. Some PSPs have not used ecosystem services indicators at all. In some cases, the matter of water use in the informal economy was raised by stakeholders as an important consideration. Often, actors within the informal economy are beneficiaries of ecosystem services. The matter of ecosystem services requires attention in the revised Guideline.

Another weakness is a failure to deal with threshold issues in assessing management scenarios. This problem relates also to the final valuation and evaluation of a Scenario and how it connects to the other technical components of the WRCS process. The 2007 Guideline do not advise on where the socio-economic evaluation should take input from the other technical components, and in turn, provide input into the other technical components. Thus, there is no guidance on how the thresholds and protection levels of water resources, assessed through the hydrology and river health disciplines should input into the socio-economic evaluation.

A symptom of this gap relates to the level of detail of the assessment. In some cases, the magnitude of ecosystem services change between scenarios are so small compared to other economic activity, that the scenarios appear insensitive to changes in ecological categories.

However, many exceptions occur. In the case of the Mvoti WRCS, a very contentious and significant trade-off has emerged between two scenarios where one scenario proposes to dispose of WWTW effluent in an estuary and another scenario proposes to dispose of the effluent at sea using a very costly pipeline. The first instance saves significantly on water treatment costs in an eThekwini-operated WWTW, thus reducing capital requirements in the near term and keeping municipal water tariffs lower in the long term. The second instance reduces impacts on the estuary, with likely indirect benefits to beneficiaries of ecosystem services (e.g. subsistence fishers, recreational fishers, property owners).

Another case emerged in the Crocodile West/Marico Water Management Area and the Mokolo and Matlabas catchments (CWMMM) where a particular scenario below the Marico-Bosveld irrigation scheme required significant water to be made available to the ecological reserve. This scenario would have incurred a significant cost to the agriculture economy, with significant job losses and risk to food security, and was not implemented.

Another case related to treatment of AMD in the Olifants and in the Crocodile-West Rivers. A particular method had to be used to demonstrate the costs and effects of treating or not treating AMD.

A particular problem with the current Guidelines relates to water quality (or water chemistry). Although the 2007 Guideline deals with water quality issues throughout the document, it is vague on proposing methods for evaluation. More work is required to develop a water quality evaluation approach that is consistent with DWS Resource Quality Services approaches, the polluter pays principle and the Waste Discharge Charge System (WDCS). This would enable a realistic assessment that is acceptable and intuitive to all stakeholders.

Two of the case studies dealt specifically with water quality: the Olifants and the CWMMM studies. In both cases, these systems were characterised by occurrence of acid mine drainage (AMD) and nutrient pollution. Several of the scenarios tested had meaningful consequences to water quality.

The CWMMM had a particularly interesting case, around the Roodeplaat Dam, where the release of a larger ecological reserve would result in a reduction on water quality. This was a counter-intuitive consequence resulting from the release of nutrient pollution captured within the system due to higher flow volumes.

In the Wilge River, in the upper reaches of the Olifants River, significant new coal mining and power generation developments are impacting water resources. The RQOs for the Wilge has not proven adequate to provide guidance to water resource management processes.

It is anticipated that in future, water quality related problems of the types discussed above will become an increasingly significant challenge that need to be addressed.

In the steps to follow in the next stages of this study, we will investigate specifically what different hydrological and eco-classification methods are available, what outputs these provide, and how these outputs are used to generate different resource classification scenarios. The objective of this work will be to investigate how we could link the outputs of these models in a consistent manner.

2.10.4 Inconsistent methodology

The Guidelines have not been able to specify a suitable set of socio-economic approaches and methodologies that would enable a common understanding of analyses and results. This has resulted in different approaches and methods getting used in the different studies and thus prevented comparison of results. Associated with this problem is a failure to standardize various aspects of the socio-economic work, including methodologies and socio-economic indicators used. Another failure arises from not standardising data sources to be used. And in addition, there has been a failure to specify a consistent, integrated set of outputs and deliverables for the socio-economic work.

The 2007 Guideline also suffers from vagueness. For instance, the Guideline refers variously to scoring systems and application of Social Accounting Matrixes and uses case study examples to demonstrate permutations of scoring techniques, production functions, micro-economic analyses and macro-economic techniques. Another example is the failure to explicitly recognise the economic role of the informal sector and its dependence on aquatic ecosystem services. Although it does deal with ecosystem services that the informal sector is reliant upon, it fails completely to recognise the importance of the informal sector and the importance of aquatic ecosystem services to this sector.

This essentially creates a situation which leaves a PSP without guidance on data sources, evaluation methods and consistent application of techniques.

As a result, PSPs have used a variety of techniques including multi-criteria analysis (MCA), cost benefit analysis (CBA), various data sources, various economic models and applications. In some cases, PSPs have used proprietary economic models. Thus, there has been no consistency in methodology.

It is important to recognise that different methodological approaches may be required in different WRCS studies. Drawing from the examples mentioned above, some study areas may have severe water quality problems, some may have significant ecosystem services problems, others may have specifically affected sectors or special interest groups. It is therefore expected that some methodological variation may exist between studies, and that not all studies would strictly follow identical methods.

A key methodological weakness here also relates to the definition of scenarios. It is common cause that scenarios that do not have significant cost or benefit consequences, require a smaller or less intensive amount of diligence to assess. Thus, the earlier and more accurate scenarios and their likely impacts can be defined, the better specific assessment methodologies and their required level of detail can be defined. Crucially, the selected methodology needs to answer the particular questions that the stakeholders are interested in (refer to Section 6.10.2). Of course, this is also an important project budget consideration, with potential costs to DWS if work cannot be completed within a specific budget.

The Letaba WRCS provides a good example of how scenarios had been formulated during the reconciliation strategy process, and were continued into the WRCS and RQO processes, eliminating unnecessary analysis and optimal iterations.

Inconsistent methodology application also has consequences for data requirements and consequently the intensity and quality of data. A large variety of data sources have been used to date. In most cases, where data has been referenced, the data are of level 3 and 4 SASQAF quality, i.e. official and acceptable data. Guidelines on data sources and their quality remain an important consideration for the revised Guideline document.

Similarly, accuracy (as also envisaged by SASQAF) is also an important consideration, especially where proprietary data or models are used.

The role of two current initiatives are really important here: firstly the water accounts development process overseen by StatsSA and the WRC; and secondly the ecosystem services accounting initiative conducted by SANBI and StatsSA. Both these processes would enable a more consistent approach to methodology and official data, and therefore also accuracy of results. These two initiatives would also serve to build trust among stakeholders in the methodology and data used as well as in the assessment process. The application of best practices in resource economics are particularly important here.

A key data issue is the delineation of economic data. For the most part, economic activity data is available at a national scale, and some socio-economic data is disaggregated to a provincial or municipal scale. However, no data is available at a WMA level. This is a challenge also to be addressed by the above to initiatives. Furthermore, detailed socio-economic information is required at IUAs in order to make better decisions during the analyses, and not only is the status quo required, but information on future drivers at this spatial resolution also needs to inform the determination of RQOs.

Consistent methodology and data would also enable improved linkage to other studies or initiatives, relating for instance to economic regulation, catchment planning or the WDCS. The various socio-economic studies have been large, relatively expensive studies, yet the outputs and benefits of these studies have been limited to the MC determination process. It has been difficult or impossible to apply the socio-economic studies used in the Classification component of the WRCS process to the RQO component. Much development and analysis work go into Classification component and the benefits of this work has to date, not been pulled through to strengthen analyses done in the RQO component. In addition, there has been a problem with "handover" of analysis tools to CMAs. The data collected, socio-economic models, analyses performed, and outputs of the socio-economic work can hold tremendous benefit to CMAs in the near future. This body of work would empower CMAs to better understand and manage their

WMAs, would improve strategic planning (e.g. CMSs), would improve the CMAs' ability to perform Economic Regulation (w.r.t. allocations, pricing strategies, revenue collection), and importantly, enable the CMAs to consistently and rapidly review the Classification and RQOs in their WMA on an ongoing basis. Currently, these benefits cannot be realized.

A very important benefit of using consistent methodology relates to empowering and enabling DWS staff to assess, during the course of the project, progress, key issues and results. To this end, standardised report templates that communicate well and clearly is of importance.

2.10.5 Logical order of methodological steps and formulation of scenarios

It emerges from the above discussions that the order of evaluation tasks proposed by the 2007 Guideline is highly problematic.

Experience during the WRCS has shown that the socio-economic evaluation of necessity has to take an iterative approach. At the start of the WRCS project it is important to create the economic context using appropriate techniques in order to support the development of IUAs, however it is premature to do an ecosystems services valuation at this stage. This is because ecosystem services valuation is extremely onerous and complex, and really only need to be done where ecosystem services are at risk to development. Thus, at this early stage it is sufficient to do an ecosystem service mapping exercise. Ecosystem service valuation should only commence once the Scenarios have been defined, and if they are at a significant level of risk, because it is through these Scenarios that ecosystem services risk are defined and evaluated.

The current order of tasks in the 2007 Guideline thus requires a large amount of work to be done at the outset of the project in anticipation of possible Scenario outcomes later in the project. This in turn affects project budgeting and delivery in a negative way.

2.10.6 Confusion among stakeholders and building trust

Following from the above, the varying approaches and outputs used by different PSPs have caused confusion among some stakeholders, especially in adjacent WMAs where stakeholders have been involved in more than one Classification/RQO process. This confusion stems from the different methods applied and different outputs delivered. Such confusion puts the WRCS process at risk (Principles 4, 7, 9 and 10), as the process is stakeholder driven and DWS needs stakeholders to participate in a meaningful and positive manner, which is not possible if the process is perceived to be methodologically flawed. The WRCS process is already a highly complex process involving a very diverse set of specialist study areas, and it is therefore important to simplify this process as much as possible, and gain the confidence of the stakeholders.

Gaining the trust of stakeholders in the evaluation process is important. Such trust is gained in various ways. We referred above to the Letaba WRCS where plausible scenarios were developed during the reconciliation strategy – thus, a stakeholder community who understands the water-related challenges and their potential future scenarios, is an important first step in building trust. In the Olifants WRCS project, tensions between various stakeholder interest groups lead to questions around the relative sizes of economic sector GVA (i.e. relative contribution to GDP) within the economic baseline. In this case much additional work had to be done to demonstrate the relative sizes of the largest water-using industries, specifically at a WMA level.

2.10.7 Legal defensibility and sufficiency of evidence

Related to the previous Section, there have been stakeholder challenges to the WRCS process, especially in the Olifants and the Mvoti-Umzumkulu studies.

In the case of the Olifants in particular, the challenge was of a legal nature. In such a case it is imperative that DWS and its PSP are able to defend the various methodologies applied (socio-economic and other methodologies) and the data used within these (Principle 7).

The Olifants WRCS outputs was challenged by the Legal Resources Centre in a letter to the Minister. The challenge was directed at various aspects of the work, including the socio-economic assessment work. The Legal Resource Centre hired independent economists to critique the work. The work however, withstood legal scrutiny and supported the eventual formalization of the WRCS outputs in the gazetting process.

Due to the variety of methods currently applied, it is not certain that all the WRCS studies are in a position to do so in a consistent manner.

It is important to once again emphasize that different methodological approaches may be required in different WRCS studies, and therefore there is a matter of sufficiency of evidence to be considered.

3 REVISED SOCIO-ECONOMIC GUIDELINES

3.1 Decision Analysis Framework

The socio-economic component of the WRCS requires a decision analysis framework that allows for the assessment of the implications of different catchment configuration scenarios at an IUA level on economic prosperity, social wellbeing and ecological condition. In keeping with principles of the WRCS the proposed framework would be required to take the following points into consideration:

- Maximise the economic returns from the use of water resources;
- Allocate and distribute the costs and benefits of utilising the water resource fairly;
- Promote the sustainable use of water resources to meet social and economic goals without detrimentally impacting on the ecological integrity of the water resource.

Based on these principles, the decision analysis framework, depicted in

Figure 3-1 was developed in order to inform the development of the socio-economic guidelines.

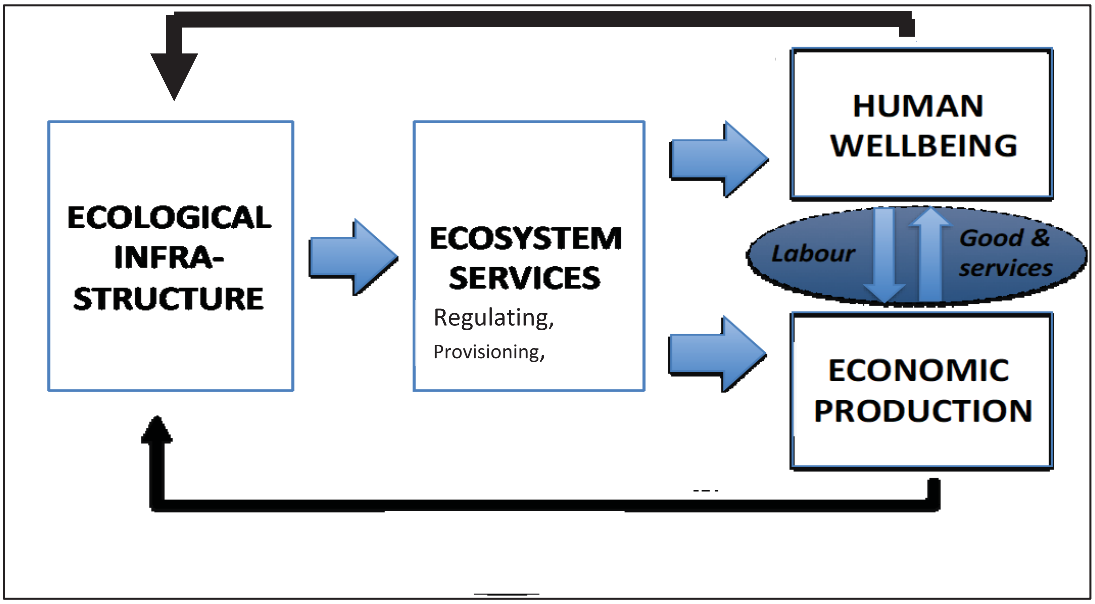

Figure 3-1: Proposed Decision Analysis Framework used to inform the development of the Socio-economic guidelines

The Decision Analysis Framework is based on the interaction of four components, ecological infrastructure (EI), ecosystem services, human wellbeing and economic production. Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable ecosystem services to people, such as fresh water, climate regulation, soil formation and disaster risk reduction. In the case of catchment management, ecological infrastructure could include aquifers, wetlands and sub-catchments. The supply of ecosystem services is dependent on the type, condition and extent of the EI. Ecological infrastructure in a good ecological condition would theoretically provide a robust flow of ecosystem services while EI in an impacted condition would deliver a less robust set of ecosystem services. In the model above, aquatic ecosystem services are provided to communities directly (through the provisioning services), which is able to influence human wellbeing and to the economy directly through the provision of raw water. Economic production may have a negative impact on ecological infrastructure through over abstraction and pollution, which in turn has an impact on the delivery of ecosystem services. The same relationship exists with communities and ecological infrastructure, but to a lesser degree. The relationship between human wellbeing and economic production can be described in economic terms, with households providing labour into economic sectors, which provide goods and services in return.

3.2 Overview of Tasks

The classification process requires an understanding at a catchment level of various components (social, economic and environmental) within the Decision Analysis Framework. This is done through a stepwise process whereby the primary characteristics within each component are identified and changes thereof are analysed against various scenarios. An overview of tasks presented in this process is given in Figure 3-2. These tasks will be further described in the Sections to follow

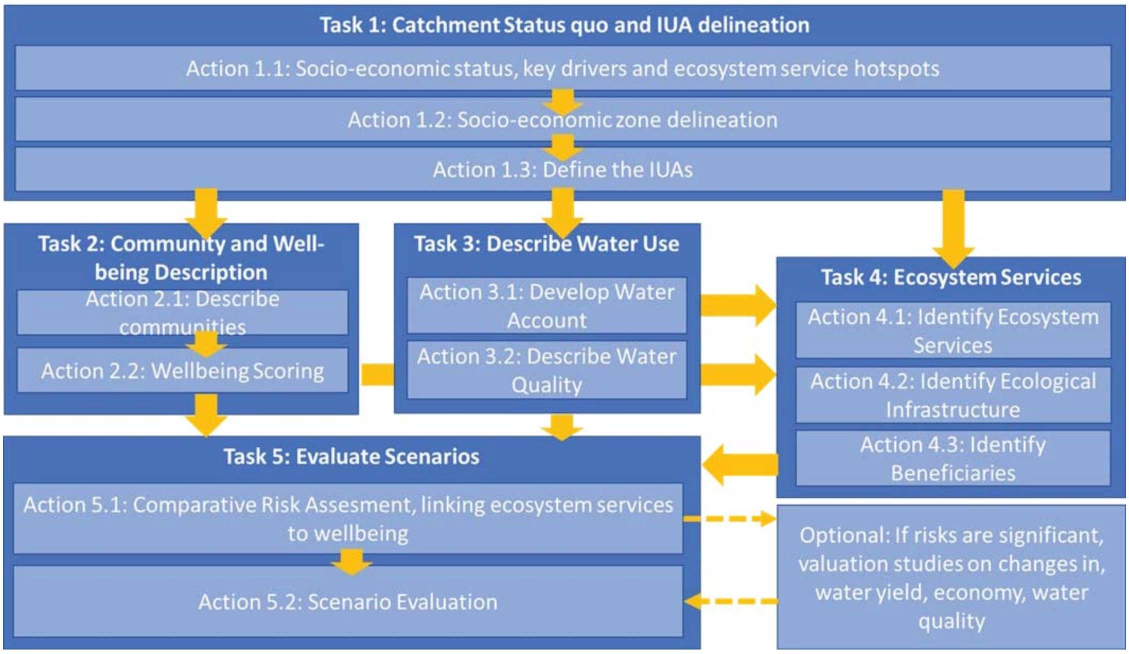

Figure 3-2: Overview of Tasks with corresponding actions for the Socio-economic Guidelines

The Tasks presented in the guideline correspond with the gazetted 7-Step Process of the WRCS (Figure 3-3).

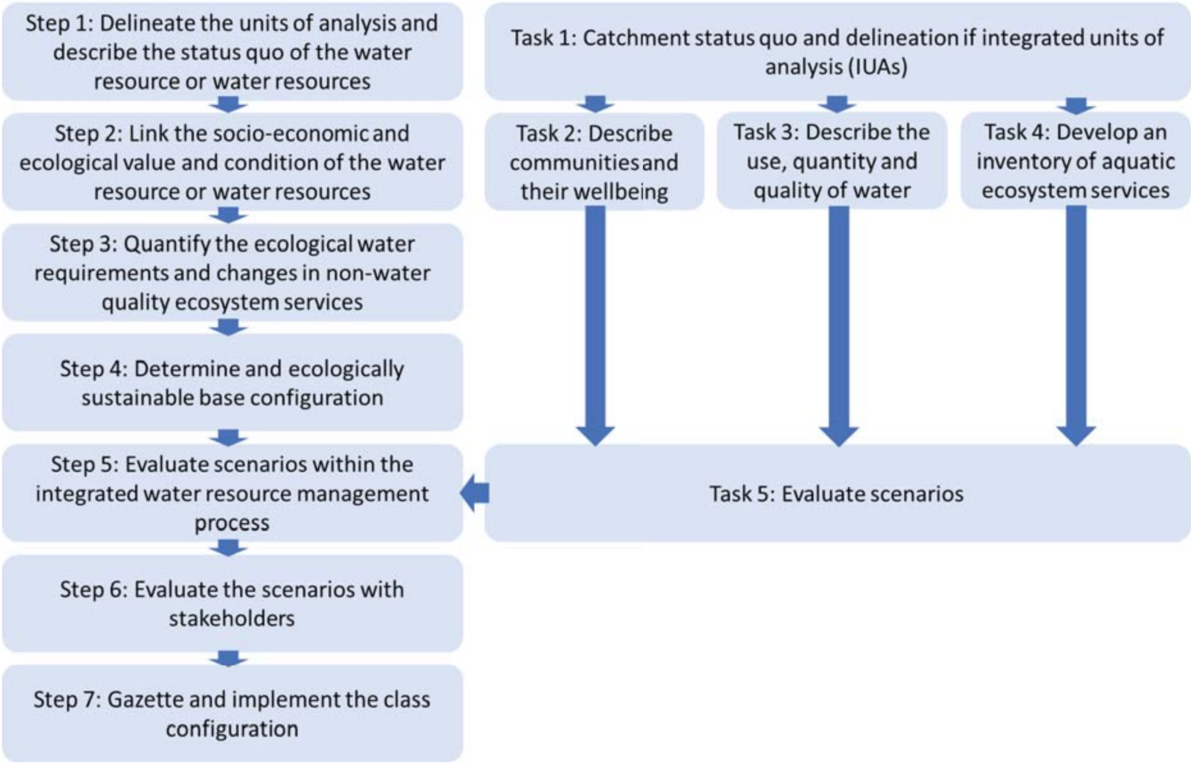

Figure 3-3: Alignment of the Socio-economic guidelines with the 7-Step process for determining MC

3.3 Task 1: Determination of Catchment Status-quo & Determination of IUAs

Integrated Units of Analysis (IUA) are a combination of socio-economic zones (SEZ) (described below), catchment boundaries and fine scale ecological information (DWS, 2007b).

The goal of an IUA is to delineate an area within catchment boundaries that is relatively homogenous in terms of both socio-economic characteristics and dependencies of communities to the services provided by aquatic ecosystems and the patterns seen in ecological features across the catchment.

IUAs are crucial for the delineation of the catchment into MCs, which describe the desired state of the water resources and the level of utilization. This classification is necessary for the process of maintaining a balance between protecting our national water resources and using them to meet economic and social goals.

The three actions required for determining the IUAs are as follows:

- Action 1.1: Describe the present socio-economic status and key drivers and ecosystem service hotspots;
- Action 1.2: Delineate socio-economic zones; and
- Action 1.3: Define the IUAs.

Although the actions have been separately described, the application of them does not require that they be completed in isolation. There are in fact common elements throughout the actions and should be approached as a whole towards achieving the outcomes of the Task at hand.

3.3.1 Action 1.1: Describe the present socio-economic status, key drivers and ecosystem service hotspots

The aim of this action is describing the present socio-economic status, key drivers and ecosystem service hotspots within the catchment at a broad scale. The sufficient completion of this action requires a general understanding of the locality of corresponding spatial features within the catchment.

The initial approach should therefore be to compile a distributional description of all social, economic and ecological features within the catchment.

This description should include, but is not limited to, features such as catchment boundaries, water resources (rivers, wetlands and dams), precipitation, towns and cities and general land cover and use.

A distributional understanding of the catchment will allow for an improved position from where the socio-economic status, key drivers and the ecological status can be described.

3.3.1.1 Socio-economic status and key drivers

The description of Socio-Economic status and key drivers requires an understanding of spatial patterns in population densities, land use and the economic drivers across the catchment. This data should be analysed using methods and tools appropriate for spatial analysis (Geographic Information Systems (GIS)).

To reiterate, this action is completed at a broad scale and the general patterns across the catchment must be identified. As an example, patterns in population data could include the identification of areas of relative high, moderate to low population densities. Land use could indicate the general but predominant land use types such as peri-urban, urban, natural or protected areas. Economic drivers could include the principle drivers of the local economy such as mining, agriculture or tourism and the corresponding present status of each from both a social and economic point of view.

Data Requirements/Sources

Suggested sources of required data are presented in Table 3-1.

Table 3-1: Recommended data requirements for describing the socio-economic status, key drivers and general spatial features across a catchment

Data Required	Possible Source	Scale
Latest Population densities	National Census data (StatsSa)	Ward Level
Latest Land Use/Cover	DEA (egis.environment.gov.za)	National
Economic contributors	StatsSa/ GDP Publication	Provincial
Catchment boundaries	Department of Water and Sanitation (DWS)	National
Water resources	South African National Biodiversity Institute (SANBI)	National
Towns and cities	DEA (egis.environment.gov.za)	National
Infrastructure	DEA (egis.environment.gov.za)	National
Satellite Imagery	Google Earth^{TM}	National
Towns and cities	DEA (egis.environment.gov.za)	National

3.3.1.2 Ecosystem service hotspots

Ecosystem service hotspots need to be identified through broadly investigating the presence of ecosystem services across the catchment. The identification and qualitative descriptions of each is the first step towards understanding the patterns of ecosystem service use across the catchment. This will provide a baseline for the appropriate selection of ecosystem services from which the use of aquatic ecosystem services will be described in Task 4

The specifics of the approach will depend on the availability of data for the given catchment and although only a brief description is required, could involve a fair level of investigation. Multiple approaches and sources of information should be explored possibly including, but are not limited to, the literature, brief consultation with experts and baseline field visits.

A starting point could include a master list of ecosystem services provided in literature and eliminate or select the services appropriate to the areas investigated. A qualitative description should accompany each ecosystem service outlining the general magnitude of its abundance and utilisation in the area. Table 3-2 provides an example of a master list illustrating potential ecosystem services provided by a river system (TEEB 2010).

Table 3-2: The Typology of Ecosystem Services (TEEB 2010)

Service Type	Ecosystem Services
PROVISIONING	Food (e.g. fish, game, fruit)
	Water (e.g. for drinking, irrigation, cooling)
	Raw Materials (e.g. fiber, timber, fuel wood, fodder, fertilizer)
	Genetic resources (e.g. for crop-improvement and medicinal purposes)
	Medicinal resources (e.g. biochemical products, models & test-organisms)
	Ornamental resources (e.g. artisan work, decorative plants, pet animals, fashion)
REGULATING	Air quality regulation (e.g. capturing (fine)dust, chemicals, etc.)
	Climate regulation (incl. C-sequestration, influence of vegetation on rainfall, etc.)
	Moderation of extreme events (e.g. storm protection and flood prevention)
	Regulation of water flows (e.g. natural drainage, irrigation and drought prevention)
	Waste treatment (especially water purification)
	Erosion prevention
	Maintenance of soil fertility (incl. soil formation)
	Pollination
	Biological control (e.g. seed dispersal, pest and disease control)
HABITAT	Maintenance of life cycles of migratory species (incl. nursery service)
	Maintenance of genetic diversity (especially in gene pool protection)
CULTURAL & AMENITY	Aesthetic information
	Opportunities for recreation & tourism
	Inspiration for culture, art and design
	Spiritual experience
	Information for cognitive development

3.3.2 Action 1.2: Delineate Socio-economic zones

The aim of this action is to delineate the catchment into Socio-Economic Zones (SEZ) based on relevant new data and data acquired in the previous step. The SEZ allocation allows for an understanding of the variation across space in terms of ecological prosperity and societal well-being and the corresponding vulnerability to changes in ecological status. Communities should be classified based on common variables indicative of their vulnerability to both impacts and changes in management class i.e. their level of dependence on natural water resources. This minimises the possibility for inappropriate management at such a broad scale.

A SEZ is typically delineated as a zone of (as far as possible) relatively homogenous socio-economic characteristics and dependencies to the services provided by associated aquatic ecosystems.

Spatial considerations for SEZ determination should include (but are not limited to), results of Action 1 but may also include additional information such as land tenure, land use type (broad categorisation), aquatic resources present and other significant variables that indicate the extent of relationship between communities and associated ecosystems i.e. Tourism.

The SEZ are initially based on general areas in the catchment but for the purposes of delineating IUAs must be aligned with quaternary catchment boundaries. This allows for a linking of the distribution of socio-economic and the ecological aspects in the catchment.

<u>Data Requirements/Sources</u>

Suggested sources of data are presented in Table 3-3.

Table 3-3: Recommended data requirements for Socio-Economic Zone determination (SEZ)

Data Required	Possible Source of Data	Scale
Latest Land Tenure	Department of Rural Development and Land Reform (DRDLR)	Local (Farm Portion)
Latest Aquatic resources	South African National Biodiversity Institute (SANBI)	National
Latest Protected areas	DEA (www.egis.environment.gov.za)	National
Latest Land Cover	DEA (www.egis.environment.gov.za)	National

3.3.3 Action 1.3: Define the IUAs

The delineation of Integrated Units of Analysis (IUAs) involves the collation of the SEZ, catchment boundaries and results of the ecological classification studies up to this point (end of Step 1-definition of IUA action) (DWAF, 2007b). It is at this point that biophysical nodes are identified and are used to retrieve ecological data that is relevant to the socio-economic characteristics of each IUA.

This process will typically occur in a workshop environment with all relevant specialists contributing their findings and agreeing on the proposed IUA delineations.

3.3.4 Outcomes

The outcomes of this task (Task 1) should be a report, with visualisations included, outlining the data sources and methodologies used to demarcate SEZ. The report should further include the process followed to collate SEZ with other required specialist results to result in the final delineation of IUAs.

3.4 Task 2: Describe Communities and Their Wellbeing

The aim of this task is to describe the wellbeing of communities within each IUA identified in the previous step.

The well-being of communities should be described using various indicators of financial, physical, human, social and natural capital assets available to those communities. The process includes the construct of an index of wellbeing which are used together to determine a Social Wellbeing Score (SWS). The approach taken was based on the approach toward classifying social wellbeing in DWAF, 2007c.

The actions required to describe communities and their wellbeing are presented below. Although the actions have been separately described, the application of them does not require that they be completed in isolation. There are in fact common elements through the actions and should be approached as a whole towards achieving the outcomes of the Task at hand. Please note that the indicators described below are just recommendations for the process and could differ based on the study area, approach and data available.

A key consideration for this Task is to start identifying the significant rural communities within each IUA. Community leaders should be contacted and informed on the processes to follow. This will have a dual function. Firstly, this will provide an opportunity to receive a narrative on the wellbeing of the community and potentially provide a source of data. Secondly, the inclusion of communities from an early stage of the WRCS process would provide increased opportunity of buy-in for the process and thus possibly reduce risks to the stakeholder engagement process (Followed in Step 6 and 7).

3.4.1 Action 2.1: Description of communities

The description of communities is largely based on the latest census data. The wellbeing descriptions are at an IUA level and fall within catchment boundaries. Catchment boundaries do not correspond with boundaries used in censuses (i.e. Census 2011 is at ward level). For this reason the descriptions will require spatial manipulation to apportion the indicator data to IUA boundaries. Recommended categories and indicators are presented in Table 3-4.

Table 3-4: Recommended categories, indicators and brief descriptions for describing the social wellbeing of IUAs

Category	**Indicators required (Latest Census Data)**	**Description of Approach**
Household Income	Annual household income	Household income could be categorised into different income types indicating variations to wellbeing i.e. very poor, poor, comfortable and wealthy.
Services and Infrastructure	• Access to water • Sanitation • Type of Dwelling	These indicators allow for an understanding of the communities' physical capital assets.
Education	Education levels	Education levels give an indication of human capital assets in a community. Education levels could be categorised into different education types indicating variations to wellbeing i.e. No education, uneducated, fairly educated, educated and highly educated.
Relationships with water resources (Vulnerability)	Source of water per household	An indication of a communities natural capital assets. An important indicator found in census data is the sourcing of water from natural resources. This data is used to determine the reliance percentage on these resources. It gives an indication of the direct reliance of the population to accessible water in the system.

3.4.2 Action 2.2: Wellbeing index scoring

Wellbeing index scoring is an approach whereby multiple indicator of well-being are integrated, resulting in an overall Social Wellbeing Score (SWS). This approach ideally gives a score between 0 and 100 where 0 is the lowest and 100 is the highest level of social wellbeing. The use of this scale allows for percentages to be used in the determination of the SWS. Indicators of wellbeing should be categorised and an average score of wellbeing determined. The overall score will be the average score among categories. Recommended categories with descriptions of approach are given in Table 3-5.

Table 3-5: Recommended scoring categories, indicators required and brief descriptions for Social Wellbeing Score (SWS) determination

Category of Score	Indicators Required	Description of Approach
Prosperity Score	Household Income (Census Data)	The prosperity score should give a measure of prosperity in the community. This can be indicated by the percentage of "Non-poor" income types.
Employment Score	Employment Status (Census Data)	This can be indicated by the percentage of employment in the community.
Human Health Score	Disease Prevalence (Multiple sources/ StatsSa/DoH)	The percentage of healthy population based on various health issues due to malnutrition, infectious disease, water borne diseases, water quality related diseases including: HIV, TB, Hepatitis, Malaria, Bilharzia, Cholera, Typhoid) and the percentage of children under 5 that are not malnourished or have diarrhoea.
Utility Score	Ecosystem Health Index (SANBI/DEA)	This score is intended to give an indication of the connection between communities and associated ecosystems through a proxy measure for satisfaction. In the past (DWAF, 2007c) the proxy indicator has been a measure of percentage transformation of aquatic resources from natural.
Relationships with water resources (Vulnerability)	Source of water per household	An indication of a communities natural capital assets. An important indicator found in census data is the sourcing of water from natural resources. It gives an indication of the direct reliance of the population to accessible water in the system.

3.4.2.1 Relationships with water sources

Vulnerability of communities in this case illustrates the reliance of households and individuals on specific water sources for daily use. This daily use includes water for drinking, food preparation and personal hygiene. Data for determining the vulnerability within a catchment can be found in the census results in the sourcing of water category. Within this category the number of households reliant on rivers, boreholes (groundwater), rainwater, reservoirs, water venders, tankers, streams and springs as their source of water can be found. The percentage of use of a specific water source acts to comparatively rank IUAs based on their vulnerability to impacts on the specific water source.

As an example, if a comparatively high percentage of households rely on groundwater for providing fresh water in a specific IUA, the vulnerability of communities to impacts on groundwater resources will be high. A measure of vulnerability specific to water resource thus informs both Task 4 and Task 5.

The percentage of use by water resource must be determined for each IUA and included in the final output.

3.4.3 Outcomes

The outcomes of this task will include a description of the social wellbeing characteristics as well as a range of wellbeing and vulnerability scores per IUA. As far as possible the data should be quantitative however the primary concern is to understand the patterns or variability of social wellbeing across the catchment. The methodologies utilised to determine the scores of wellbeing and vulnerability must be should be explicitly described.

3.5 Task 3: Describe the Use and Value of Water

The objective of this task is to describe the way in which water is used on an IUA level, and to estimate the value generated by that use. This step builds on analysis produced in Task 1 and will describe the relationships that determine how the value is influenced by sectoral use of water within the context of the resources that is abstracted.

Water provides goods (e.g. drinking-water, irrigation water) and services (e.g. hydroelectricity generation, recreation and amenity) that are utilized by agriculture, industry and households. Provision of many of these goods and services is interrelated, determined by the quantity and quality of available water.

Each water user has an existing water allocation and water assurance guarantee. Reconciliation strategies and All Town strategies determine what quantity of water is demanded within each WMA. These strategies assess the current situation which incorporate ‘normal changes’ in future water usage patterns, i.e. normal economic and demographic growth, normal price changes, etc. These strategies can be used as an input in describing the allocation of water per sector.

Water flow accounts, which includes physical and monetary flow accounts can be used as a tool to describe the use and value of water as it shows the industries and areas using the most water.

Water flow accounts are useful for analysis on how economic changes impact the environment and how changes in water availability impact the economy. An example of a water flow account is shown in Figure 3-4 and records the flow of water between the environment, including supply, use and return of water by industry and households.

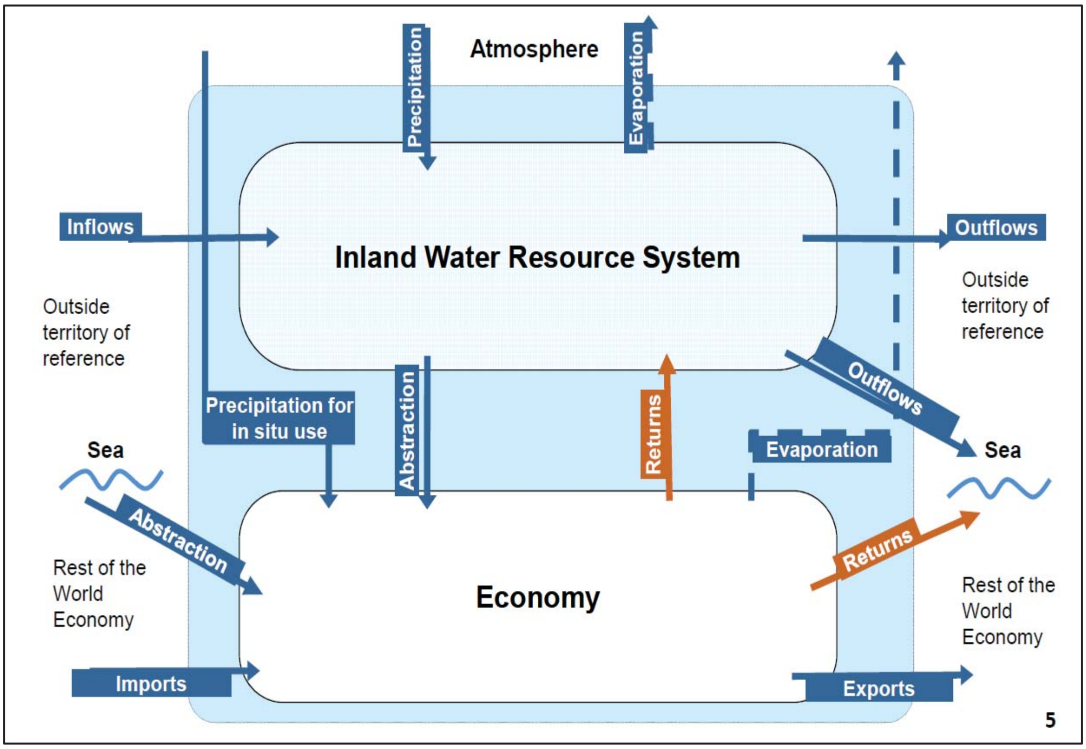

Figure 3-4: Stock-Flow Model of Water Flow Account

Please note: StatsSa and the Water Research Commission (WRC) are currently (2017) developing a national Physical Water Flow Account. This account will be updated every 5 years (due to frequency of data capture) and will include information per Water Management Area (WMA). This provides a valuable for opportunity whereby this account may be utilised as an input for the socio-economic classification.

3.5.1 Action 3.1: Development of a physical water account

Both physical and monetary accounts are based on supply and use tables (SUTs).

Physical water flow accounts provide information on the volumes of water exchanged between the environment and the economy (abstraction and returns) and water exchanged within the economy. The rows represent the supply, and the columns represent the end-use. Statistics South Africa is currently developing water accounts for each catchment. This information is used to identify beneficiaries of water provisioning services. However, the accounts are not comprehensive, and the practitioner is advised to add transactions from other sources.

Table 3-6 summarises the compilation of data required for physical flows.

Table 3-6: Inputs required for the development of physical flow account

Water users	Data required	Possible data source
• Agriculture • Commercial Forestry • Domestic Household	Volume of wastewater treated	DWS Green drop data
	System input volume per municipality	DWS no drop system data

Water users	Data required	Possible data source
• Industry and Power	Municipal water sources	StatsSa NFCM
	Total mean annual runoff, flows between catchments and other countries	Water Resources 2012
	Source of water and water use	DWS Catchment and All Town reconciliation strategies
	Volume of groundwater extracted and used	DWS Groundwater Strategy
	Volume of water used in the electricity industry	StatsSa Electricity LSS
	Water supply by water boards in the country	Water boards annual reports

3.5.2 Action 3.2: Water quality account

Water Quality accounts provides information on the state of the quality on water resources. Water quality account assist in reporting consequences of economic development that result in ecological degradation. Integration of water quality account and water flow account will assist in quantifying available water that is suitable for use.

Table 3-7 describes data needed for compiling water quality accounts.

Table 3-7: Inputs required for the development of water quality account

Data Required	Data Source
Water parameters for the particular Catchment	Classification water quality results from monitoring

Water accounts are supporting methodologies useful in assessing impacts on how economic changes impact the environment and how changes in water availability and quality impact the economy. The output of this task is a quantified account of water use in the catchment. This assists in defining the use per economic sector of water. The output will identify the volume and quality associated at an IUA level.

3.6 Task 4: Develop an Inventory of Aquatic Ecosystem Services

Following on from Action 1, the purpose of this step is to identify the ecosystem services (ES) within the catchment at an IUA level and determine a broad idea of the demand of these services by communities and the economic sectors that utilize them. The approach is based on a supply-demand framework developed by Quayle & Pringle (2014).

3.6.1 Action 4.1: Identify the ecosystem services to be assessed

The TEEB (2013) classification system provides a typology of ecosystem services that is based on a number of previous studies e.g. the Millennium Ecosystem Assessment (MA, 2005). This typology can be used to identify the relevant ecosystem services within each IUA within the catchment. The identification would be conducted at a desktop level in conjunction with relevant experts and using tools such as Google Earth and aerial photography. This action would draw heavily on the outcomes of Action 1 i.e. the wellbeing assessment as well as outputs from other experts such as hydrology.

Output: A list of relevant ecosystem services to be assessed.

3.6.2 Action 4.2: Identify ecological infrastructure & supply of ecosystem services

The aim of this step is to identify the ecological infrastructure, which in turn supplies the flow of ecosystem services identified in Action 1. Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to society (SANBI 2014). Within a catchment ecological infrastructure could include wetlands, aquifers, sub-catchments and any other ecosystems that provide services. The identification of ecological infrastructure is similar to Step 2 of the integrated framework steps i.e. Delineate and Prioritize Resource Units proposed by DWS (2016). The identification would be conducted at a desktop level in conjunction with relevant experts i.e. wetland and river experts and using tools such as Google Earth and aerial photography.

Output: A list of relevant ecological infrastructure to be assessed. If possible the results must be aligned with resource units identified. The resource units must be obtained from the wetland, river, groundwater and hydrological components of the classification process.

3.6.3 Action 4.3: Determine beneficiaries and demand for ecosystem services

Ecosystem services are defined as the benefits that society receives from ecosystems (MA, 2005). Therefore understanding who benefits from these services is an important component when determining the entire ecosystem service value chain. It is important to note that the demand of the ecosystem services will often differ spatially, as demand for certain ecosystem services could be at a national or global scale i.e. carbon sequestration and demand for others could be at a quaternary catchment scale (or smaller) i.e. water provisioning or harvesting of medicinal plants (Quayle & Pringle 2014).

The identification would be conducted at a desktop level in conjunction with relevant experts and using tools such as Google Earth and aerial photography. This action would draw heavily on the outcomes of Task 2 and Task 3.

3.6.4 Outputs

The main output of the Task should be an inventory of relevant ecosystem services, the associated ecological infrastructure and resource units and an indication of the relevant beneficiaries of ecosystem services per IUA.

Table 3-8 below shows an example of the outputs of this Action.

Table 3-8: Example table showing the relevant ecosystem services, associated ecological infrastructure and demand for these services

Service Category	Service	Ecological Infrastructure	Demand	Unit of Measurement
Provisioning	Freshwater	Delineation of aquifers	Local & regional demand	Volume of water abstracted
Regulating	Water quality	Delineated wetlands	Local & regional demand	Water quality standards
Cultural & amenity	Ecotourism	Lake	Local & international	Number of tourists visiting site

3.7 Task 5: Evaluate Scenarios

The objective of this task is to evaluate the selected scenarios within the socio-economic framework. Scenarios, in the context of water resource management and planning are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

3.7.1 Action 5.1: Environmental effect statement

The aim of developing environmental effect statements is to provide context on the broad effects that scenario changes have at the IUA level. It quantifies the change in water quantity and quality for each IUA and scenario and highlights specific ecosystem services that are potentially at risk. This allows participants of the analysis to form a causality chain of the effects of changes in the environment to beneficiaries.

Examples:

A reduction in water quality especially that of increased turbidity will impact the provisioning of fresh water to use by local communities for their livelihoods. The impacts to commercial water use may not be as great due to access to alternatives.

The reduced flow will reduce the extent of wetted areas and thus functional aquatic habitats. This will reduce the capacity for provisioning services of which play a vital role in the highly rural IUA (i.e. Raw materials and fish collection capacity will be reduced).

3.7.2 Action 5.2: Comparative risk assessment

The aim of this Action is to determine the risk the selected scenarios pose to ecosystem services. This process will be informed by outputs of Tasks 2, 3 and 4.

A Comparative Risk Assessment (CRA) methodology, takes a rigorous approach to determining the risk posed to ecosystem services by the scenario. Box 1 below gives a brief overview of the methodology followed in the process.

In this approach, the ecosystem service (and their attributes) list developed in Action 10 would be a starting point for the assessment. The list of ecosystem services would be assessed in the CRA workshop by a team of multi-disciplinary experts including ecologists, social specialists and hydrologists. Through the CRA process, a list of ecosystem services at risk from the scenario would be generated. The prioritised list would contain a descriptive chain of causality for each ecosystem service/scenario interaction. If required and if budget is available, prioritised ecosystem services could then be valued.

Comparative Risk Assessment (CRA) is a method for assessing, comparing, ranking and describing formally the risks in an environment with different elements at risk, and for each of which different kinds and depths of information are available.

The CRA is used as:

- A method for the prioritising and describing of risks that would arise from the predicted environmental effects of the proposed scenario; and
- A technique to analyse the chain of causality resulting from the scenario

Ecosystem service risk is the function of the likelihood and consequence of the hazards to which the ecosystem service is exposed. In the context of WRCS, an environmental asset is equivalent to ecological infrastructure. Thus:

Risk to ecosystem service = f(likelihood, consequence)

of environmental effect on an ecosystem asset.

The consequence of the hazard is the change in the ecosystem service arising from the environmental effect of the scenario on the exposed asset.

Box 1. Overview of methodology for a Comparative Risk Assessment

3.7.3 Optional Task: Ecosystem services economic valuation

In the event that risks to ecosystem services are high, it may be necessary to use economic valuation techniques will assist in the evaluation of the trade-offs between the various scenarios. Blignaut and Lumby (2004) developed a framework to support decisions when choosing valuation techniques:

- If market values are available, then changes in productivity techniques can be employed,
- If non-distorted (efficient) market prices are not available, then surrogate market approaches such as the travel cost and hedonic pricing methods can be used
- If market prices are not available, but direct (efficient) proxies are, a variety of assumed preference techniques such as damage cost, replacement cost, cost of illness or other benefit transfer methods (BTM) can be used
- When indirect proxies are available, observed behaviour techniques such as the travel cost and hedonic pricing methods can be used
- If no market prices or proxies exist, hypothetical behaviour methods such as contingent valuation methods or conjoint analysis methods can be used.

It is often necessary to use a combination of valuation techniques rather than a single technique to value ecosystem services.

3.7.4 Action 5.3: Scenario evaluation

The outputs of this task must include a prioritised list of scenarios based on the cumulative extent of risk to ecosystem services they pose, a list of ecosystem services at risk per scenario and a list of beneficiaries at risk per scenario.

4 DECISION SUPPORT TOOL

4.1 Overview

The Decision Support Tool is an Excel based model that aims to provide realistic socio-economic information when determining trade-offs resulting from different water use scenarios. When taking into consideration the Task list proposed in Deliverable 4 (Figure 3-2), the Decision Support Tool is intended to be used in Task 5 i.e. Evaluation of Scenarios. The outputs of Tasks 1-4 will provide the content of the Decision Support System. The model is comprised of 2 separate Excel workbooks and 2 optional one input workbook page named the Socio-economic Comparison Tool. The full list of workbooks is given below:

1. The Socio-economic Comparison Tool (SECT);

The outcome of the SeCT will determine whether to use additional Excel workbooks presented below:

1. Water quality load model
2. Economic model

The components, input requirements and outputs of the Decision Support System are represented in Figure 4-1 below.

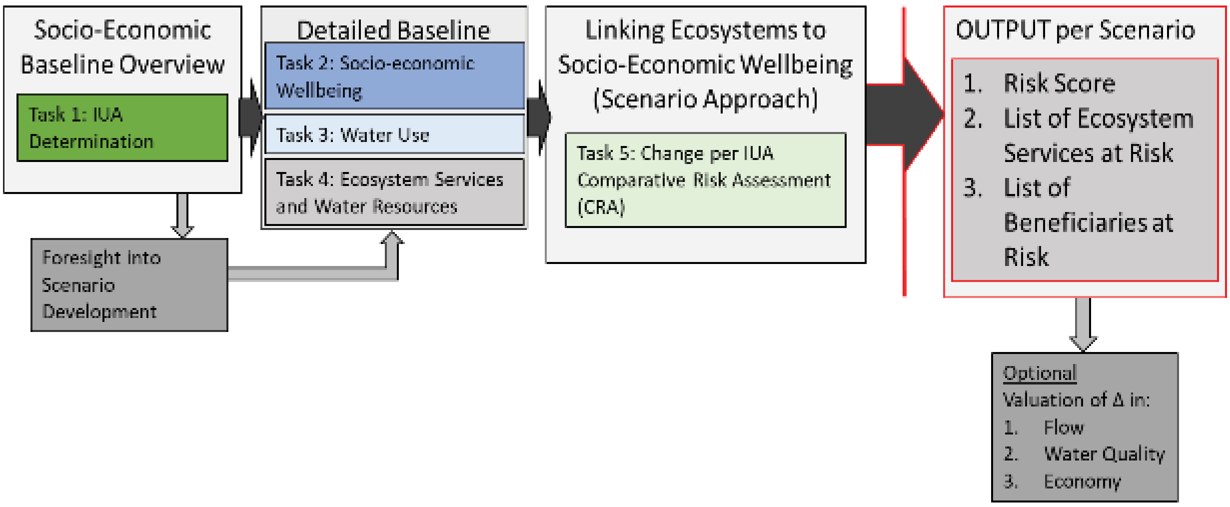

Figure 4-1: Schematic representation of the Decision Support Tool

These components are discussed in detail in the proceeding Sections.

4.2 The Socio-Economic Classification Tool

The Socio-economic Classification Tool (SeCT) serves as a dashboard that is used to initiate the analysis, as well as provide an overview of the results. The main aim of the SeCT is to compare catchment scenarios based on risks to ecosystem services. In order to achieve this the model serves as a repository for the information required for the analysis.

Figure 4-2: Socio-economic Classification Tool instruction dashboard

The stepwise functions captured within the SECT Instruction dashboard are explained below:

Task 1. The delineation of Integrated Units of Analysis (IUAs) involves the collation of the SEZ, catchment boundaries and results of the ecological classification studies up to this point (end of Step 1-definition of IUA action) (DWS, 2007b). It is at this point that biophysical nodes are identified and are used to retrieve ecological data that is relevant to the socio-economic characteristics of each IUA. This process will typically occur in a workshop environment with all relevant specialists contributing their findings and agreeing on the proposed IUA delineations.

Task 2. The description of communities is largely based on the latest census data. The wellbeing descriptions are at an IUA level and fall within catchment boundaries. Catchment boundaries do not correspond with boundaries used in censuses (i.e. Census 2011 is at ward level). For this reason the descriptions will require spatial manipulation to apportion the indicator data to IUA boundaries.

Index scoring is an approach whereby multiple indicator criteria are collated to result in a final integrated score. In this case criteria contributing to social well-being and water vulnerability are integrated, resulting in both an overall Social Wellbeing Score (SWS) and Vulnerability Score (VS). The use of this scale allows for percentages to be used in the determination of the SWS and VS. This approach results in a score falling between 0 and 100 (derived from percentage of the population) where 0 is the lowest and 100 is the highest level of either social wellbeing or vulnerability.

Task 3. Physical water flow accounts provide information on the volumes of water exchanged between the environment and the economy (abstraction and returns) and water exchanged within the economy. The rows represent the supply, and the columns represent the end-use. Statistics

South Africa is currently developing water accounts for each catchment. This information is used to identify beneficiaries of water provisioning services. However, the accounts are not comprehensive, and the practitioner is advised to add transactions from other sources.

Water Quality accounts provides information on the state of the quality on water resources. Water quality accounts assist in reporting consequences of economic development that result in ecological degradation. Integration of water quality account and water flow account will assist in contextualising ecosystem service risks.

Task 4. The TEEB (2013) classification system provides a typology of ecosystem services that is based on a number of previous studies e.g. the Millennium Ecosystem Assessment (MA, 2005). This typology can be used to identify the relevant ecosystem services within each IUA within the catchment. The identification would be conducted at a desktop level in conjunction with relevant experts and using tools such as Google Earth and aerial photography. This action would draw heavily on the outcomes of Action 1 i.e. the wellbeing assessment as well as outputs from other experts such as hydrology.

The aim of this step is to identify the ecological infrastructure, which in turn supplies the flow of ecosystem services identified in Action 1. Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to society (SANBI 2014). Within a catchment ecological infrastructure could include wetlands, aquifers, sub-catchments and any other ecosystems that provide services. The identification of ecological infrastructure is similar to Step 2 of the integrated framework steps i.e. Delineate and Prioritize Resource Units proposed by DWS (2016). The identification would be conducted at a desktop level in conjunction with relevant experts i.e. wetland and river experts and using tools such as Google Earth and aerial photography.

Ecosystem services are defined as the benefits that society receives from ecosystems (MA, 2005). Therefore, understanding who benefits from these services is an important component when determining the entire ecosystem service value chain. It is important to note that the demand of the ecosystem services will often differ spatially, as demand for certain ecosystem services could be at a national or global scale i.e. carbon sequestration and demand for others could be at a quaternary catchment scale (or smaller) i.e. water provisioning or harvesting of medicinal plants (Quayle & Pringle 2014).

Task 5. The environmental effect statement provides context on the broad effects that scenario changes have at the IUA level. It quantifies the change in water quantity and quality for each IUA and scenario. It also highlights specific ecosystem services that are potentially at risk.

The CRA assesses the impact that scenarios will have on well-being through ecosystem services. Populating the CRA occurs in a workshop setting with multidisciplinary exerts that include hydrologists, ecologists and the socio-economic team. This operation, imports data from preceding steps to autofill columns marked automatic and prepopulate columns marked select with dropdown lists. Links to frameworks and data provide context to the practitioners using the CRA. The practitioners use this information to guide the description of the benefits and environmental effects that are directly inputted into the assessment and are marked manual.

This sheet compares scenarios based on their cumulative ecosystem risk scores. Although each individual risk is qualitative, a simple score ranging from 1 to 8 is given to each risk (ranging from low to extreme), is given. The cumulative impacts of each scenario on ecosystem risks is provided as a risk score.

4.3 Comparative Risk Assessment

A Comparative Risk Assessment (CRA), now widely accepted as an approach to deal with a heterogeneous problem, with environmental and developmental complexity, and where there is a necessary reliance on drawing together information from both explicit scientific sources, together with tacit knowledge and relevant opinion (e.g. Peterson and Hulting, 2004; O'Laughlin, 2005; and Kruger et al., 2006).

In the CRA method, experts formulate the chains of causality between a development activity or management scenario, the resulting change in ecosystem assets and effect on ecosystem services. In addition, the CRA serves to rate the consequences associated with the subsequent environmental effects and its uncertainty. CRA is both an analytical process and a methodology for prioritizing complex problems. Comparative risk assessment is a multi-attribute evaluation procedure which allows for a theoretically sound and structured progression by way of manageable individual steps. For each step (such as structuring the problem, structuring and weighting the attributes, sensitivity analysis) a range of practically tested techniques exist. The strength of the CRA is that it facilitates an explicit examination of assumptions and values and thus aids in a transparent comparative risk evaluation. This approach is therefore eminently suitable for those comparative risk assessment processes in which a variety of evaluators, both experts and other stakeholders take part.

It is also similar to Ecological Risk Assessment (ERA), which is the process of predicting or estimating the likelihood and magnitude of adverse ecological effects that may arise as a result of one or more threats (e.g. Van Dam et al., 2006).

The SeCT involves this facilitated process of expert assessment and input providing the identification and description of the following:

- The Ecological Infrastructure (EI) and ecosystem services (ES) at risk from the various scenarios;
- The linkages between these services and human well-being;
- The scenarios putting EI and ES at risk;
- The quantum of risk of each Scenario-EI-ES interaction, derived from the likelihood and consequence of a specified interaction or risk scenario; and

The SeCT provides an assessment and ranking of risks to ecosystem services that arise from exposure to one or more scenarios. Ecosystem services and ecological infrastructure are defined in Appendix 3.

4.3.1 Methodology

4.3.1.1 Overview

The SeCT process is a facilitated workshop process whereby suitably experienced experts familiar in the Classification process are interrogated in order to fully understand the level of risk posed by a water use scenario on a specific ecosystem service. The expertise required of the participants in the SeCT workshop should include hydrology, ecology, resource economics, social science and water related engineering. However, other experts may be required depending on the conditions of the WMA and the scenario parameters.

4.3.1.2 Step 1: Identification of EI, related ESs and sector beneficiaries

The first step is to identify how the given scenario impacts the ecological infrastructure, related ecosystem services and economic sector beneficiaries in each of the IUAs. Ecological Infrastructure is defined in this case as rivers, streams, wetlands, lakes, aquifers or estuaries while, ecosystem services are defined by the classification framework proposed by The

Economics of Environment and Biodiversity (TEEB) (2010). Twelve economic sectors as beneficiaries of these services were identified and include:

1. Agriculture;
2. Mining;
3. Manufacturing;
4. Electricity and water;
5. Construction;
6. Wholesale, retail and motor trade, catering and accommodation;
7. Transport, storage and communication;
8. Finance, real estate and business services;
9. Government services;
10. Personal services;
11. Tourism;
12. Households; and
13. Society.

4.3.1.3 Step 2: Risk assessment

Once the relevant parameters have been identified, the next step is to determine the level of risk for each of the EI-ES-Scenario interactions.

Ecosystem risk is the function of the likelihood and consequence of a scenario to which EI is exposed. Thus:

Risk = f (likelihood, consequence) *of environmental effect on EI.*

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

The likelihood of an impact is the change in possibility that a specific scenario will have an impact on the EI and therefore the benefits received. The likelihood rating framework can be seen in Table 4-1. The consequence of the scenario is the change in the service from the environmental effect of the scenario on the exposed EI. A consequence rating framework can be seen in Table 4-2. Likelihood and consequence categories are chosen for each ES. It is important that the certainty is recorded to ensure transparency of the level of confidence in categories chosen. Risks are then automatically ranked according to risk levels and a description of each is given (Environmental effect statement) which includes the underlying chain of causality between environmental effect and its consequence.

Table 4-1: Qualitative and quantitative classes of likelihood of impacts (environmental effect, or resultant change in the flow of an ecosystem service) of a scenario having an ecological consequence to a service from EI. Adapted from the classification adopted by the IPCC (2007)

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

Table 4-2: Qualitative measures of consequence to ecosystem services arising from impacts linked to scenarios. Adapted from the classification adopted by the IPCC (2007)

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

Table 4-3: Levels of risk, assessed as the product of likelihood and consequence in the event of an environmental effects on EI. Adapted from the classification adopted by the IPCC (2007)

Likelihood Rating	Consequence Rating				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Possible	Low	Medium	High	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Very unlikely	Low	Low	Low	High	Extreme
Extremely unlikely	Low	Low	Low	Medium	High

The output of step 2 is an aggregate risk assessment for each of the EI-ES-Scenario interaction for each IUA.

4.3.1.4 Step 3: Environmental effect statement

The final step is to describe the thought process and logic behind the allocation of this risk category. The description should be specific, allowing for transparency into the decisions made.

4.3.1.4.1 Outputs

The tool functions to identify and prioritise the risks to ecosystem services posed by various developmental scenarios. The output is thus a prioritised list of risks, with diagnostic and causal descriptions for each priority risk. High and extreme risks are classed as priority risks. These risks and their relative weight (High risk=3, Extreme risk=4) were summed for each scenario to allow for a comparison of cumulative risks between scenarios. The beneficiaries of the identified ES will be at the greatest risk due to a specific scenario.

4.4 The Water Quality Model (WQM).

The cost water pollution can be estimated by estimating the water quality externality benefits enjoyed by polluting industries. This can be accomplished by identifying the:

- most important water quality indicators representing the pollution associated with these activities,
- water treatment technologies required for the reduction of these identified pollutants,
- estimating the cost of treating to Recommended Ecological Category.

4.4.1 Inputs

4.4.1.1 Step 1

Concentrations of water quality indicators must be allocated to the range of ecological categories forming the first input into the model. Concentrations of these water quality indicators must be allocated to the various ecological categories using known literature, tacit expert knowledge and the results of the EWR studies to this point.

4.4.1.2 Step 2:

The next step is to input the measure of the impacts on water quality due to changing scenarios. At this point the variation in ecological category must be drawn from the Scenario Tool.

4.4.1.3 Step 3:

The final input is the mean annual runoff (MAR) for selected EWR sites. This is necessary to calculate the load and yield per EWR site.

4.4.2 Outputs

Once the inputs are in place the model will calculate the treatment costs to return system to the recommended ecological category. This will be presented in (R million / year) and represents the water quality externality benefits enjoyed by various industries.

4.5 The Economic Model

The aim of the economic analyses should be on estimating the relative economic changes (differences) that will be caused by the identified scenarios on a catchment and macro-economic scale. All scenarios proposed are likely to either have a positive or negative change in flow volume. The changes in flow will impact economic Sectors and the development of a Hybrid Water Account[5] in Task 3, will model this impact across the water dependent economic Sectors.

In order to understand the impacts of the scenarios on a macro-economic scale and the social implications, the 2007 Guideline proposed the use of a Social Accounting Matrix (SAM) such as those developed by the Development Bank of Southern Africa (DBSA).

In this Action we propose the use of a SAM to estimate the relative economic changes at a catchment and macro-economic scale. Box 2 below explains the salient features of a SAM.

[5] A Hybrid Water Account is a hybrid model consisting of a physical water account developed in Action 6 and a monetary flow account developed in Action 7

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

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

A significant problem with SAMs is that they are generally available only at a national level and not at a provincial, or even WMA level. Statistics SA recommends a simple methodology for constructing I-O tables, using annually published supply and use tables (SUT).

Box 2. Major features of a Social Accounting Matrix

4.5.1 Inputs Required

There are two main inputs to the economic model:

1. The cost of poor water quality; and
2. The expected changes to sector final demand.

4.5.1.1 Input 1: Cost of Poor water quality

The model imports figures from the Water Quality Model, and assumes the externalities of water pollution are borne by the economy.

4.5.1.2 Input 2: Expected changes to sectoral final demand

The effects of each scenario on final demand within different Sectors are obtained from expert studies. The final demand is input as either a rand value or a percentage change in that Sector.

The impacts of these changes in final demand per Sector are processed through an input-output table that describes the economy of the catchment.

4.5.2 Outputs

The output of the Economic Model is the impact of each scenario on GDP either in Rands or as a percentage. The effect on compensation is also determined, and in the future, this can be used to determine the impacts on employment as well.

5 CONCLUSION AND RECOMMENDATIONS

The main aim of the project was to revise and update the current WRCS Socio-Economic Guideline. To achieve this, intermediary aims included the investigation and recording of successes and failures of the current WRCS and Resource Quality Objectives (RQO) socio-economic studies in a gap analysis, and address the gaps identified through the recommendation of standardised data sources, economic indicators used, analysis approaches and methodologies and reporting outputs.

The 2007 guidelines have not been able to specify a suitable set of socio-economic approaches and methodologies that would enable a common understanding of analyses and results. This has resulted in difficulty in comparing the results of classifications, and in some cases, huge omissions. This challenge was addressed by stipulating the use of a comparative risk assessment methodology that also provided consistent and comparable outputs.

The 2007 guidelines are not clear on how the economic analysis should link to and integrate with the other components of the WRCS process. To address this issue, the methodology includes the use of an ecosystem service framework to translate ecological changes to impacts on beneficiaries.

The order of evaluation tasks proposed by the 2007 Guideline is highly problematic. The existing guideline required onerous work at the start of the process that may be premature if the information is not required later in the process. This issue was addressed by moving detailed analyses to later stages of the process.

The varying approaches and outputs used by different PSPs have caused confusion among some stakeholders, especially in adjacent WMAs where stakeholders have been involved in more than one Classification/RQO process. The standardisation and simplification of the process makes the outputs easier for stakeholders to understand.

There have been stakeholder challenges to the WRCS process, especially in the Olifants and the Mvoti-Umzumkulu studies. The process was updated to improve transparency and build trust with stakeholders. Consistent outputs also mean that stakeholders can easily compare results.

In summary, the revised guideline and complementary tool was found to significantly simplify the socio-economic component of the classification system. This leads to the process being faster and therefore less resource intensive, less confusing to stakeholders, more legally defensible, and avoids duplicating work. The process also allows for linking ecosystem services to the economy through a modular approach to valuation.

While the aims and objectives of the project have been fulfilled, there are opportunities for further research and optimisation of the process. It is recommended that future projects seek to standardise:

- Social Wellbeing Scoring is highly contentious, and the updated guideline recommended indicators that could contribute to developing the score. There is an opportunity for future research into developing a universal scoring system that is applicable to all catchments.
- Water Quality is another issue that is difficult to simplify as there are many different indicator pollutants that have different effects on the fitness of use. Further research is required to determine whether water quality categories or individual pollutant concentrations is more appropriate in the socio-economic analysis.
- Ecosystem service valuation methods are described in the guideline, and are highly dependent on data availability. The SeCT could be updated to incorporate these methods to further standardise the process in the future.

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7 APPENDIX 1: OLIFANTS WMA CASE STUDY

The Olifants WMA is a highly utilised and regulated catchment and like many other WMAs in South Africa its water resources are becoming more stressed due to an accelerated rate of development and the scarcity of water resources. There is an urgency to ensure that water resources in the Olifants WMA (Figure 7-1) are able to sustain their level of uses and be maintained at their desired states. The determination of the Management Classes (MC) of the significant water resources in Olifants River System will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised is maintained and adequately managed within the economic, social and ecological goals of the water users and the catchment. The ultimate goal of the study is the implementation of the WRCS in the Olifants WMA in order to determine the management class (MC). The purpose of the MC once set, is to establish clear goals relating to the quantity and quality of the relevant water resource in order to facilitate a balance between protection and use of water resources.

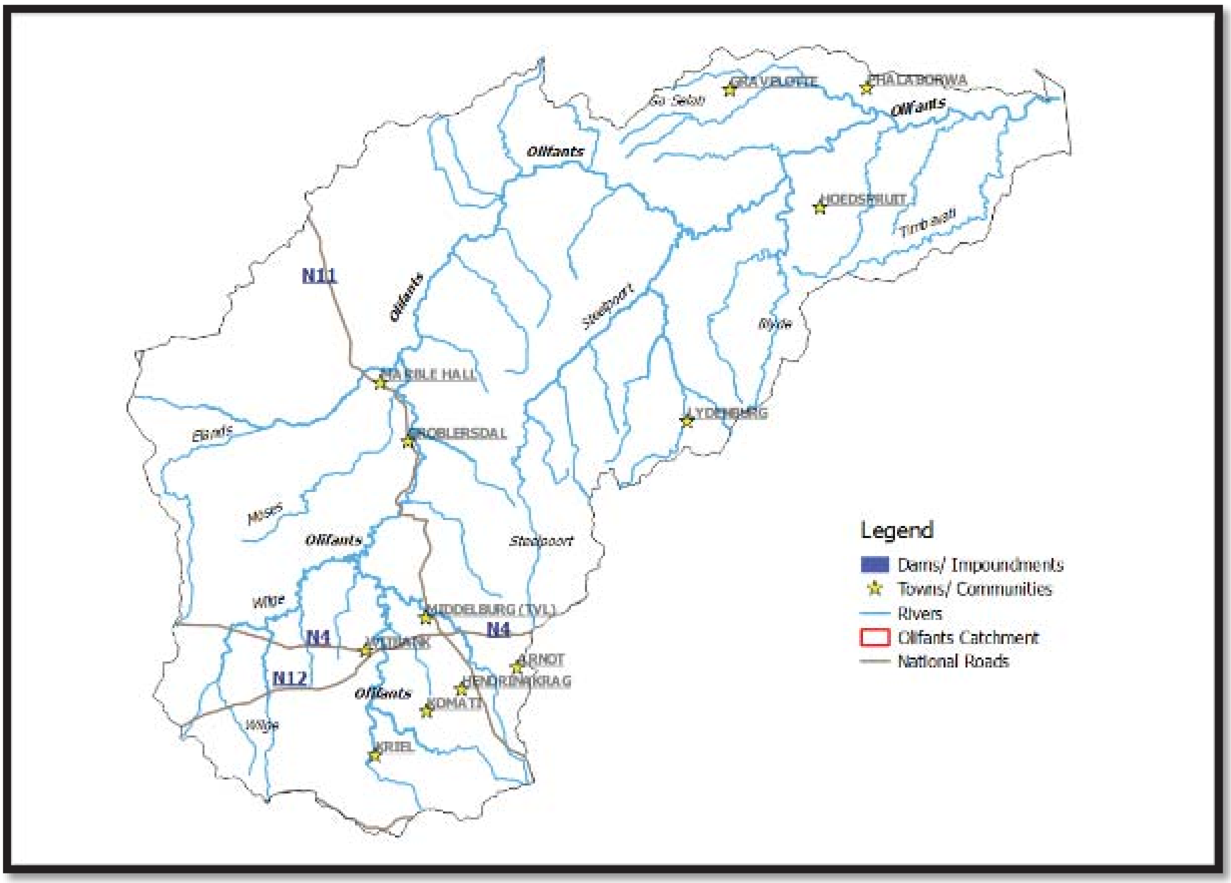

Figure 7-1: Map of the Olifants WMA

7.1 Task 1. Catchment Status-quo and Delineation of Integrated Units of Analysis (IUAs).

The goal of an IUA is to delineate an area within catchment boundaries that is relatively homogenous in terms of both socio-economic characteristics and dependencies of communities to the services provided by aquatic ecosystems and the patterns seen in ecological features across the catchment.

7.1.1 Action 1. A distributional description of social, economic and ecological features within the catchment

described the present socio-economic status, key drivers and ecosystem service hotspots within the catchment at a broad scale. The sufficient completion of this action required a general understanding of the locality of corresponding spatial features within the catchment.

7.1.1.1 Social and Economic Description

The project team produced a demographic description of the Upper-Olifants, Steelpoort, Middle-Olifants, Letaba, Lower-Olifants and Shingwedzi sub-catchments found within the Olifants Catchment South Africa.

Demographic characteristics of the Olifants Catchment and subsequent sub-catchments were identified using Census data (2011). Data was analysed, processed and placed on a spatial scale to understand geographic extent and variation. This was done using Quantum GIS (2.8.2 Wien). A total of 488 wards were used to represent the demography the catchment, with 112, 42, 197, 18, 36, and 83 representing the Letaba, Lower-Olifants, Middle-Olifants, Shingwedzi and Upper-Olifants Sub-Catchments respectively.

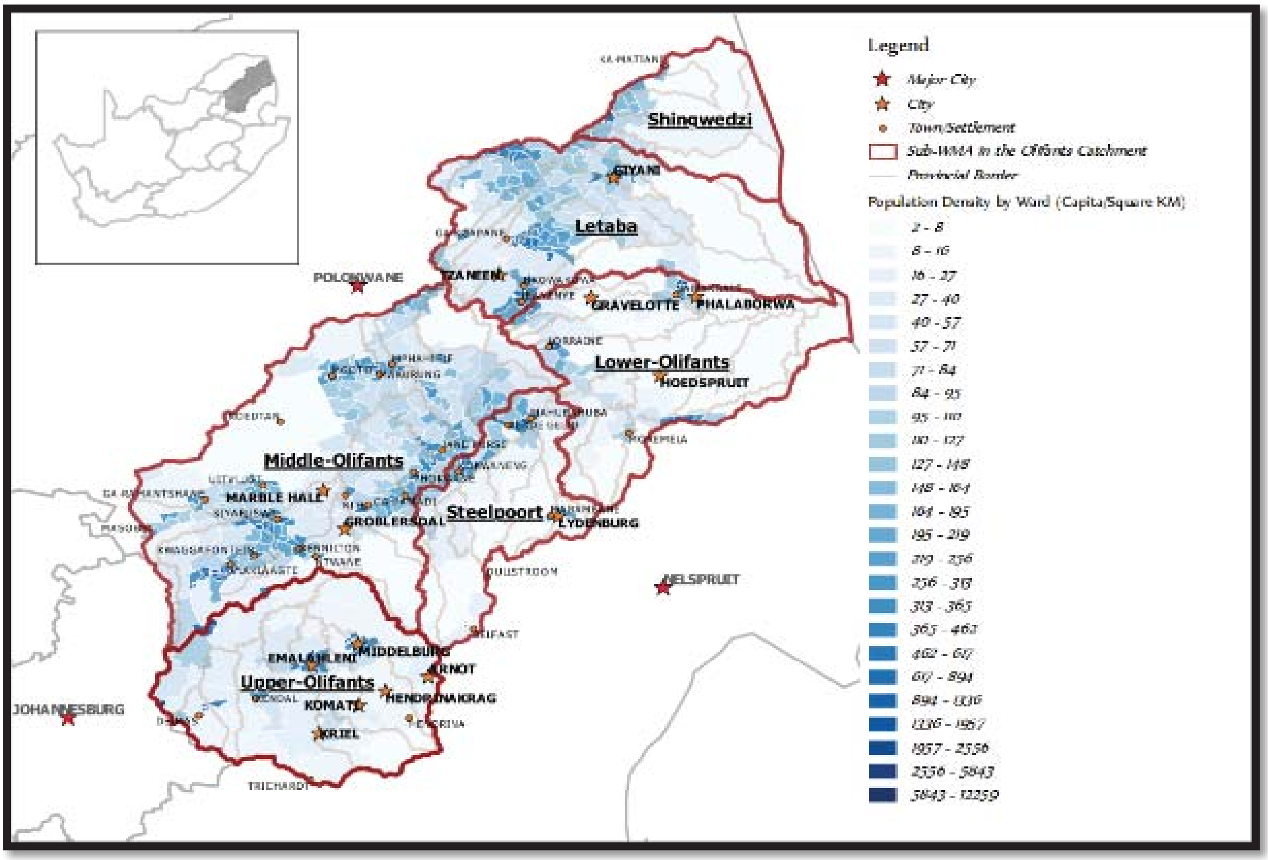

Figure 7-2: Population density (pop/Ha) by ward in the Olifants Catchment (Census 2011).

The Olifants Catchment has a population of approximately 4.8 million (4 755 469) people. Increased densities occur in the areas of larger cities such as eMalahleni, Tzaneen, Giyani, Phalaborwa, Groblersdal and Marble Hall and towns and settlements such as Laklaagte, Siyabuswa, Jane Furse, Ga-Kgapane, and Ka-matlani (Figure 7-2). The demographic is predominantly black (94%), with the smaller proportion being white (5%) and the rest (1%) other races (Figure 7-3). The leading languages spoken are Sepedi (43%), Xitsonga (20%), IsiNdebele (10%) and isiZulu (9%) (Census 2011).

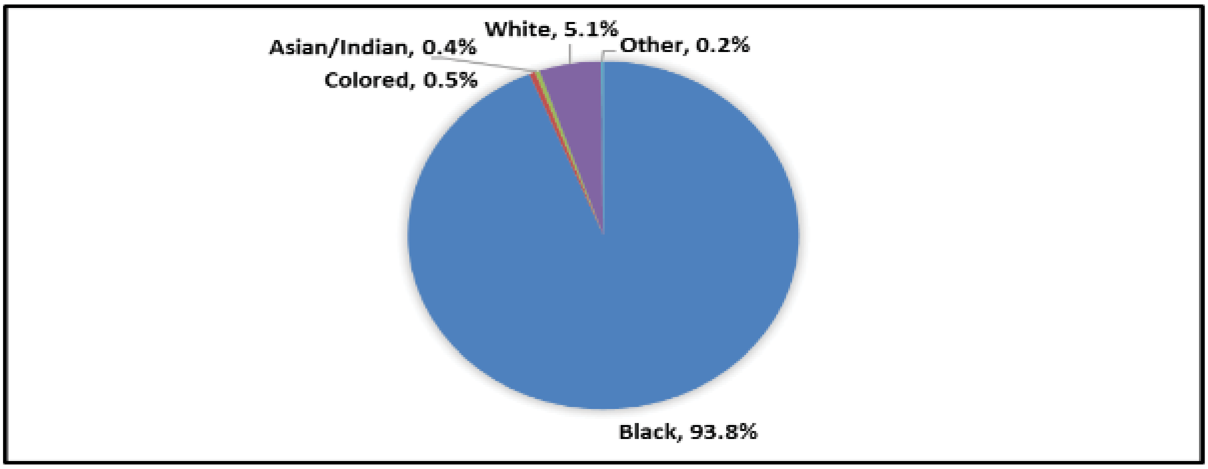

Figure 7-3: Population demographics of the Olifants Catchment (Census 2011).

The demographic characteristics of the Olifants Catchment are varied from upstream to downstream with the highest diversity of demographic groups typically occurring in the southern reaches and less diverse groups in the northern reaches. This is attributed to the variation in economic development of the landscape. Toward the southern extent of the catchment urbanisation and land use intensity increases toward Gauteng province and the cities of eMalahleni and Middelburg. The northern reaches are less developed, characterised by a greater proportion of smaller towns, settlements and rural land uses.

The level of education in the catchment is relatively balanced between little to no (28%), some (39%), and relatively well educated people (32%) (Figure 7-4). These patterns skew toward increased levels of education in the southern reaches of the catchment (Upper-Olifants and Steelpoort).

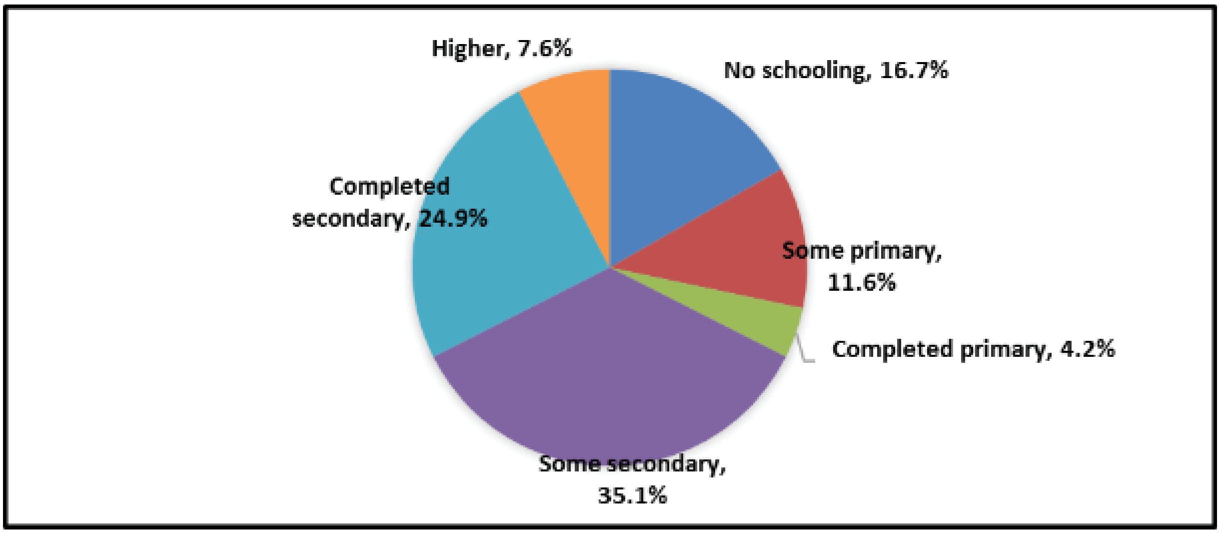

Figure 7-4: Education level demographics in the Olifants Catchment (Census 2011).

A large proportion of the catchment is not economically active (45%), with a further quarter (24%) of the population being unemployed (Figure 7-5). Only a third of the population (31%) are employed of which 68% are done so in the formal Sector. The most common income groups between households are the R 9601 to R 19 600 and the R 19 601 to R 38 200 a month belonging to 20% and 21% of households (Figure 7-6). 14% of households earn no income at all. These employment and income characteristics are again skewed toward higher levels of employment and economic activity toward the southern reaches of the catchment and less towards the les developed northern reaches.

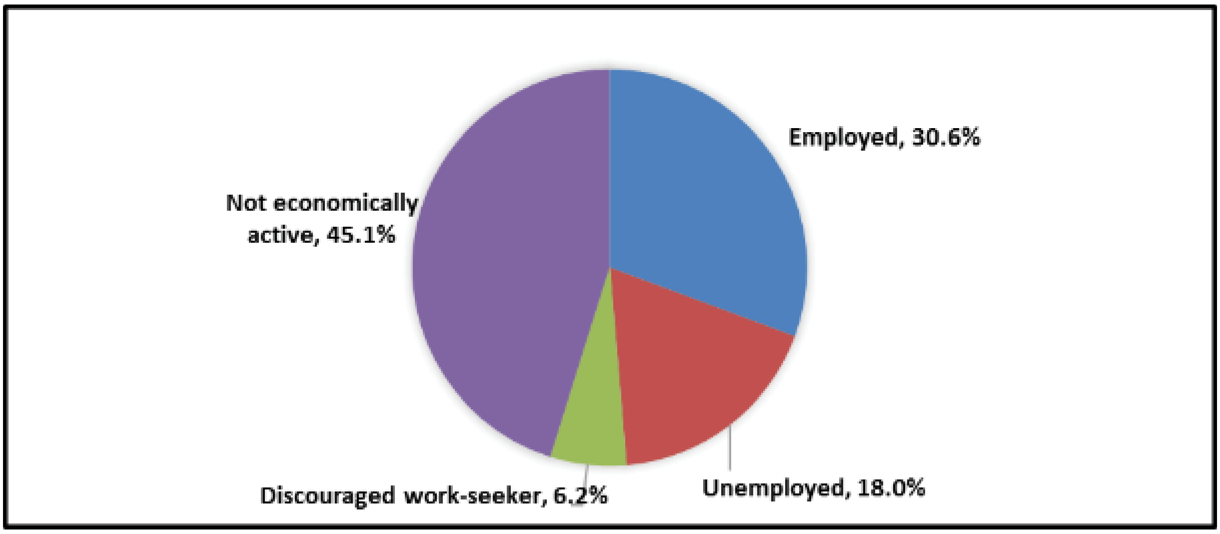

Figure 7-5: Employment status (Age 15-64) demographics in the Olifants Catchment (Census 2011).

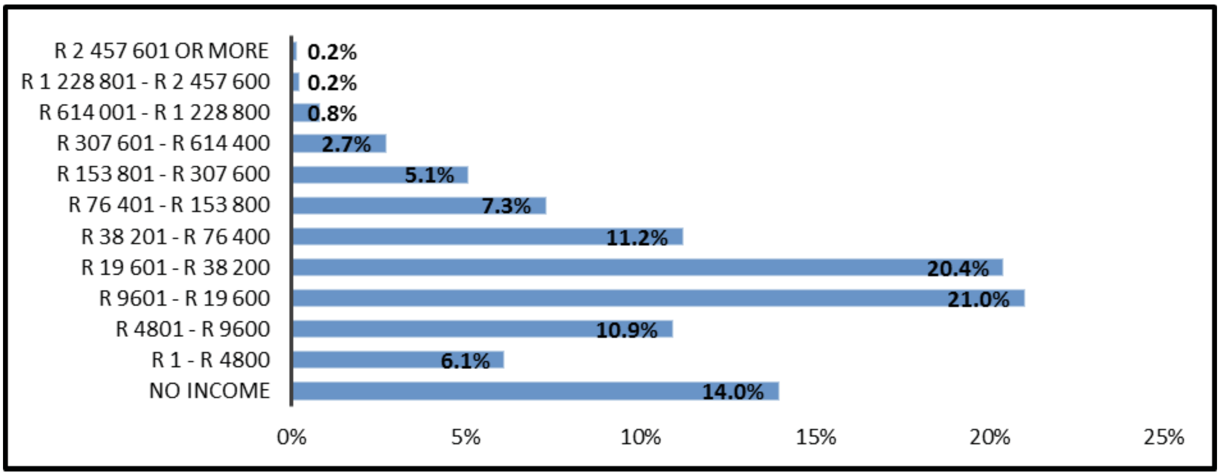

Figure 7-6: Income group per households in the Olifants Catchment (Census 2011).

The majority (82%) of households reside in concrete and brick structures, with much smaller proportions living in informal (9%) and traditional (5%) dwellings (Figure 7-6). The proportion of informal dwellings increase toward the southern reaches of the catchment. Most of the households (75%) have access to piped water either in their homes (24%), their yards (35%) or within 200m (16%) of their homes (Figure 7-9). 14% of households have no access to piped water. The toilets used in the catchment are predominantly pit latrines with (15%) and without (51%) ventilation (Figure 7-7). 31% have access to flushing toilets. The bulk of the population get their water from the local or regional water scheme (69%) and boreholes (13%) (Figure 7-9). A relatively large proportion source their water from more natural features in the landscape such as rivers and streams (5%), dams or stagnant water (4%) and springs (1%).

Energy use in the catchment are predominantly wood and electrical sources. Cooking and heating are typically done using electricity (55% and 47%) and wood (35% and 31%). Electricity (87%) is the chief source for lighting purposes (Figure 7-11).

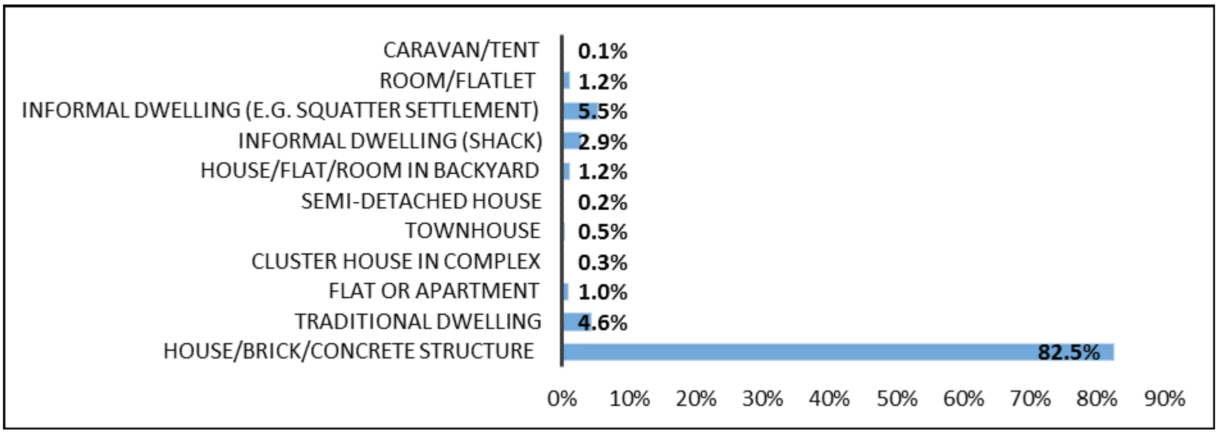

Figure 7-7: Dwelling demographic of the Olifants Catchment (Census 2011).

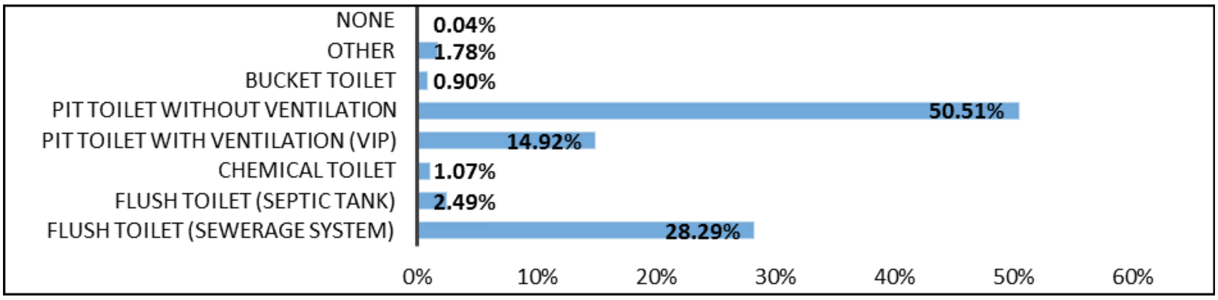

Figure 7-8: Toilet system demographic in the Olifants Catchment (Census 2011).

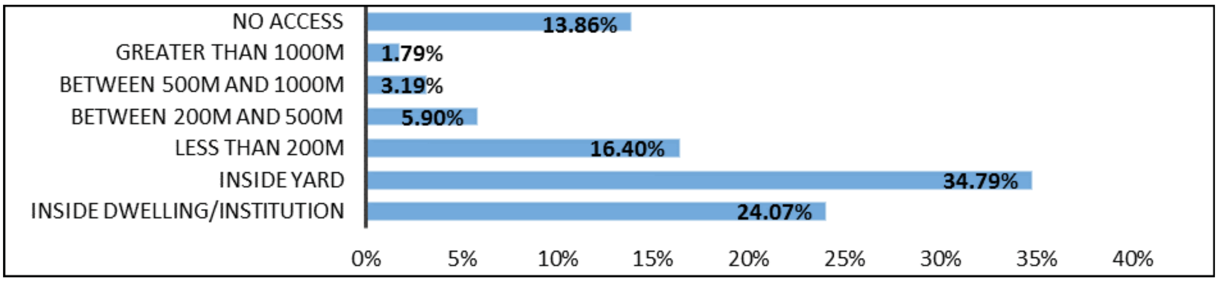

Figure 7-9: Water access demographic of households in the Olifants Catchment (Census 2011).

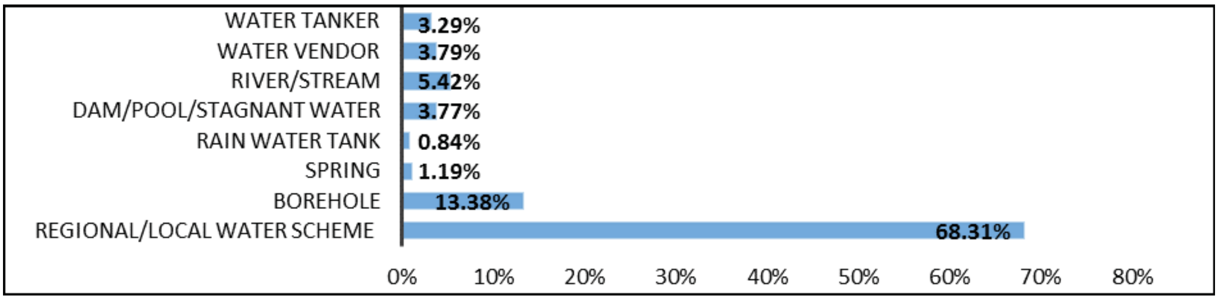

Figure 7-10: Source of water of households in the Olifants Catchment (Census 2011).

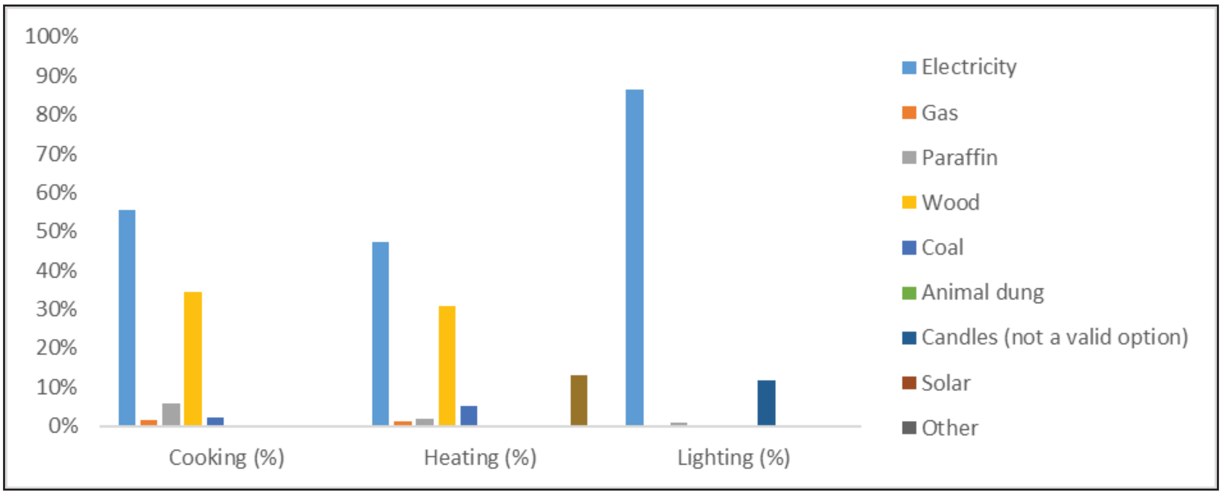

Figure 7-11: Energy type and use of households in the Olifants Catchment (Census 2011).

7.1.1.1.1 Upper-Olifants Sub-Catchment

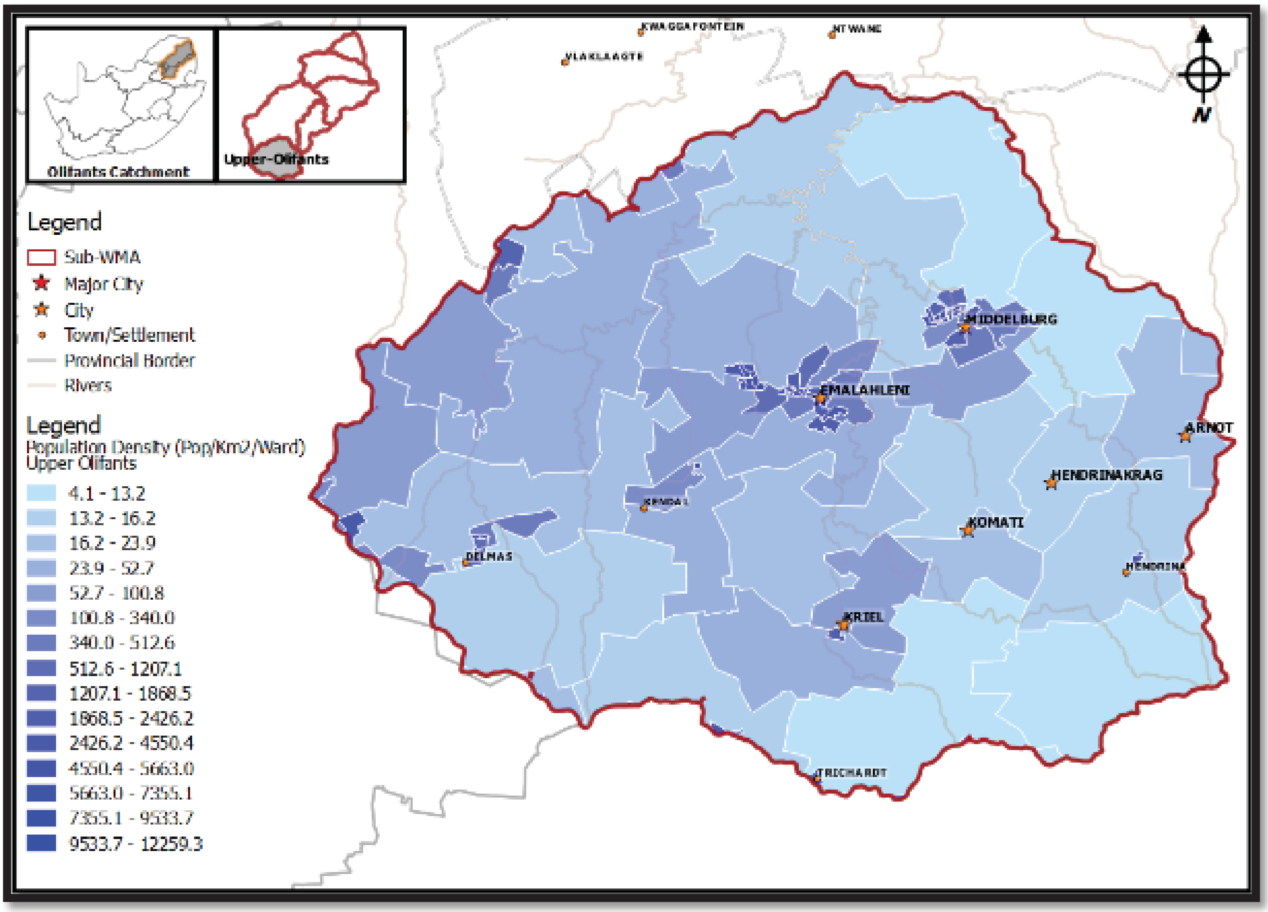

Figure 7-12: Population density (pop/Ha) by ward in the Upper-Olifants Sub-Catchment (Census 2011).

The population within the catchment is approximately 940 thousand (938 230) people with the highest densities residing within wards closely associated with the large cities (Figure 7-12). This sub-catchment has the highest diversity of races in the Olifants, with 78% of the population being black, 18% white and 2% being other races (Figure 7-13). Languages spoken vary greatly with the major languages being isiZulu (35%), Afrikaans (18%), IsiNdebele (15%), Sepedi (10%) and English (6%) (Census 2011).

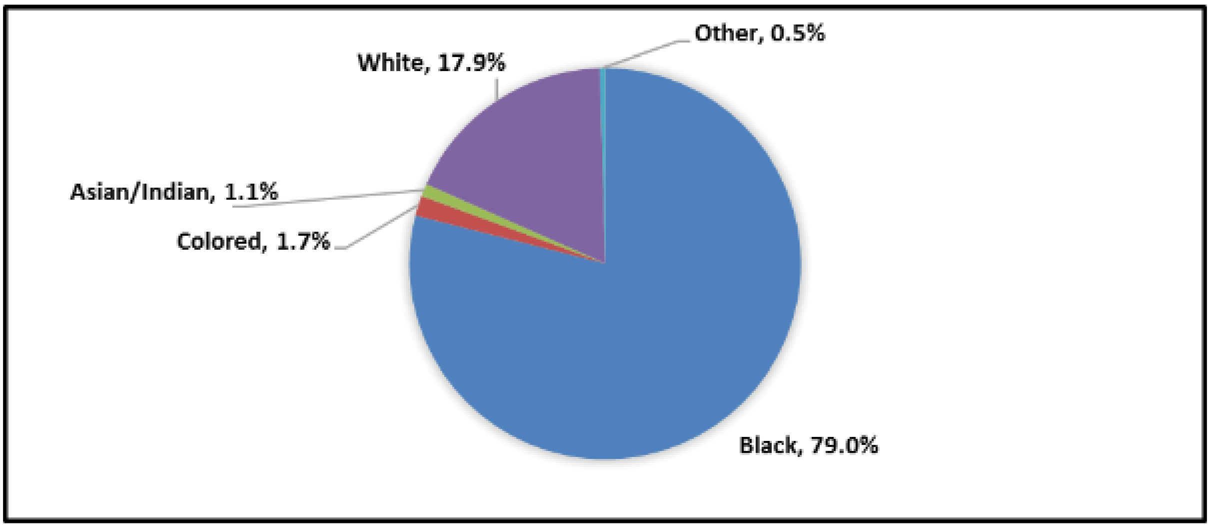

Figure 7-13: Population demographics of the Upper-Olifants Sub-Catchment (Census 2011).

Education levels are relatively varied in the sub-catchment but nonetheless are the highest compared to the other sub-catchments in the Olifants. The largest proportion of 35% having some education at secondary level, 32% having completed secondary schooling and 11% with higher education (Figure 7-14). A relatively smaller proportion has had little to no formal education with 10% having some primary education and 8% having no formal education (Figure 7-14).

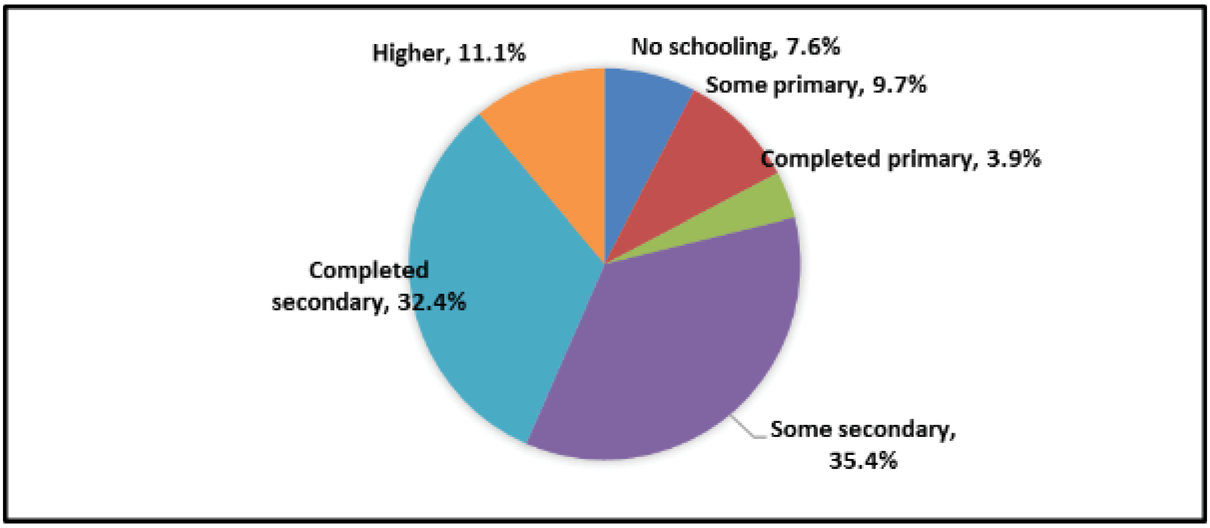

Figure 7-14: Education level demographics in the Upper-Olifants Sub-Catchment (Census 2011).

Relative to other catchments a smaller proportion (30%) of the working-age population are not economically active (Figure 7-15). Of the economically active population, 20% are unemployed and a comparatively large 50% are employed. Of the employed population, 74% and 11% are employed in the formal and informal Sectors respectively. The largest income group in the sub-catchment earns between R 19 601 and R 38 200 per month include 18% of households and the second largest earning between R 38 201 and R 76 400 at 16% of households (Figure 7-16). 13% of households have no income and 3% earn less than R4 800 a month.

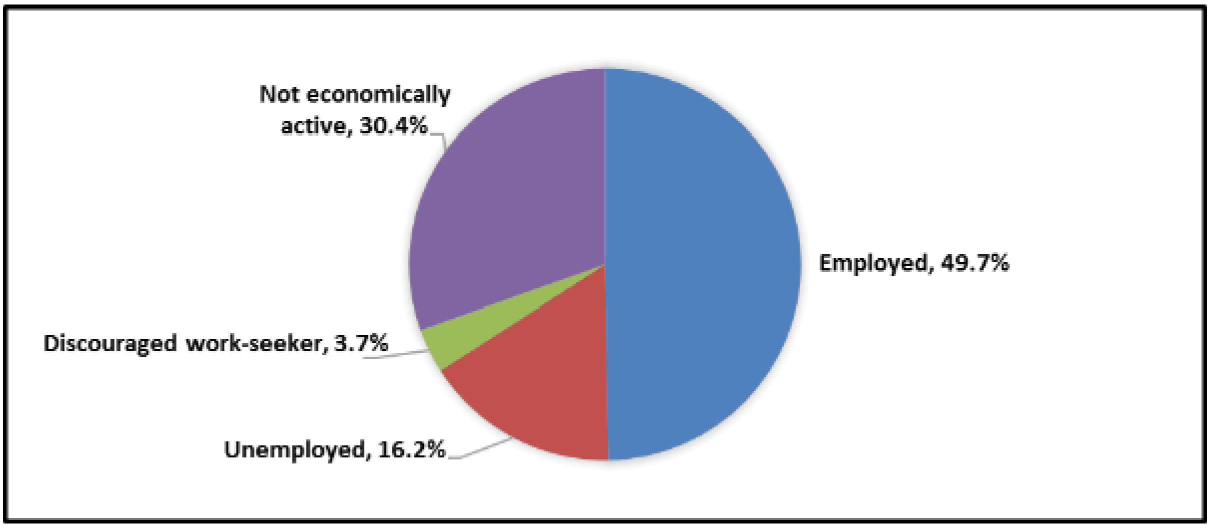

Figure 7-15: Employment status (Age 15-64) demographics in the Upper-Olifants Sub-Catchment (Census 2011).

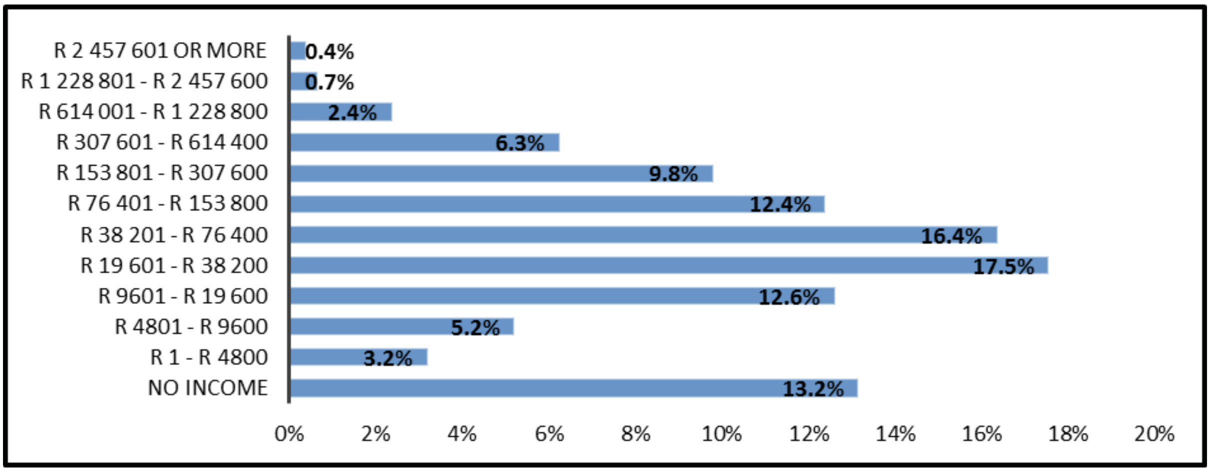

Figure 7-16: Income group per households in the Upper-Olifants Sub-Catchment (Census 2011).

A large proportion of households (70%) reside within concrete or brick homes (Figure 7-17) and approximately 82% have access to piped water within their properties (Figure 7-19). A high proportion (75%) has access to flushing toilets with a smaller percent (20%) utilising pit latrines (Figure 7-18). This sub-catchment has the highest proportion of informal dwellings (8%) within the Olifants Catchment (Figure 7-17).

Most households (88%) have access to water provided by the municipality, with 6% and 4% having access to water through boreholes and water tanks respectively (Figure 7-20). Many households in the sub-catchment have access to electricity for lighting (81%), cooking (74%) and heating (62%) purposes. The secondary energy alternative is wood, being used by 13% and 14% for cooking and heating purposes respectively (Figure 7-21).

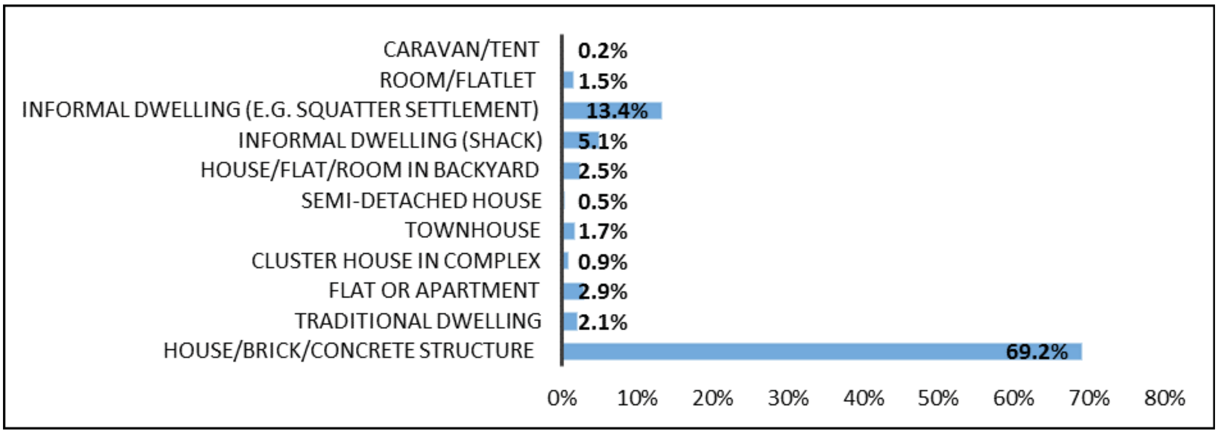

Figure 7-17: Dwelling demographic of the Upper-Olifants Sub-Catchment (Census 2011).

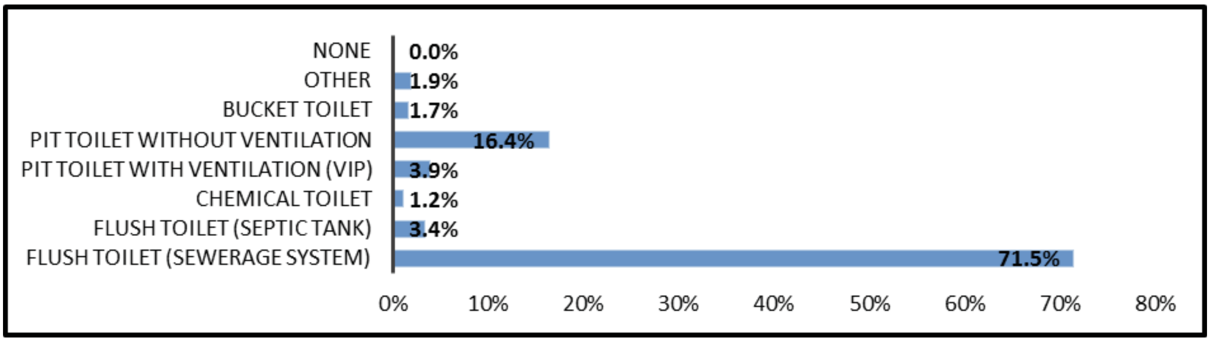

Figure 7-18: Toilet system demographic in the Upper-Olifants Sub-Catchment (Census 2011).

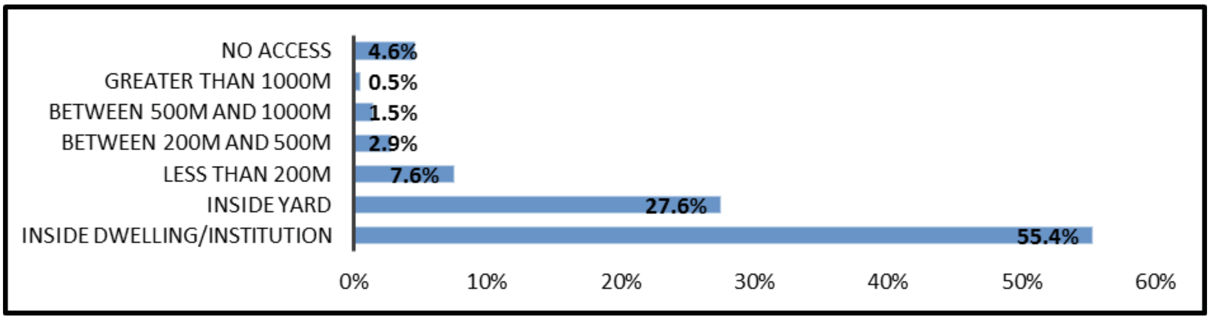

Figure 7-19: Water access demographic of households in the Upper-Olifants Sub-Catchment (Census 2011).

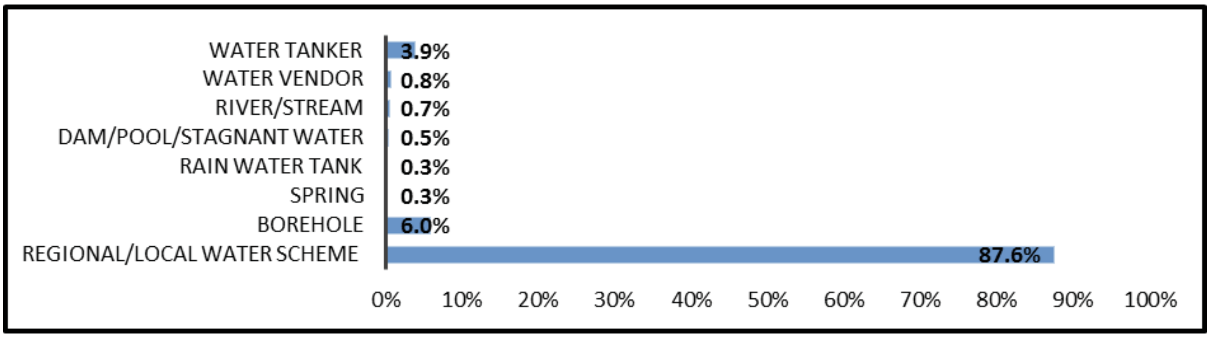

Figure 7-20: Source of water of households in the Upper-Olifants Sub-Catchment (Census 2011).

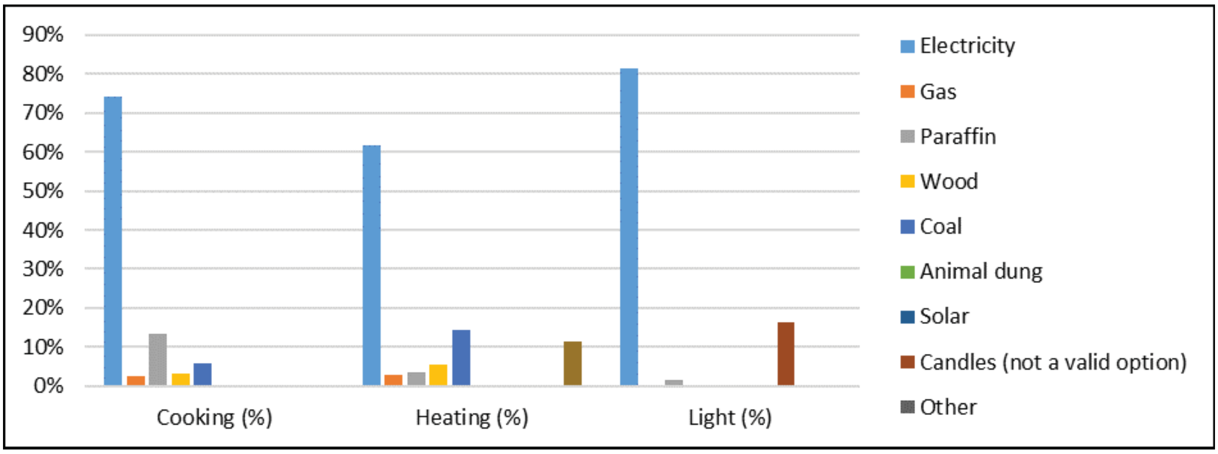

Figure 7-21: Energy type and use of households in the Upper-Olifants Sub-Catchment (Census 2011).

7.1.1.1.2 Middle-Olifants Sub-Catchment

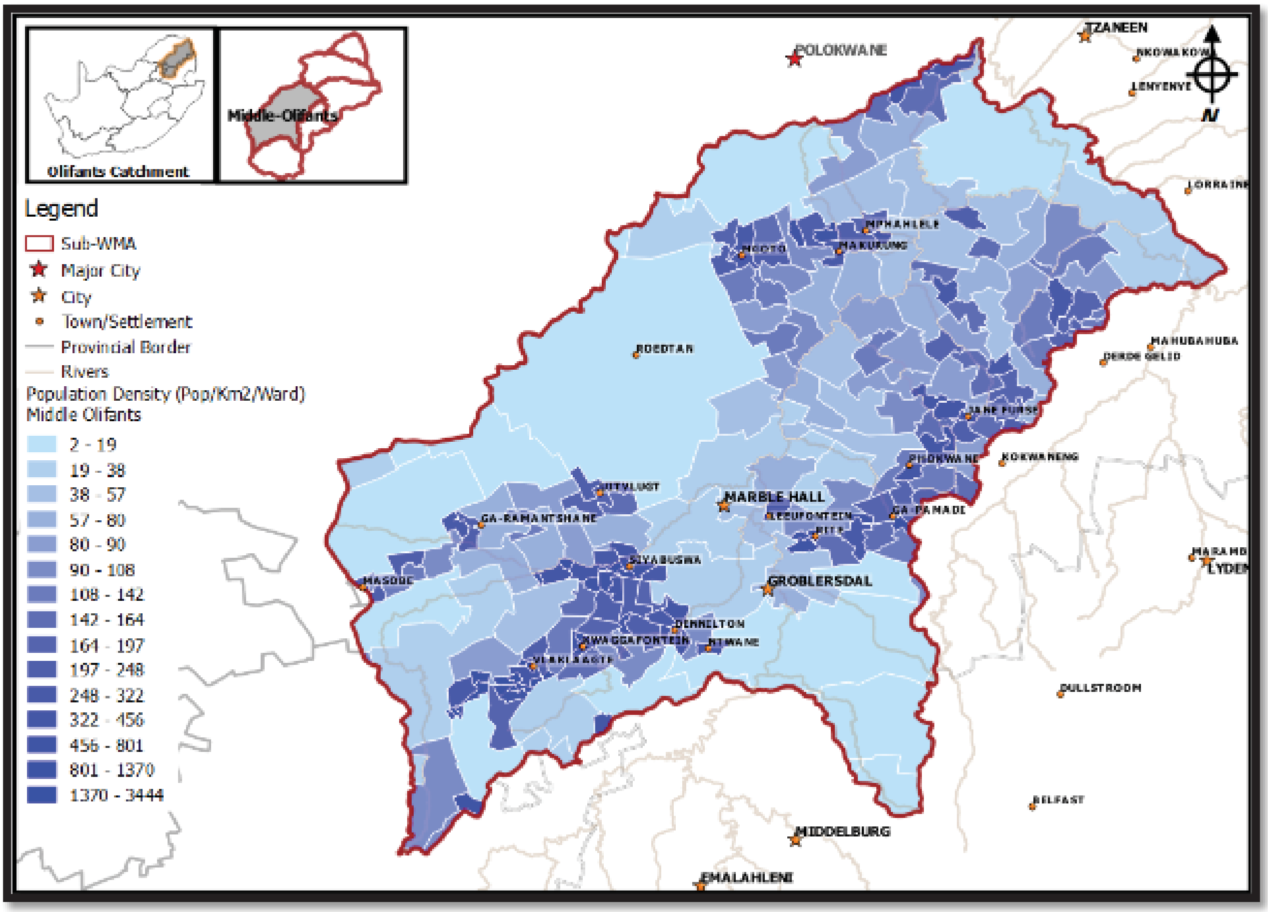

Figure 7-22: Population density (pop/Ha) by ward in the Middle-Olifants Sub-Catchment (Census 2011).

The Middle-Olifants Sub-catchment has the largest population of all sub-catchments in the Olifants with approximately 1.7 Million people (1 771 163). The population densities increase around the towns and settlements of Kwaggafontein, Jane Furse, Vlaklaagte and Siyabuswa (Figure 7-22). 98% of the residing population are black (Figure 7-23) and Sepedi is spoken by 63% of the population with IsiNdebele being spoken by 18% (Census 2011).

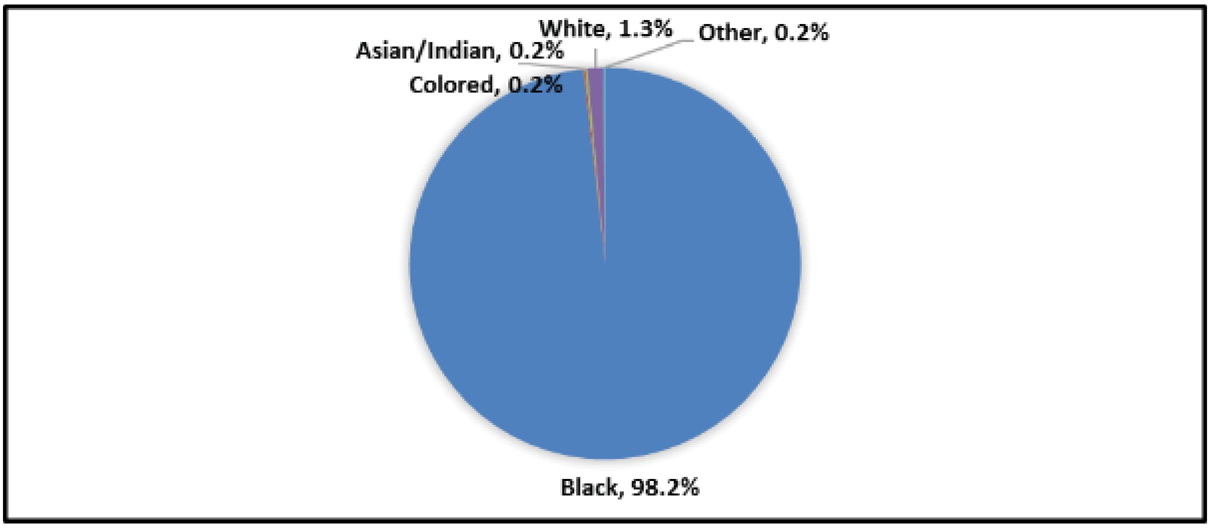

Figure 7-23: Population demographics of the Middle-Olifants Sub-Catchment (Census 2011).

A third of the population (32%) has little to no formal schooling (Figure 7-24). A larger proportion (39%) has completed primary school and has had some secondary schooling while almost a third of the total population (30%) has completed secondary school or has a higher education.

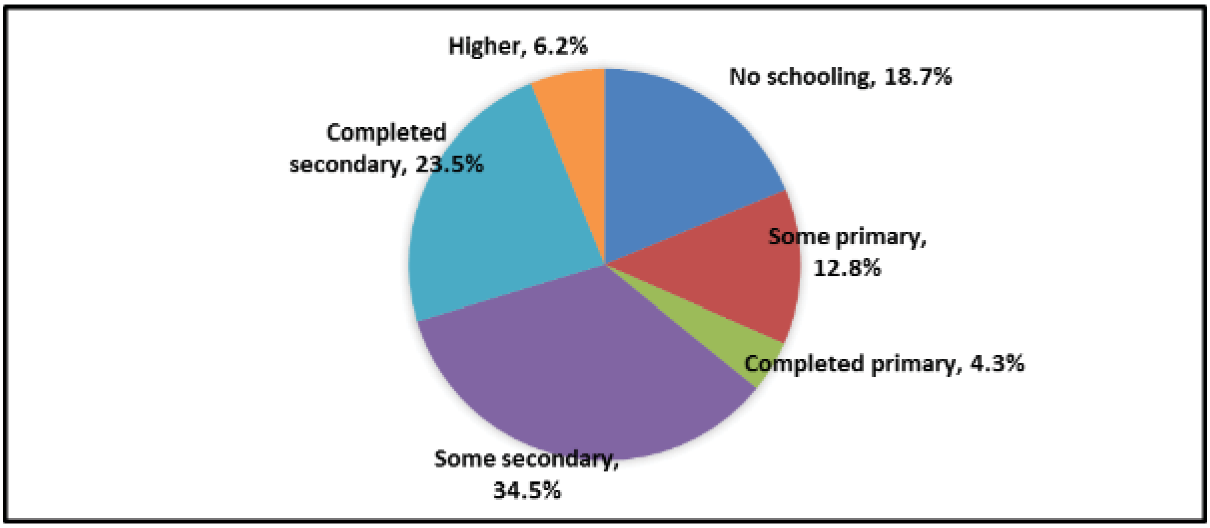

Figure 7-24: Education level demographics in the Middle-Olifants Sub-Catchment (Census 2011).

Just less than half (49%) of the population in the Middle-Olifants Sub-Catchment are not economically active while only 25% have jobs and the rest are looking for employment (Figure 7-25). Most (62%) of the employed population are employed in the formal Sector and the rest in the private and informal Sectors. The predominant income groups of households are the R 9 601 to R19 600 and the R19 601 to R38 200 belonging to 24% and 22% of households respectively (Figure 7-26). 14% of households have no income and 6% earn less than R 4 800 a month.

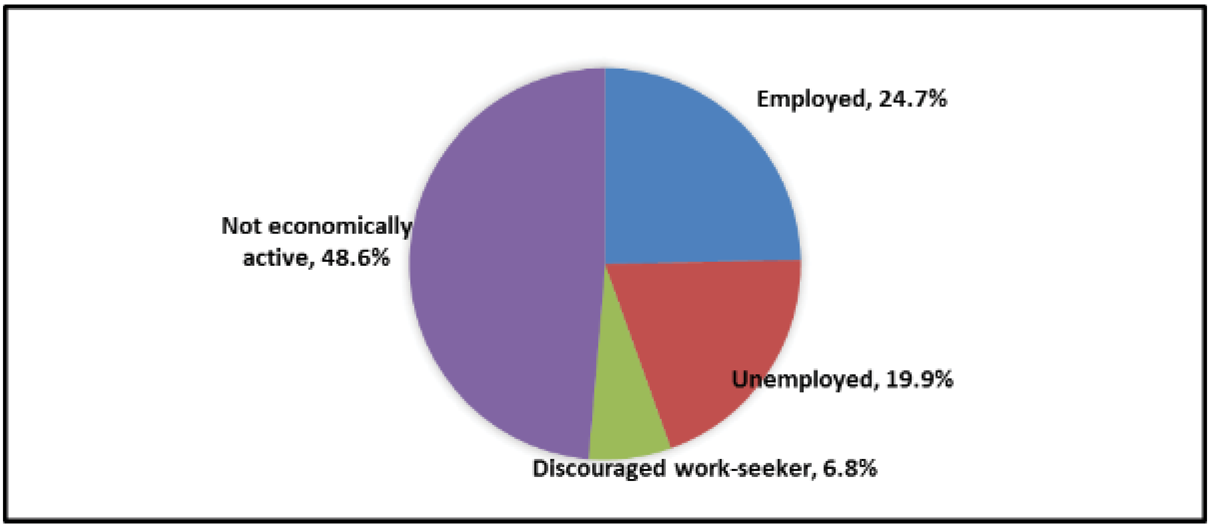

Figure 7-25: Employment status (Age 15-64) demographics in the Middle-Olifants Sub-Catchment (Census 2011).

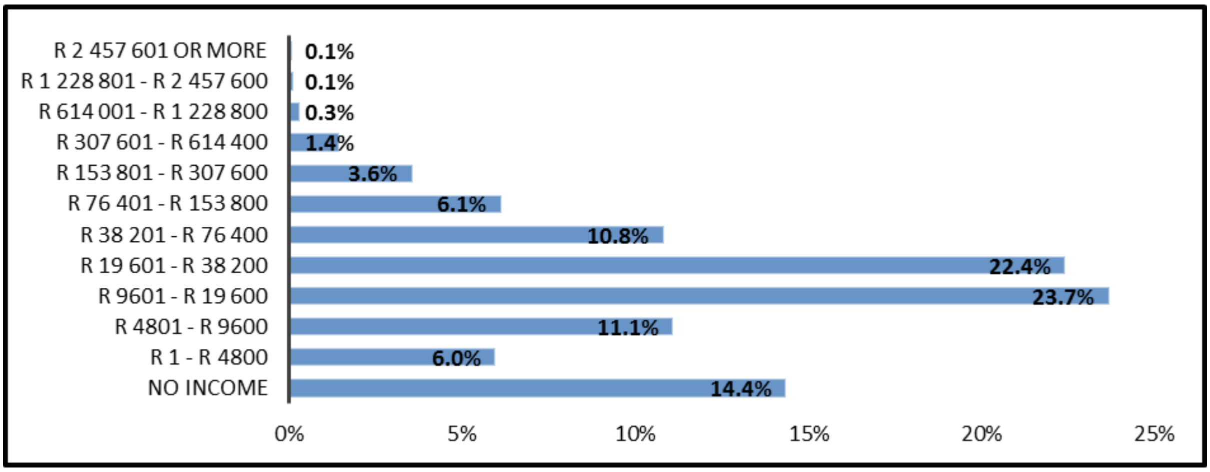

Figure 7-26: Income group per households in the Middle-Olifants Sub-Catchment (Census 2011).

The majority of households reside within brick and concrete structures (87%) (Figure 7-27), most of which have access to piped water (within their homes, in their yards or within 200m) (Figure 7-29). The greatest proportion being 59% having access to a tap in their homes or yard. A relatively large proportion of 18% has no access to piped water whatsoever. 83% of households use pit latrines as toilets (Figure 7-28). The source of water used comes mostly from regional and local water schemes (65%) and boreholes (14%) while 7% of households get their water from natural sources such as rivers and streams (Figure 7-30).

Electricity is the leading source of energy in the sub-catchment with 62%, 51% and 90% of households using it for cooking, heating and lighting purposes respectively (Figure 7-31). Wood follows as the predominant alternative with 29% and 28% using it for cooking and heating.

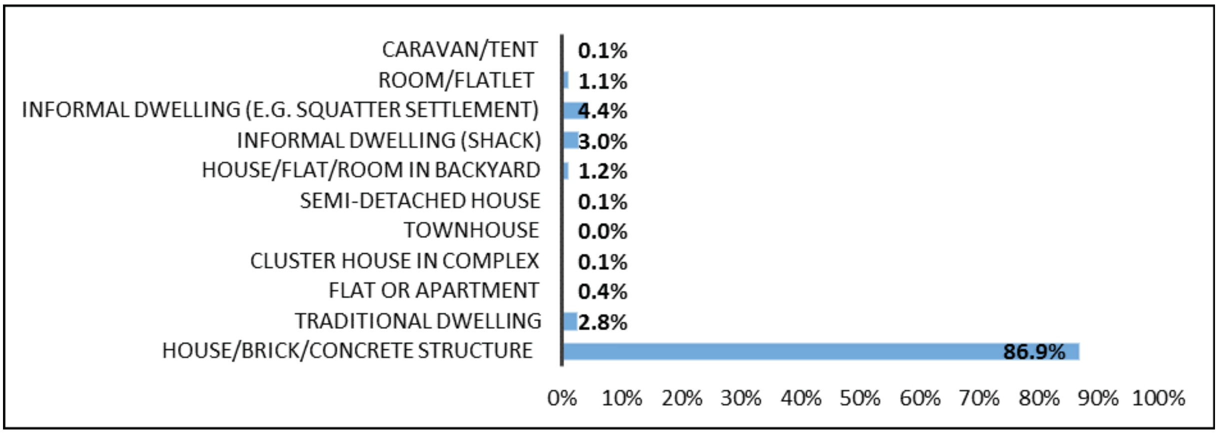

Figure 7-27: Dwelling demographic of the Middle-Olifants Sub-Catchment (Census 2011).

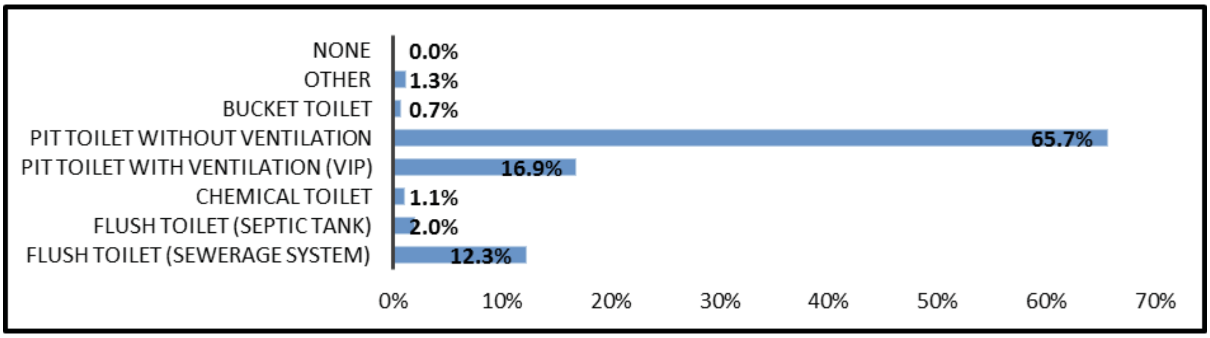

Figure 7-28: Toilet system demographic in the Middle-Olifants Sub-Catchment (Census 2011).

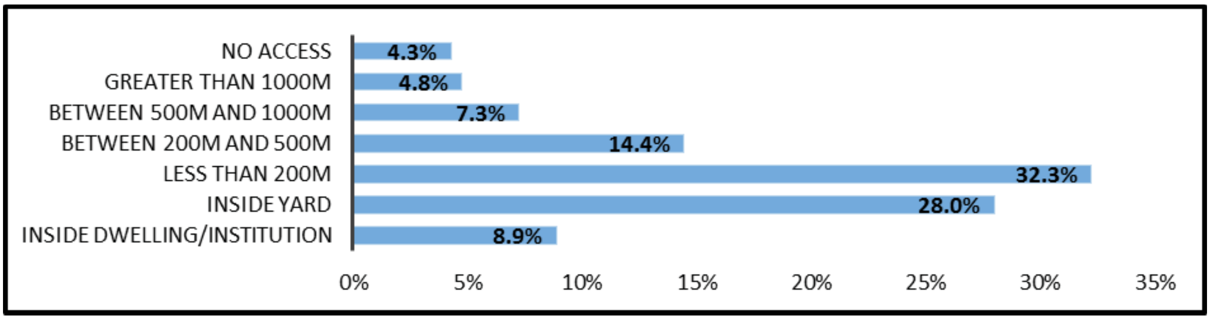

Figure 7-29: Water access demographic of households in the Middle-Olifants Sub-Catchment (Census 2011).

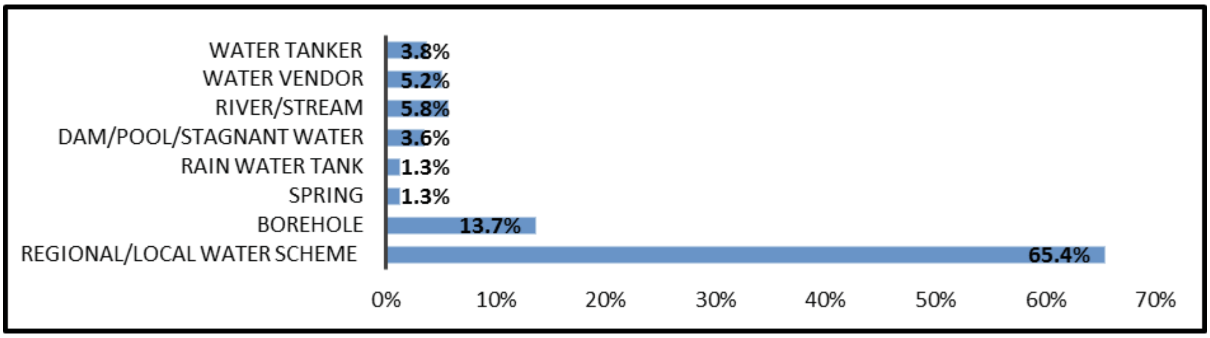

Figure 7-30: Source of water of households in the Middle-Olifants Sub-Catchment (Census 2011).

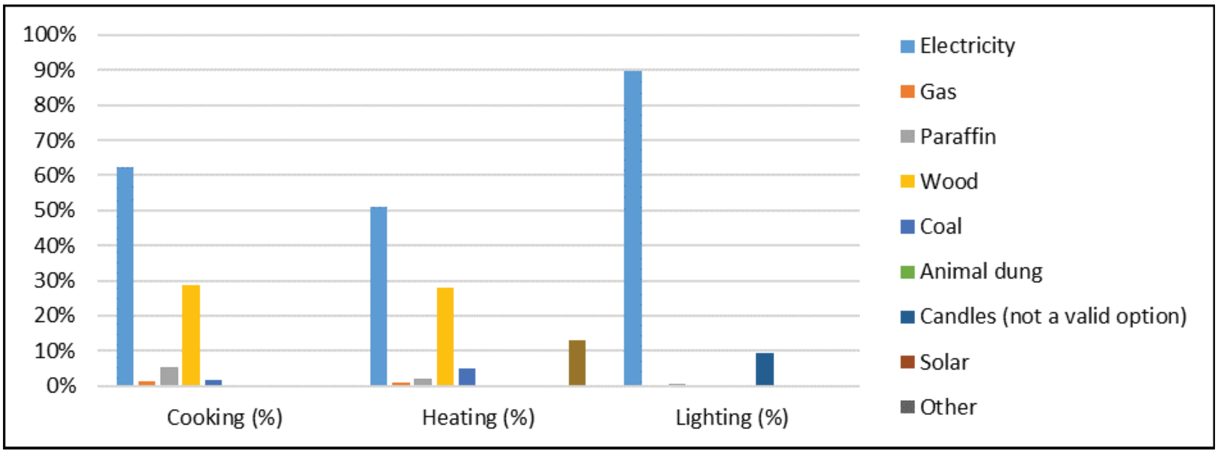

Figure 7-31: Energy type and use of households in the Middle-Olifants Sub-Catchment (Census 2011).

7.1.1.1.3 Steelpoort Sub-Catchment

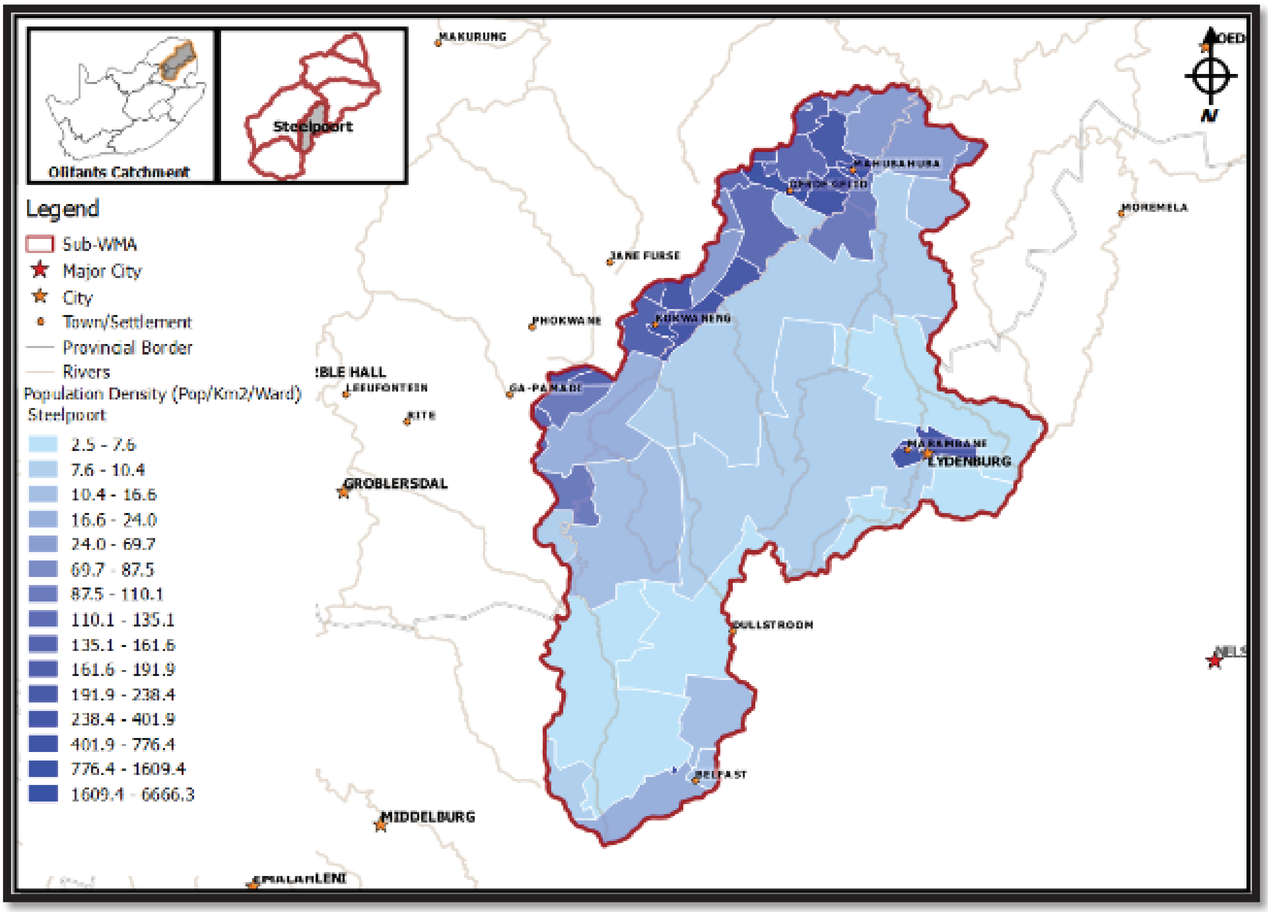

Figure 7-32: Population density (pop/Ha) by ward in the Steelpoort Sub-Catchment (Census 2011).

The Steelpoort Sub-Catchment has a population of approximately 345 thousand people (345220). The population is most dense in the areas of Lydenburg, Kokwaneng and Derde Gelid (Figure 7-32). This population is predominantly black (94%) followed by a much smaller proportion of white residents (5%) (Figure 7-33). Sepedi is the chief language spoken by 70% of the population with other languages being Afrikaans (5%), IsiNdebele (6%), IsiZulu (5%), and SiSwati (7%) (Census 2011).

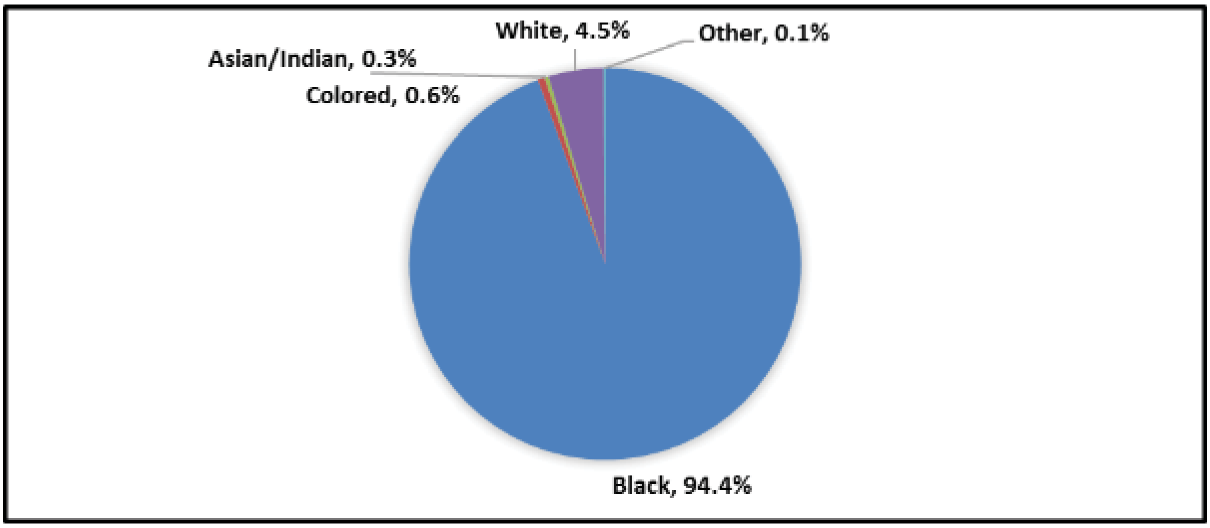

Figure 7-33: Population demographics of the Steelpoort Sub-Catchment (Census 2011).

A quarter of the population has little (10%) to no (15%) formal education (Figure 7-34). A relatively high 30% has received higher level education with 25% having completed secondary education and 5% higher education.

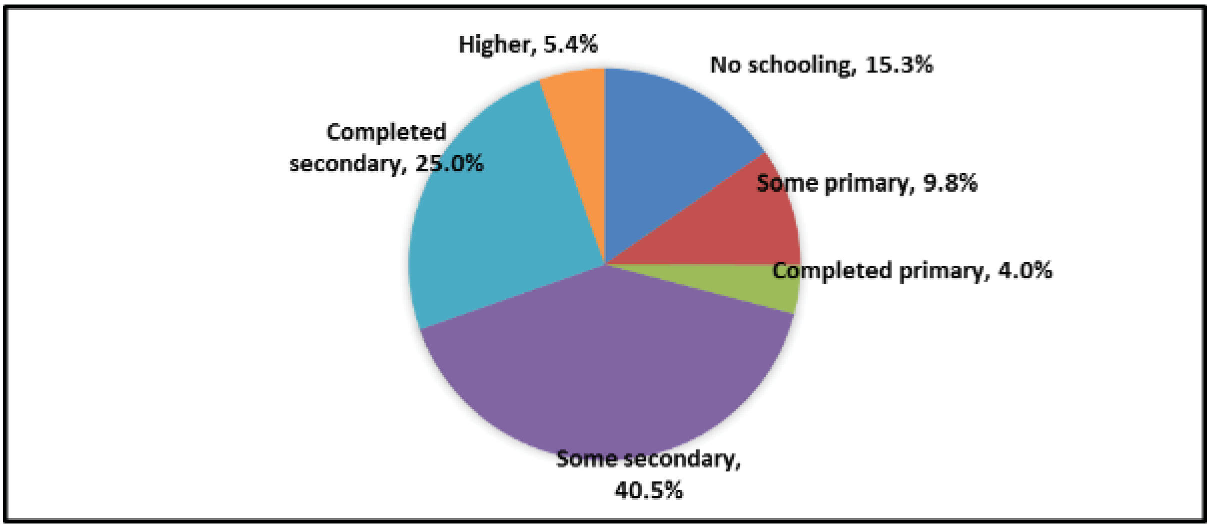

Figure 7-34: Education level demographics in the Steelpoort Sub-Catchment (Census 2011).

A large proportion of 43% of population are not economically active (Figure 7-35). A further 26% are unemployed and are actively seeking employment. The remaining 31% are employed mostly in the formal Sector. Income groups in this catchment are relatively diverse with the higher proportions of households earning in the R 9601 to R 19 600 and the R 19 601 to R 38 200 income groups (figure 7-36). 15% of households have no income and 5% earn less than R4800 per month.

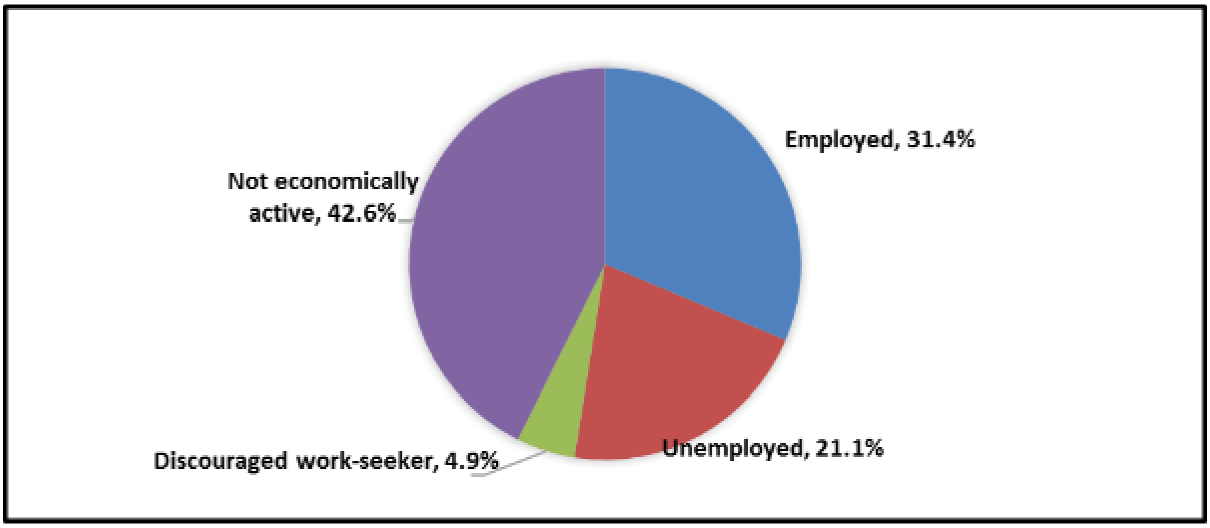

Figure 7-35: Employment status (Age 15-64) demographics in the Steelpoort Sub-Catchment (Census 2011).

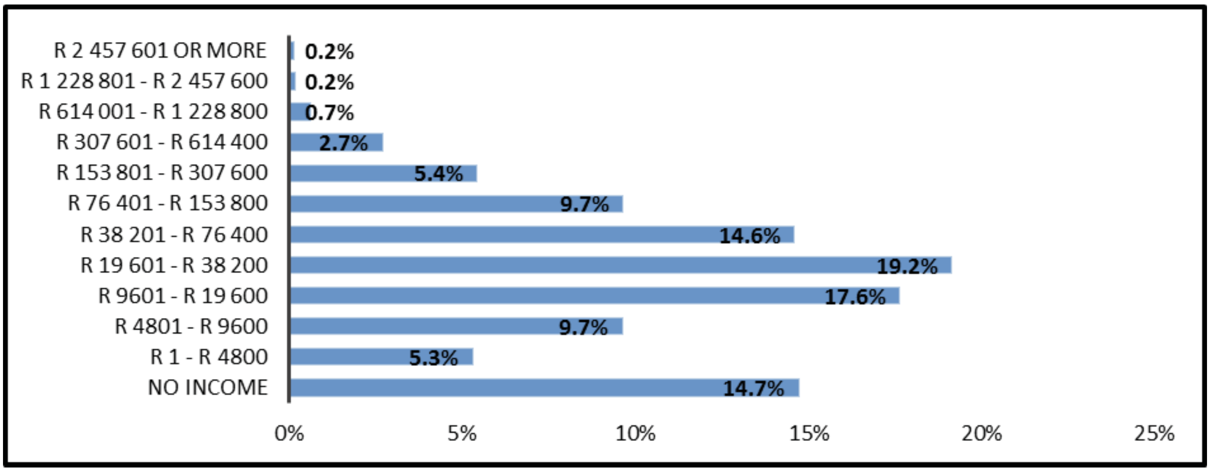

Figure 7-36: Income group per households in the Steelpoort Sub-Catchment (Census 2011).

Similarly to the Middle-Olifants, the Steelpoort has a comparatively larger proportion (14%) of households living in informal dwellings (shack) and a reduced proportion of households (76%) living in brick and concrete structures (Figure 7-37). Most households have access to piped water with approximately 66% of access being evenly spread through homes, yards and within 200m of homes (Figure 7-39). A relatively large 21% of households have no access to piped water. The source of water in the sub-catchment is predominantly from municipal water schemes and boreholes (71%), but 15% do get their water directly from natural sources (i.e. Rivers and springs) (Figure 7-40). The most commonly used toilets are pit latrines with (6%) and without (57%) ventilation. 30% of households have access to flushing toilets that are connected to the sewer system (Figure 7-38).

Electricity is the main source of energy in the sub-catchment, used by most households for lighting (82%) but less so for cooking (61%) and heating (48%) (Figure 7-41). Wood is the second most used source of energy pedominantlybeig used for cooking (25) and heating (27%).

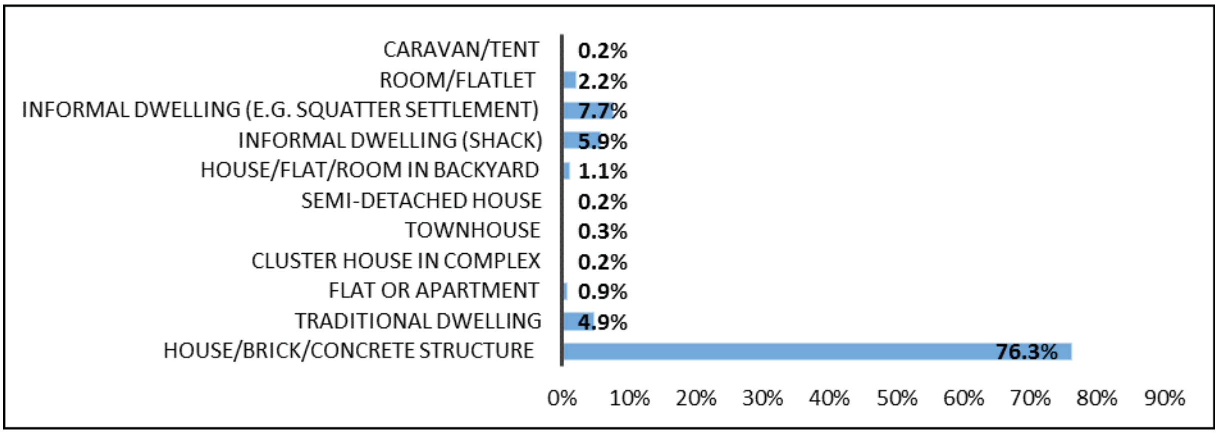

Figure 7-37: Dwelling demographic of the Steelpoort Sub-Catchment (Census 2011).

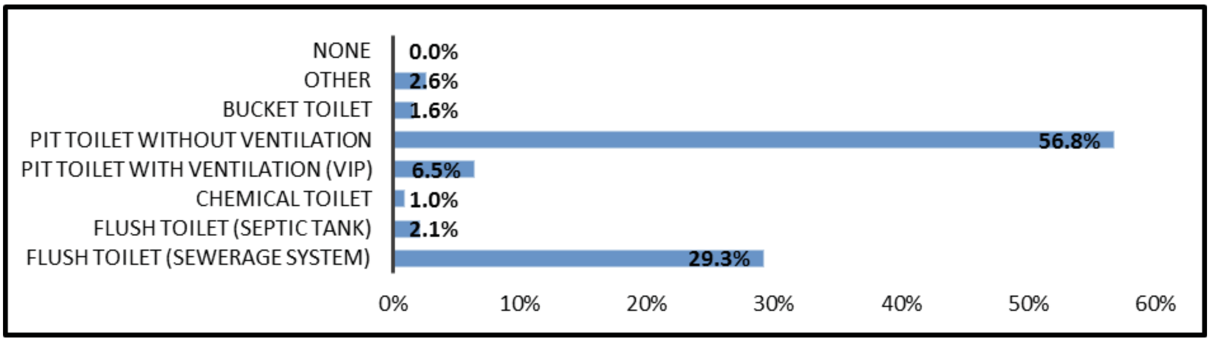

Figure 7-38: Toilet system demographic in the Steelpoort Sub-Catchment (Census 2011).

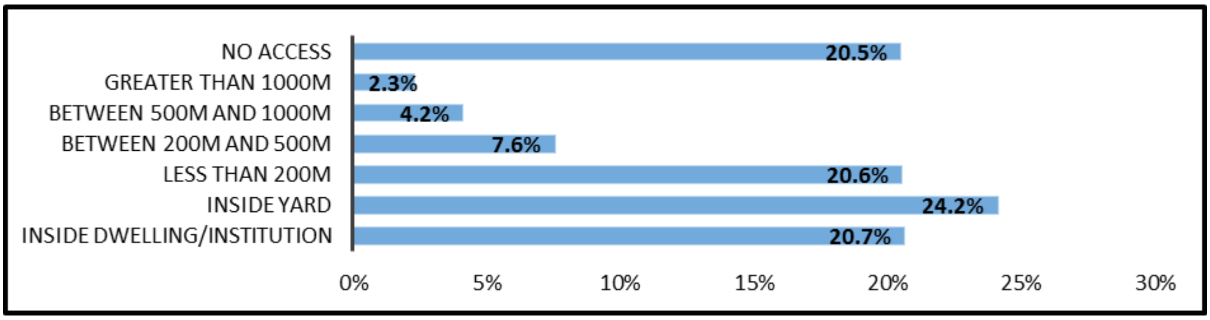

Figure 7-39: Water access demographic of households in the Steelpoort Sub-Catchment (Census 2011).

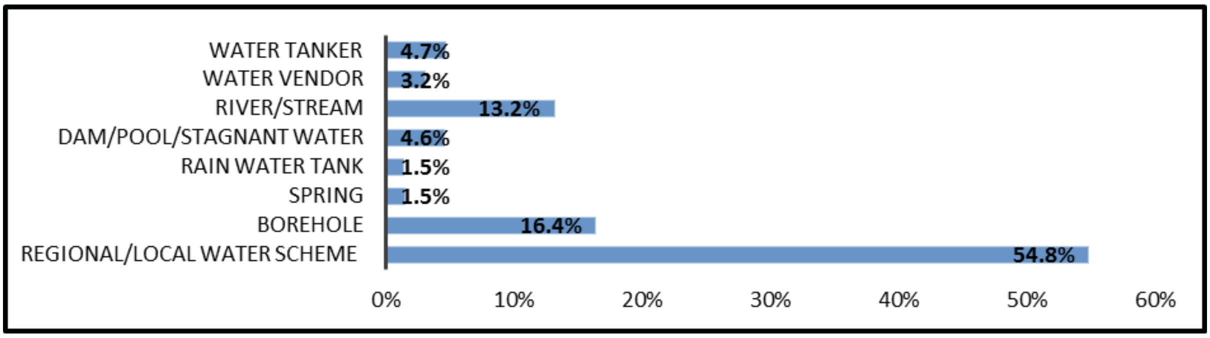

Figure 7-40: Source of water of households in the Steelpoort Sub-Catchment (Census 2011).

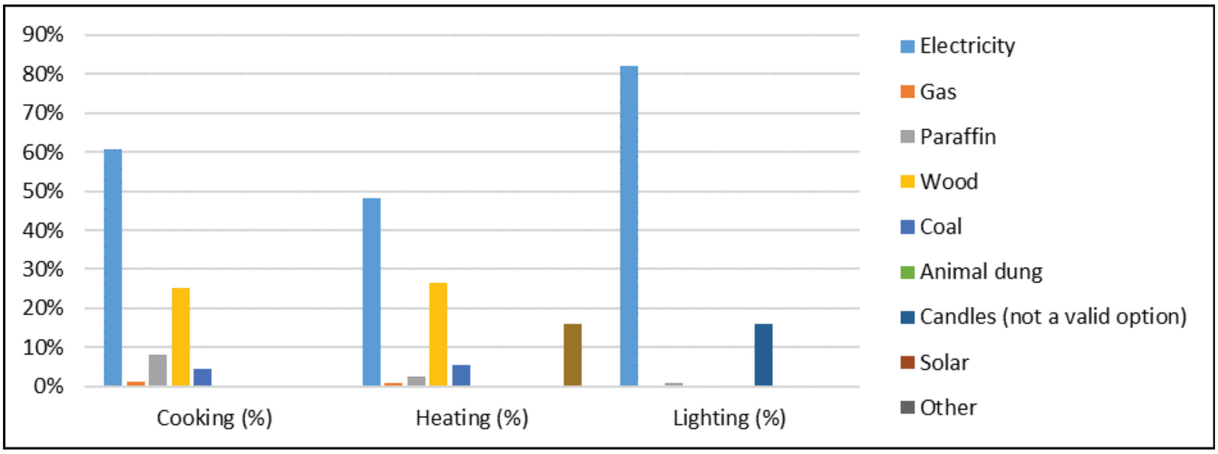

Figure 7-41: Energy type and use of households in the Steelpoort Sub-Catchment (Census 2011).

7.1.1.1.4 Lower-Olifants Sub-Catchment

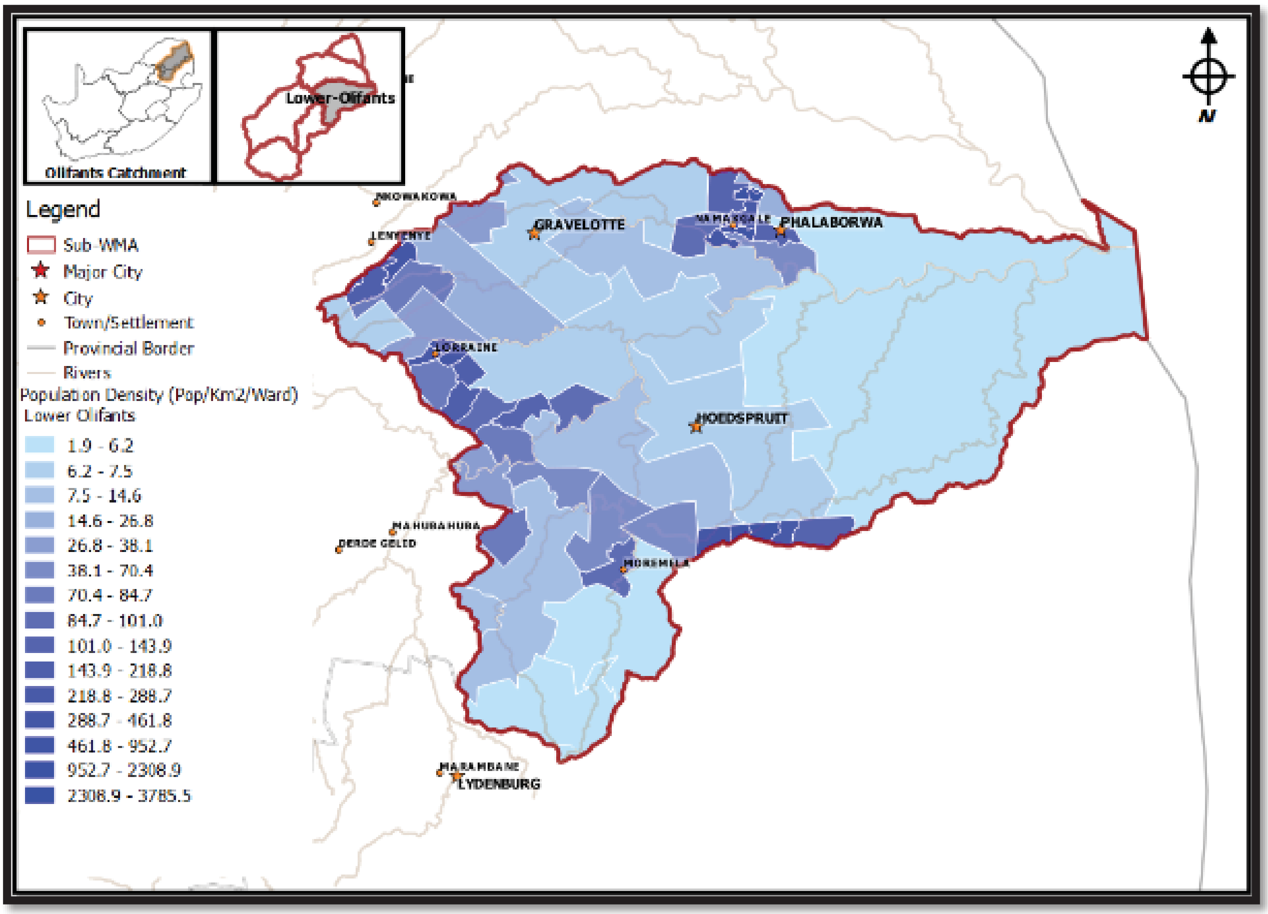

Figure 7-42: Population density (pop/Ha) by ward in the Lower-Olifants Sub-Catchment (Census 2011).

The population of the Lower-Olifants Sub-Catchment is approximately 350 thousand (350 933) of which most are black at 96% and 3% are white (Figure 7-43). Population density hotspots include areas surrounding Phalaborwa, Lorraine and Moremela (Figure 7-42). The languages predominantly spoken are Sepedi (59%) and Xitsonga (31%) (Census 2011).

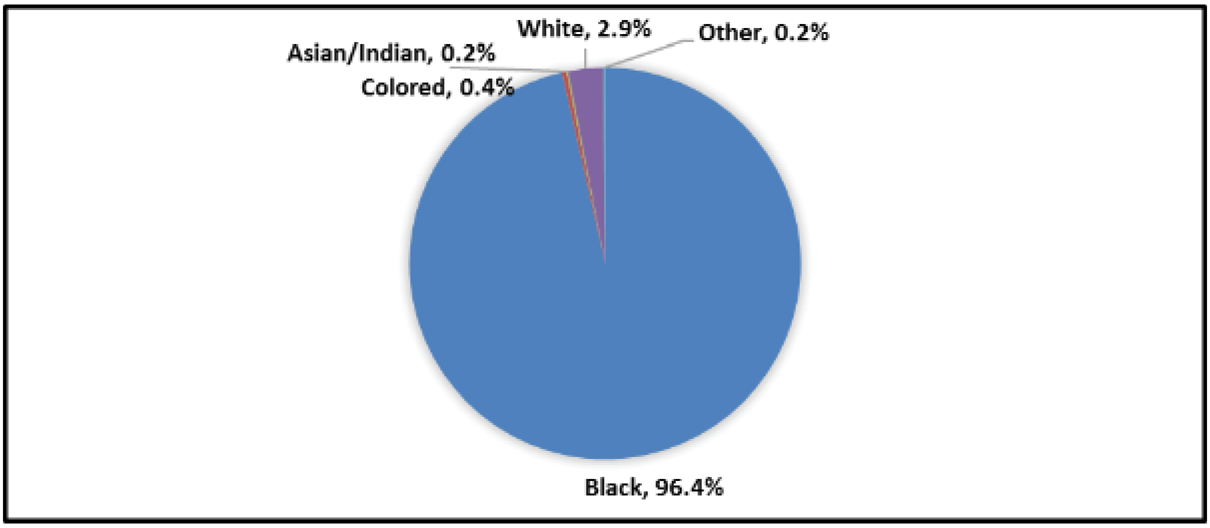

Figure 7-43: Population demographics of the Lower-Olifants Sub-Catchment (Census 2011).

Approximately a third of the sub-catchment has little (12%) to no (18%) formal education while approximately another third has a much higher level of education having completed secondary (23%) and obtained higher (6%) education (Figure 7-44).

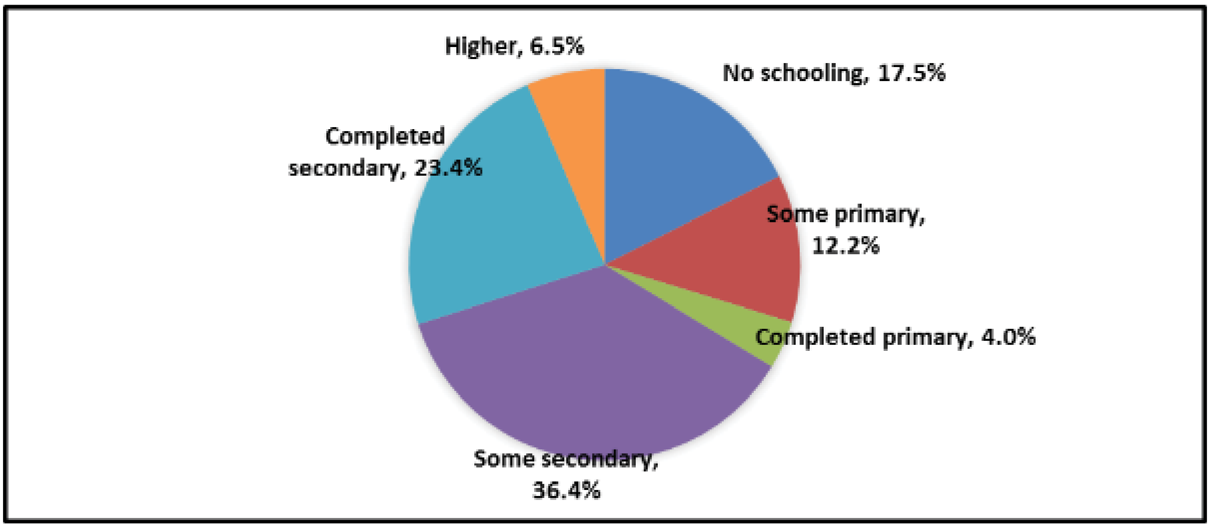

Figure 7-44: Education level demographics in the Lower-Olifants Sub-Catchment (Census 2011).

Almost half of the sub-catchment (47%) does not actively take part in the economy (Figure 7-45). Only 27% are employed, most of which in the formal Sector (66%). The leading income groups per household are earnings between R 9601 to R 19 600 and R 19 601 to R 38 200 per month with 23% and 20% of households respectively (Figure 7-46). 14% of households have no income and 7% earn less than R 4 800 per month.

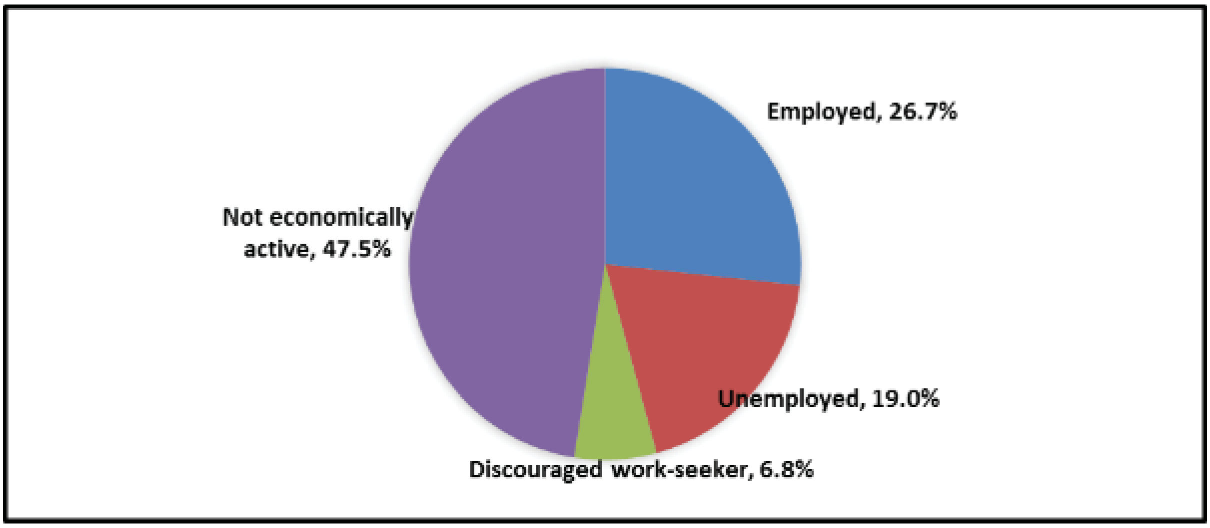

Figure 7-45: Employment status (Age 15-64) demographics in the Lower-Olifants Sub-Catchment (Census 2011).

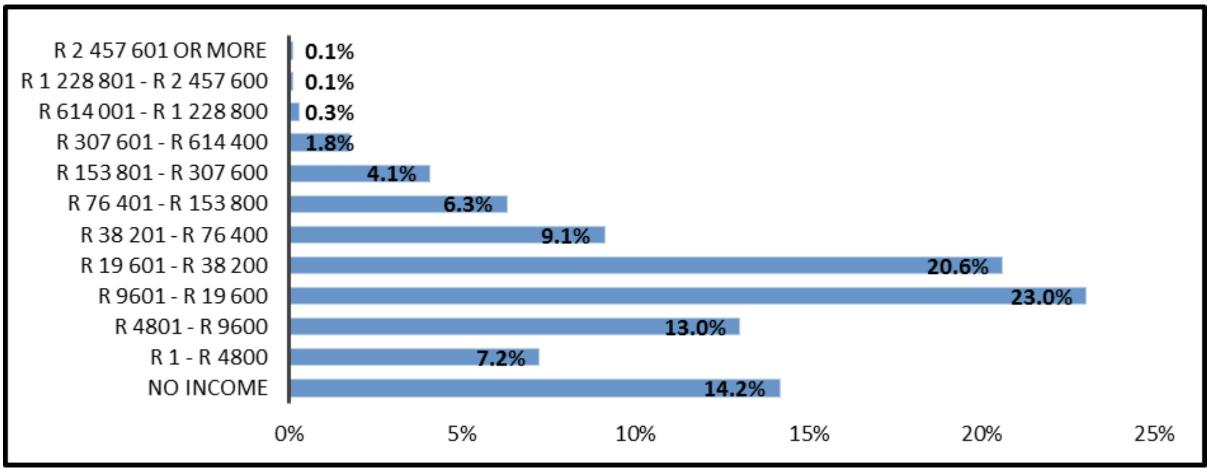

Figure 7-46: Income group per households in the Lower-Olifants Sub-Catchment (Census 2011).

Housing in the sub-catchment is chiefly characterised by brick and concrete houses (92%) and traditional made homes (4%) (Figure 7-47). 19% of households have access to piped water within their homes and another 38% in their yards (Figure 7-49). 32% need to leave their property to get access to piped water and another 13% do not have access at all. 74% of households utilise pit latrines and 24% have access to flushing toilets (Figure 7-48). Much of the sub-catchments water is sourced from the municipality (59%) and boreholes (15%) (Figure 7-50). A large proportion of households get their water through more natural sources such as rivers or streams (13%) and dams (6%).

Electricity is used by 89% of households for lighting purposes (Figure 7-51). Both wood and electricity are used to a similar degree for cooking and heating purposes (Approximately 48% and 40% respectively). 19% of households do not use energy for heating.

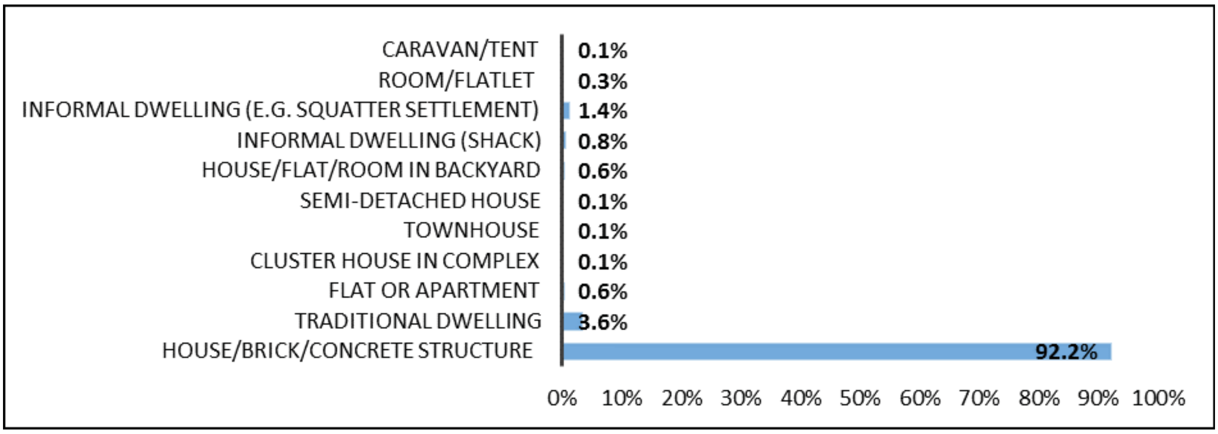

Figure 7-47: Dwelling demographic of the Lower-Olifants Sub-Catchment (Census 2011).

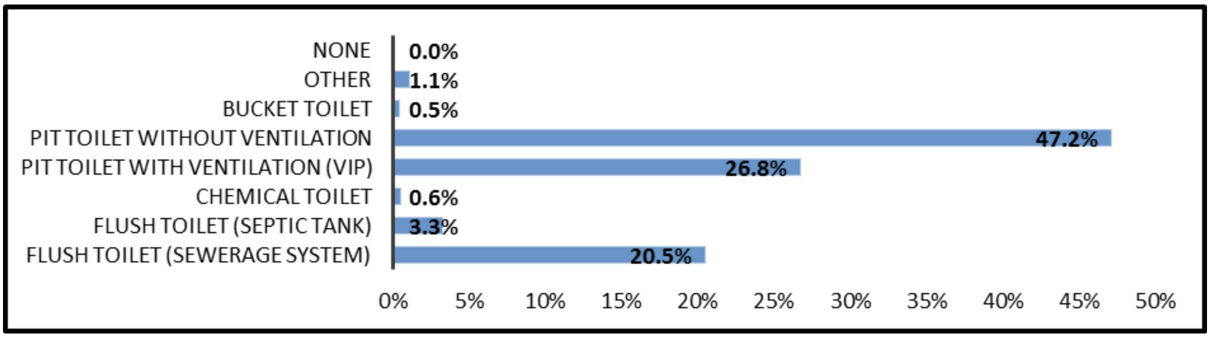

Figure 7-48: Toilet system demographic in the Lower-Olifants Sub-Catchment (Census 2011).

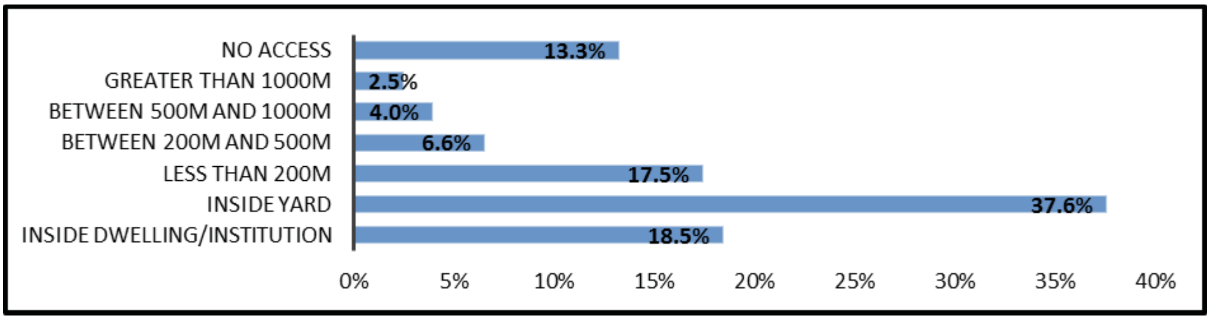

Figure 7-49: Water access demographic of households in the Lower-Olifants Sub-Catchment (Census 2011).

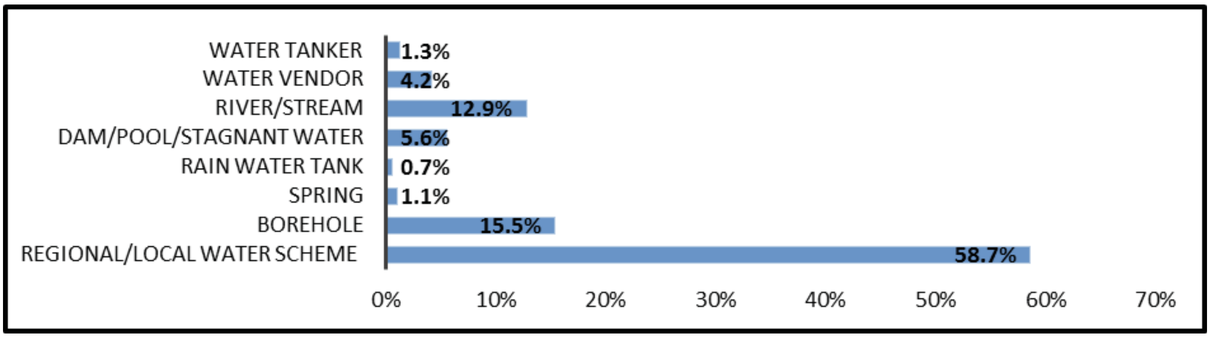

Figure 7-50: Source of water of households in the Lower-Olifants Sub-Catchment (Census 2011).

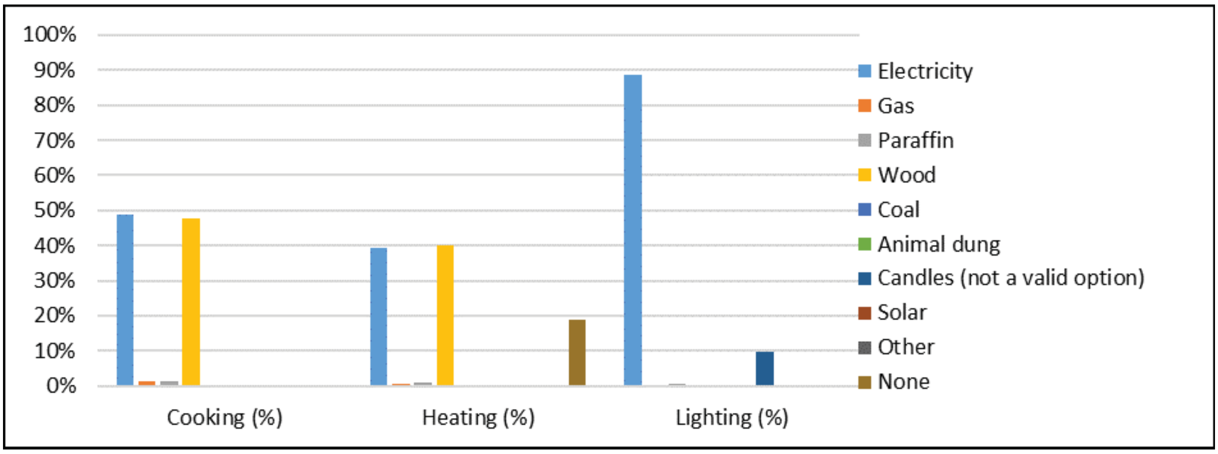

Figure 7-51: Energy type and use of households in the Lower-Olifants Sub-Catchment (Census 2011).

7.1.1.1.5 Letaba Sub-Catchment

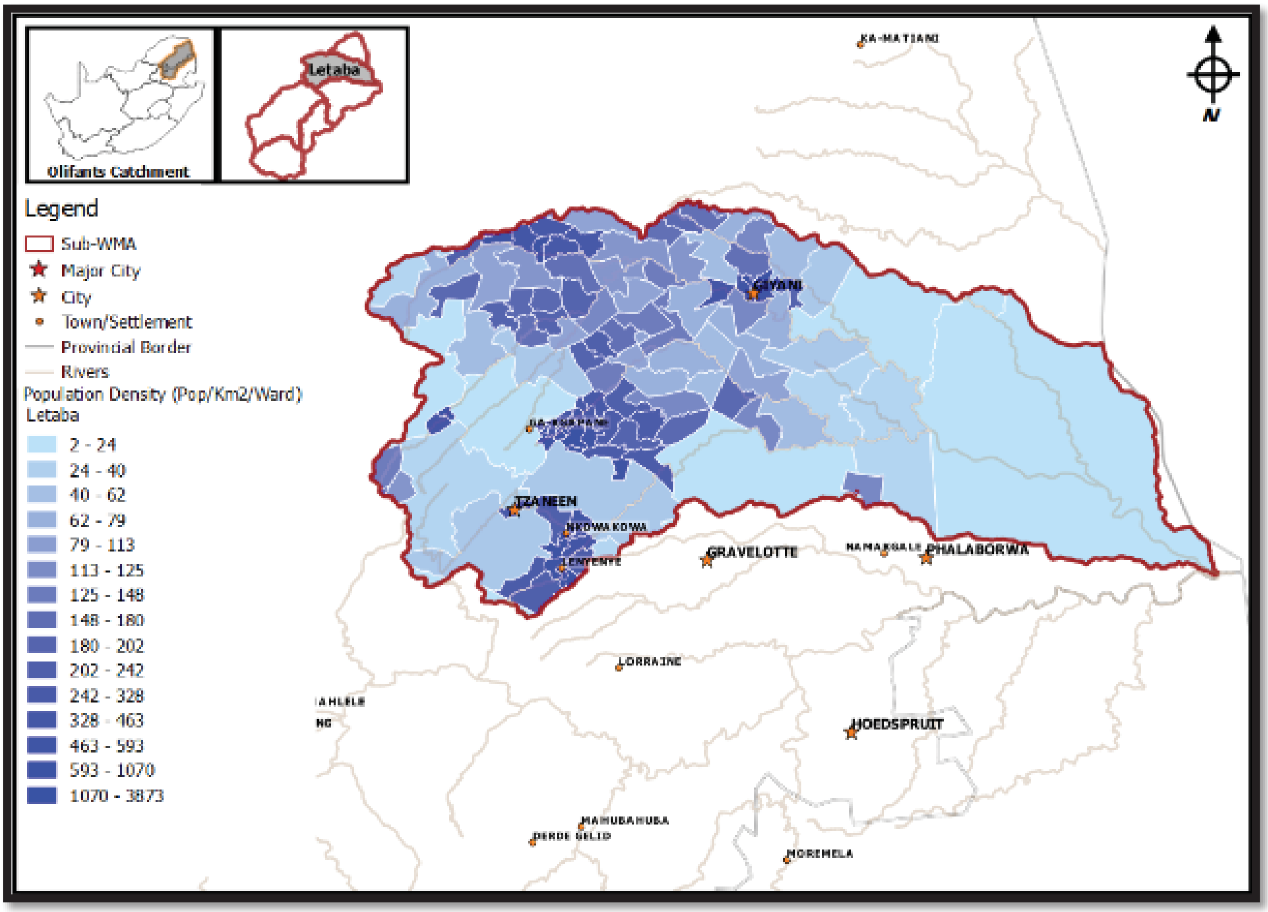

Figure 7-52: Population density (pop/Ha) by ward in the Letaba Sub-Catchment (Census 2011).

There are approximately 1.1 million (1 110 335) people residing in the Letaba Sub-Catchment of which the highest densities are in the areas of Tzaneen, Ga Kgapane and Giyani (Figure 7-52). The vast majority are black (97%) much less being white (2%) (Figure 7-53). Two main languages are spoken in the area, these are Xitsonga (46%) and Sepedi (35%) and to a lesser degree Tshivenda (12%) (Census 2011).

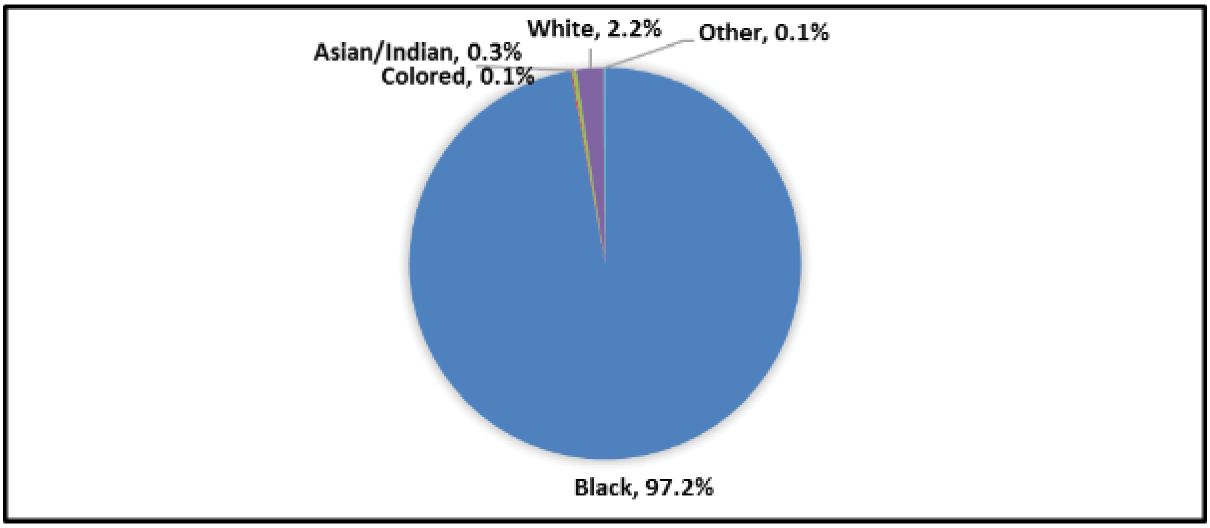

Figure 7-53: Population demographics of the Letaba Sub-Catchment (Census 2011).

A third of the Letaba population have little to no formal education (33%), with only 11% having some primary and 22% having no formal education at all (Figure 7-54). Another third have some secondary education and the last third are relatively well educated having completed secondary education (21%) and have had higher education (8%).

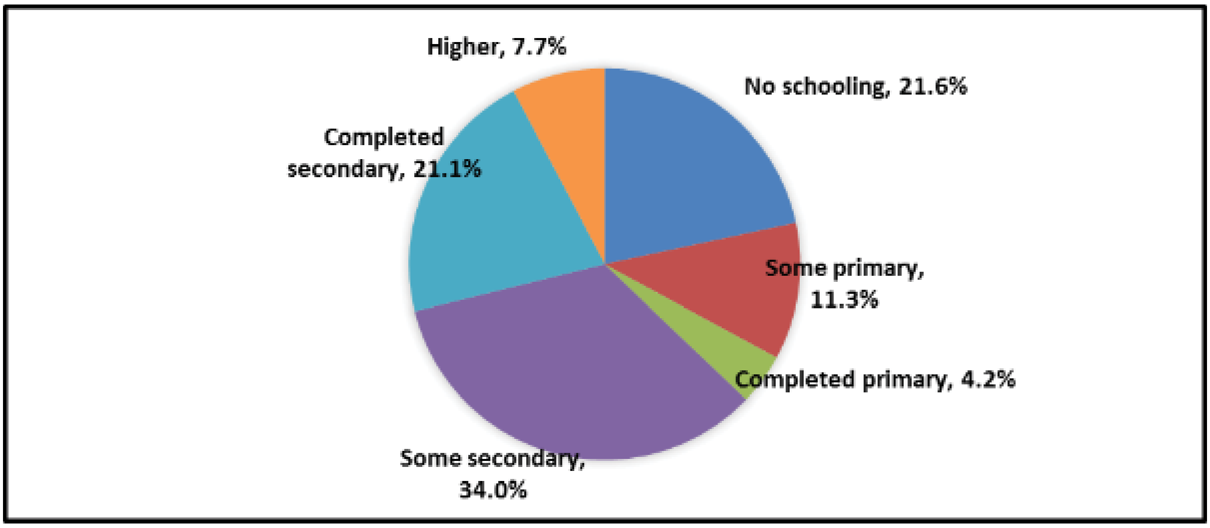

Figure 7-54: Education level demographics in the Letaba Sub-Catchment (Census 2011).

More than half (51%) of the residents in the Letaba Sub-Catchment are not economically active (Figure 7-55). Only half of residents who are economically active are actually employed, with the rest looking for employment. Of the employed individuals, 65% are employed in the formal Sector (Census 2011). The largest income group of 24% of households earn between R9601 and R19600 a month closely followed by 21% of the R19601 to R38200 income group (Figure 7-56). 14% of households in the catchment have no income and 8% earn less than R 4 800 a month.

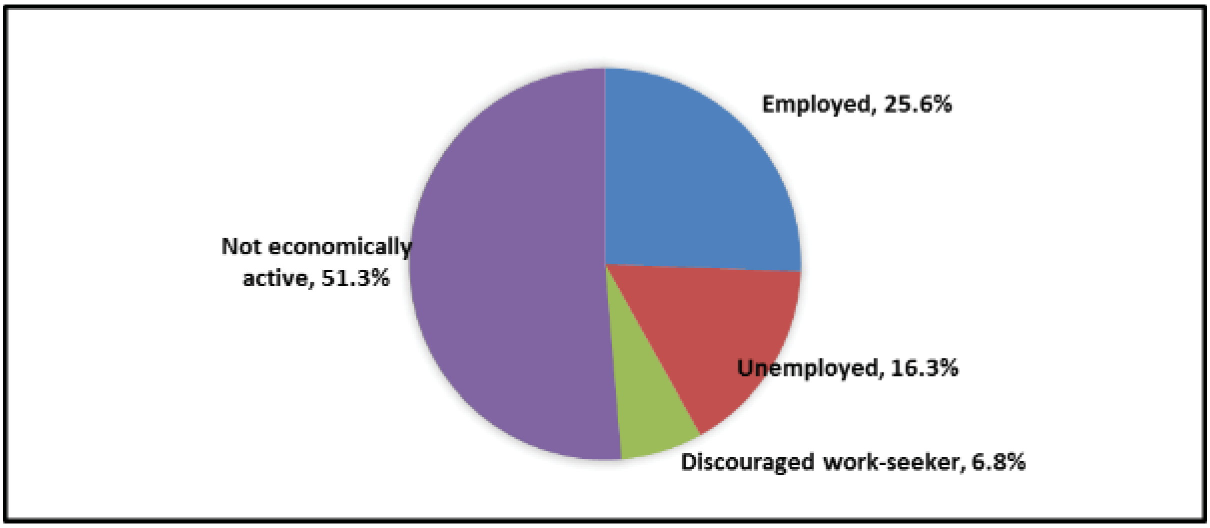

Figure 7-55: Employment status (Age 15-64) demographics in the Letaba Sub-Catchment (Census 2011).

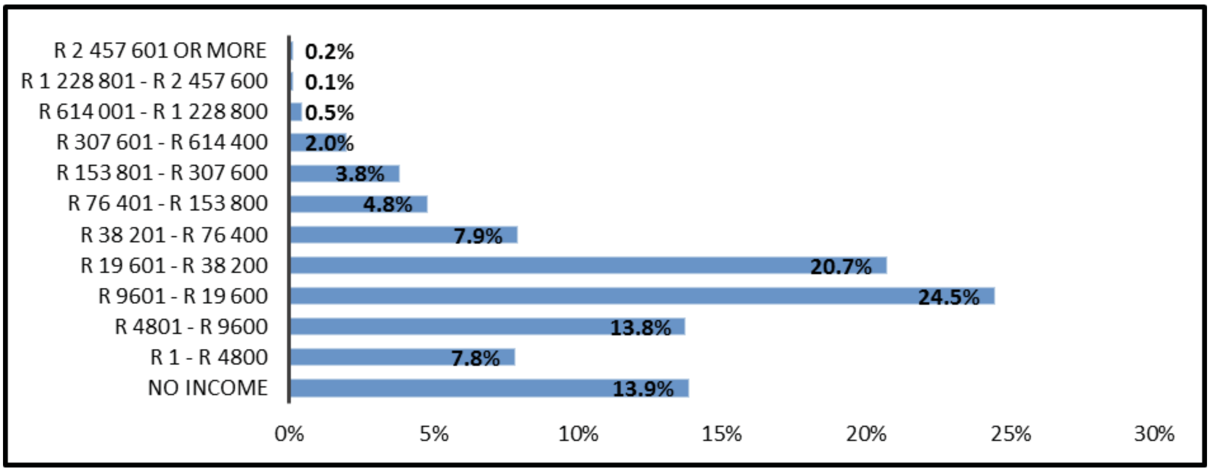

Figure 7-56: Income group per households in the Letaba Sub-Catchment (Census 2011).

Although most of the sub-catchments households live within brick or concrete houses (89%) (Figure 7-57), only 15% have piped water within their homes however 31% have access in their yards and 22% within 200m of their homes (Figure 7-59). 16% of residents have no access to piped water. The majority of households get their water from the municipality (58%) with a smaller yet substantial proportion using boreholes (19%) (Figure 7-60). The rest get water through more traditional and natural means.

Only 19% of households have flushing toilets therefore households in the sub-catchment predominantly use pit toilets with 58% and 20% of households using ventilated and non-ventilated pit latrines (Figure 7-58).

Energy use varies greatly with its purpose with most households (88%) having access to electricity for lighting (Figure 7-61). Electricity is still a common source of energy for cooking and heating however wood is the predominantly used source for these purposes being used by 61% and 48% respectively.

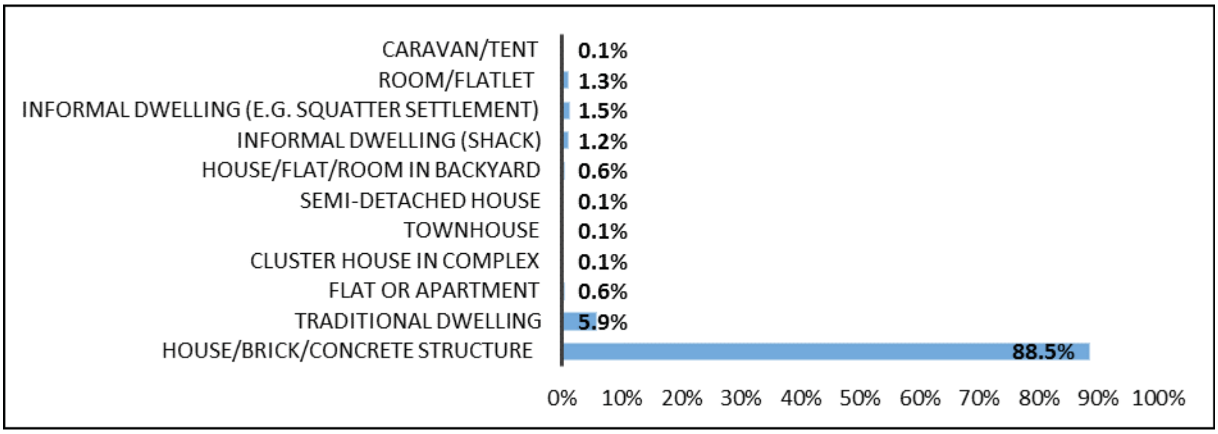

Figure 7-57: Dwelling demographic of the Letaba Sub-Catchment (Census 2011).

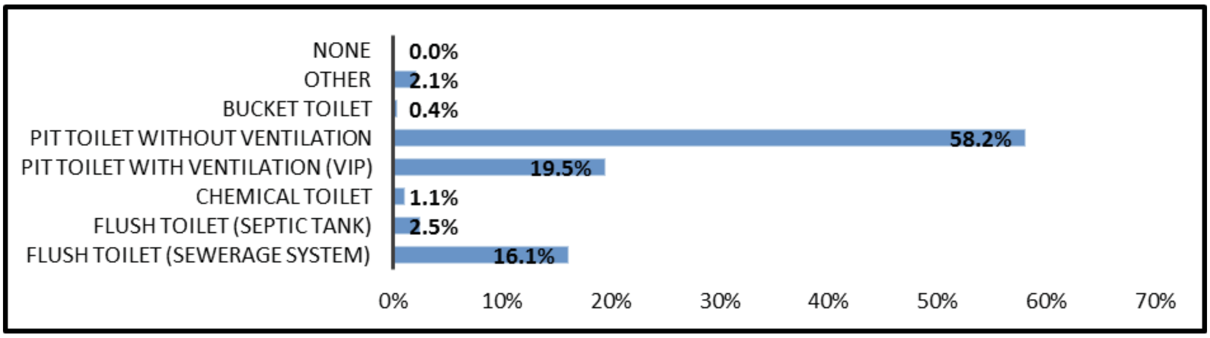

Figure 7-58: Toilet system demographic in the Letaba Sub-Catchment (Census 2011).

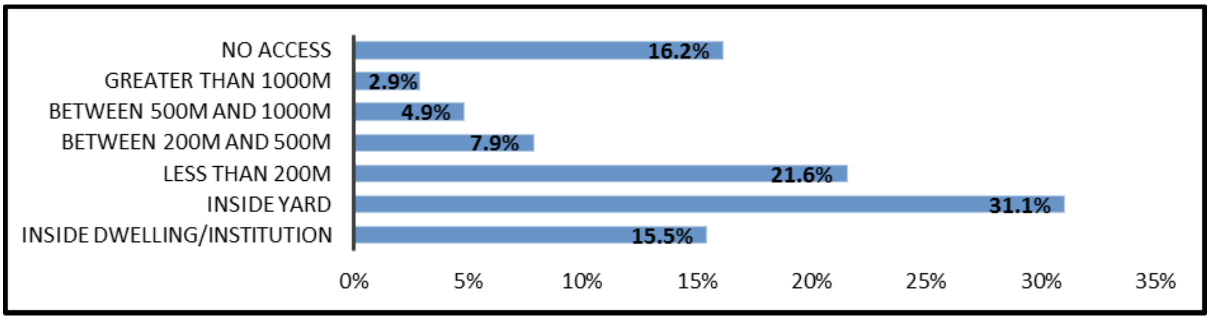

Figure 7-59: Water access demographic of households in the Letaba Sub-Catchment (Census 2011).

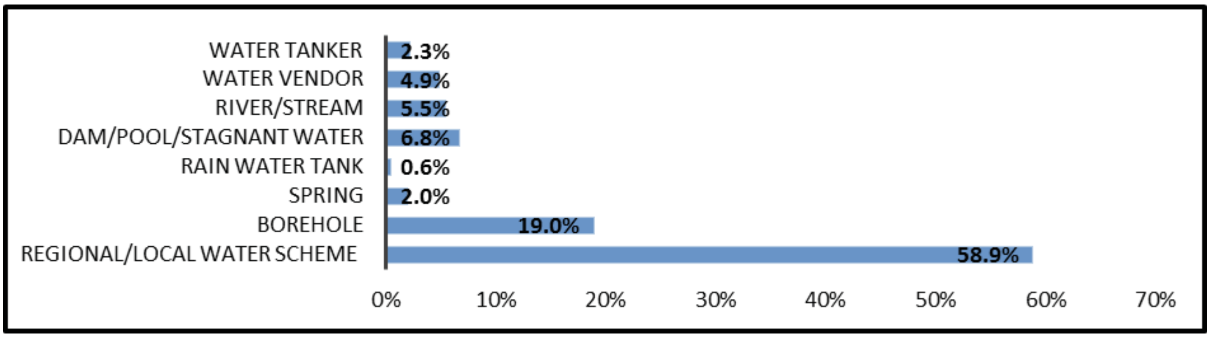

Figure 7-60: Source of water of households in the Letaba Sub-Catchment (Census 2011).

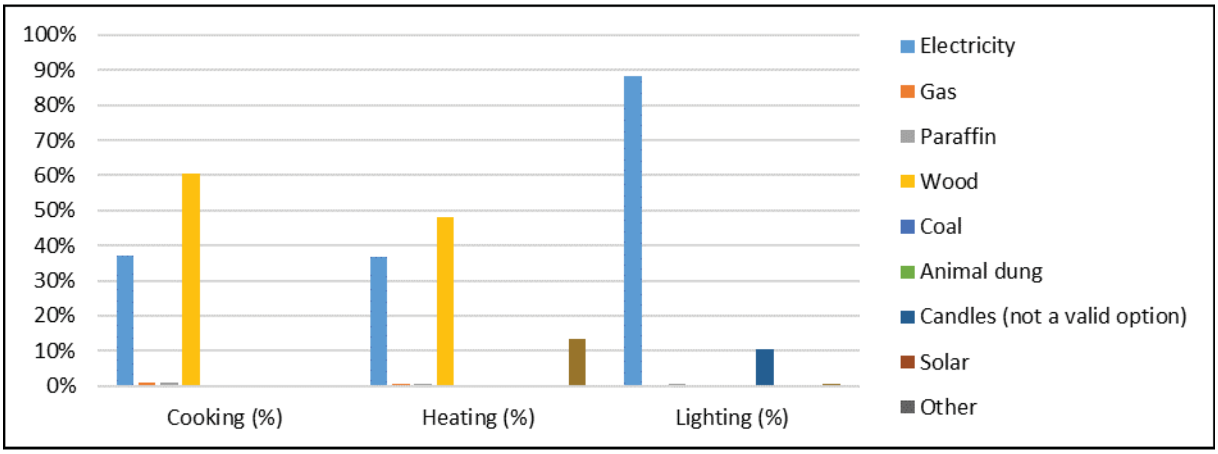

Figure 7-61: Energy type and use of households in the Letaba Sub-Catchment (Census 2011).

7.1.1.1.6 Shingwedzi Sub-Catchment

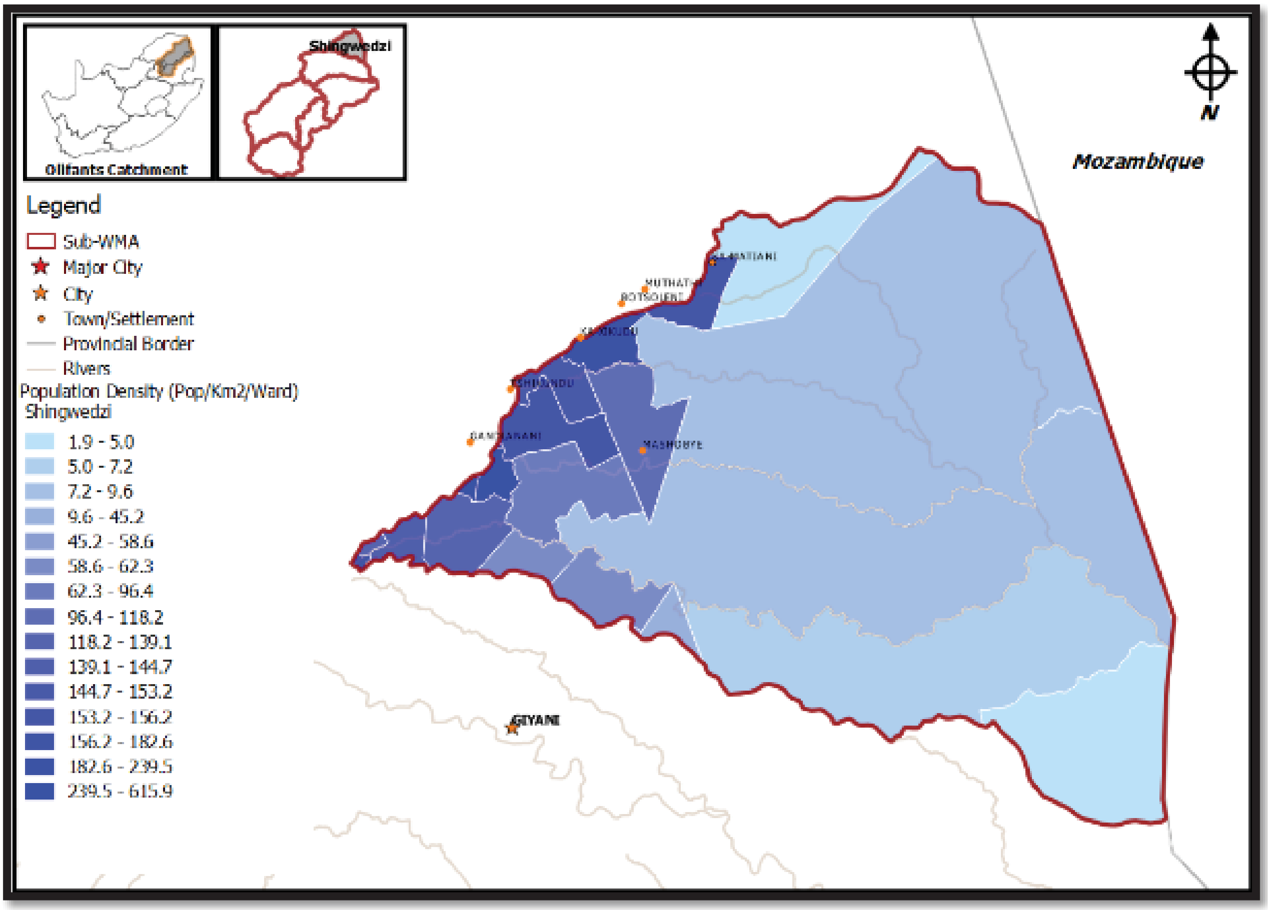

Figure 7-62: Population density (pop/Ha) by ward in the Shingwedzi Sub-Catchment (Census 2011).

The Shingwedzi Sub-Catchment has a population of approximately 240 thousand (238 937) people with densities increasing around the rural areas of Ganolanani, Ka-Xikudu and Muthathi (Figure 7-62). Almost the whole population is black (99.7%) (Figure 7-63) speaking predominantly Xitsonga (90%) and to a lesser degree Tshivenda (9%) (Census 2011).

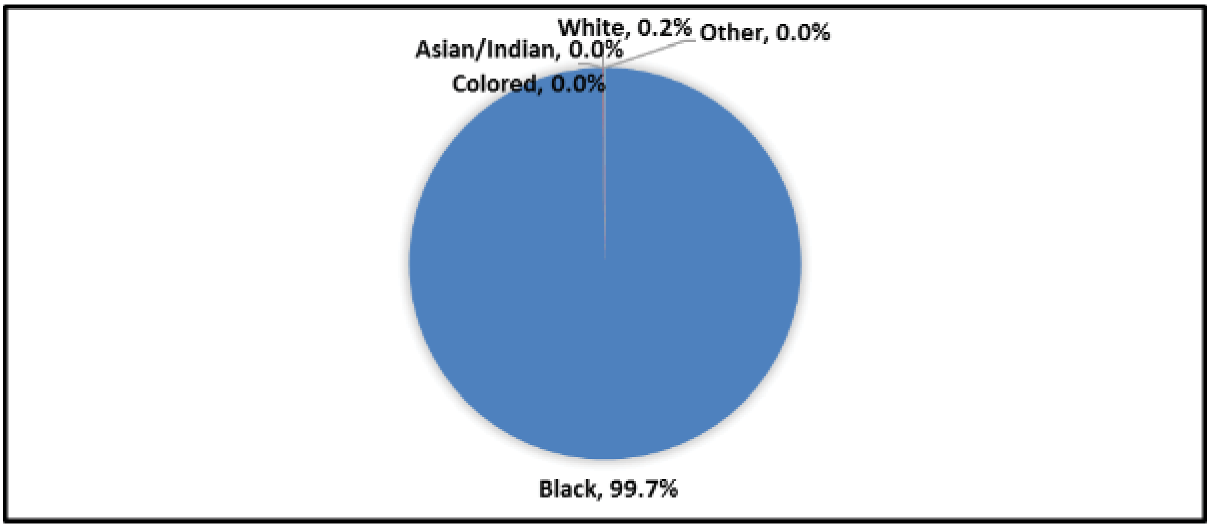

Figure 7-63: Population demographics of the Shingwedzi Sub-Catchment (Census 2011).

Education in the catchment is the lowest of all sub-catchments in the Olifants with 38% having little or no formal education and only 24% having completed secondary school or having higher education (Figure 7-64).

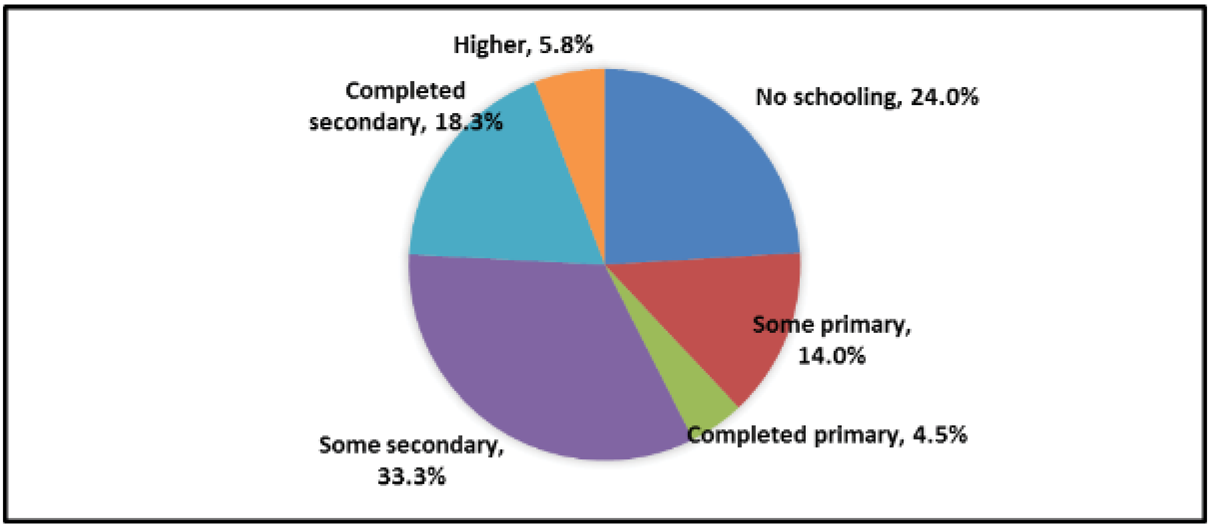

Figure 7-64: Education level demographics in the Shingwedzi Sub-Catchment (Census 2011).

Shingwedzi has the highest proportion of individuals (51%) that are economically inactive compared to other sub-catchments in the Olifants (Figure 7-65). To make matters worse 26% of the population are unemployed. Only 14% of residents in the region are employed of which 70% are employed in the formal Sector. The average income groups are the lowest compared to neighbouring sub-catchments. The most common income groups being R 4 801-R 9 600 (20%) and R 9 601-R 19 600 (24%) (Figure 7-66). 14% of households have no income and 11% have a monthly income of less than R4800.

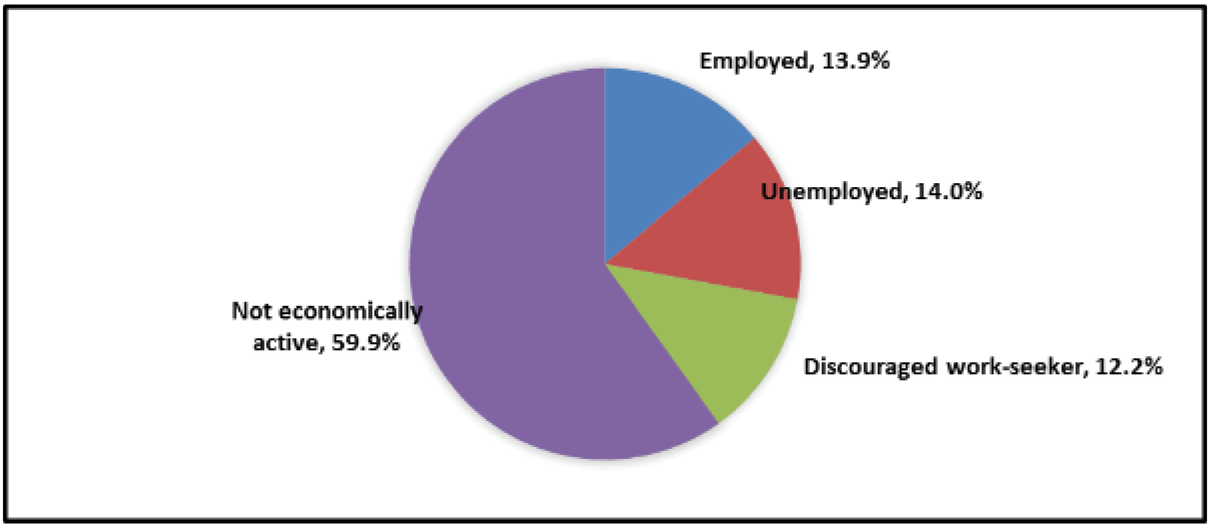

Figure 7-65: Employment status (Age 15-64) demographics in the Shingwedzi Sub-Catchment (Census 2011).

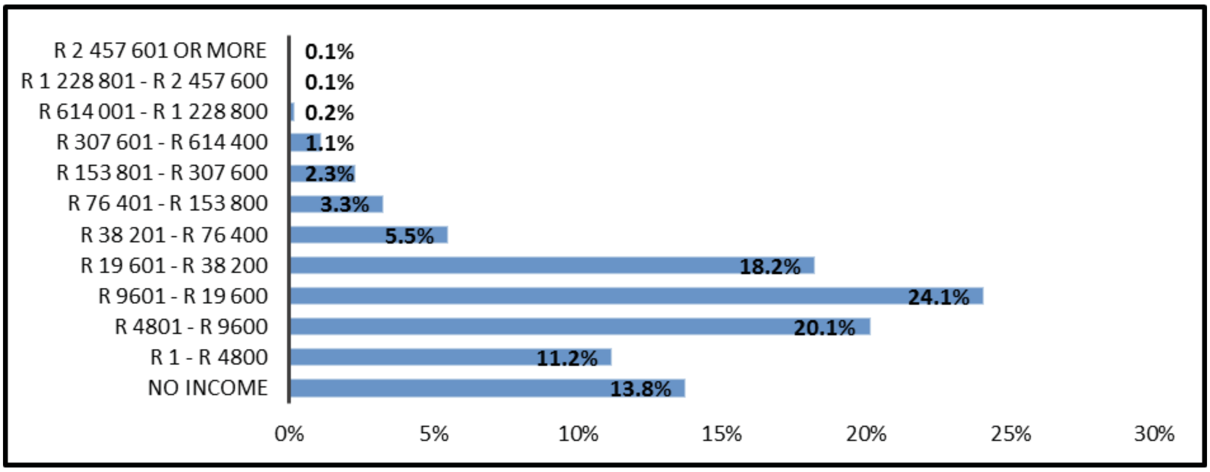

Figure 7-66: Income group per households in the Shingwedzi Sub-Catchment (Census 2011).

The characteristics of dwellings in the Shingwedzi Sub-Catchment are typically that of brick and concrete structures (75%) and traditional structures (23%) (Figure 7-67). Although this sub-catchment has the highest proportion of formal structures and the lowest proportion of informal dwellings (compared to other sub-catchments in the Olifants), piping infrastructure to these dwellings is minimal with only 9% of dwellings having piped water (Figure 7-69). Much of the households only have access to piped water in their yards (28%) or within 200m of their homes (32%). 26% have access further than 200m from their homes and 4% have no access to piped water. Most of this water comes from the municipal water scheme (83%) and to some lesser extent boreholes (10%) (Figure 7-70). As expected with the lack of plumbing within homes, only 9% of dwellings have flush toilet connected to a sewerage system (Figure 7-68). Most lavatories are pit toilets that are either ventilated (27%) or not (58%). Electricity is the key source of energy for lighting (85%) in the catchment however wood is the major source of energy for cooking (82%) and heating (73%) (Figure 7-71).

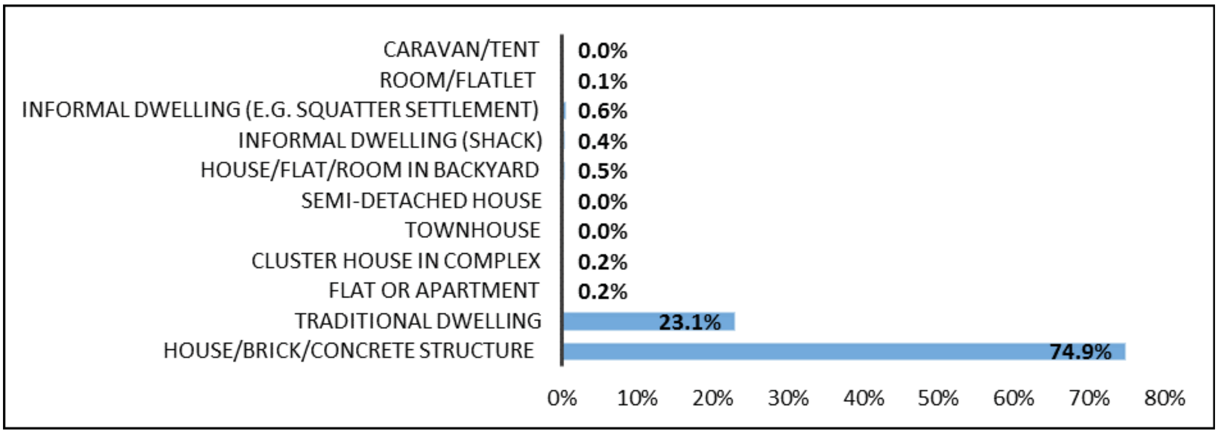

Figure 7-67: Dwelling demographic of the Shingwedzi Sub-Catchment (Census 2011).

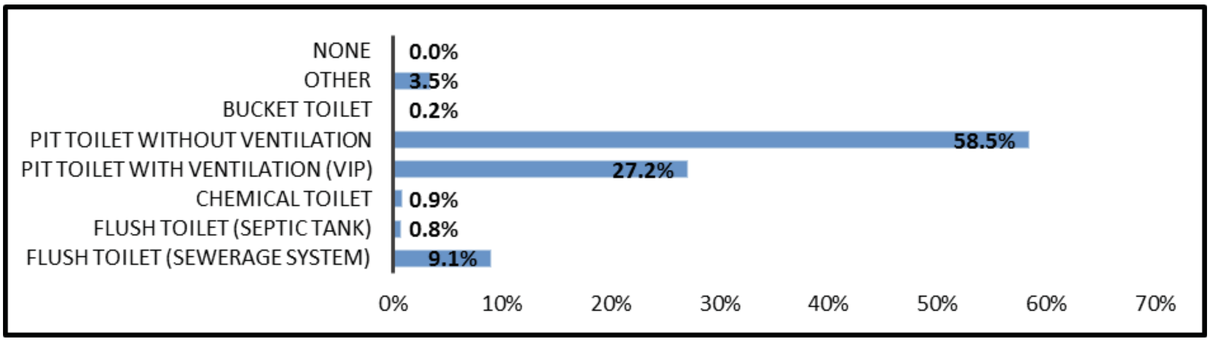

Figure 7-68: Toilet system demographic in the Shingwedzi Sub-Catchment (Census 2011).

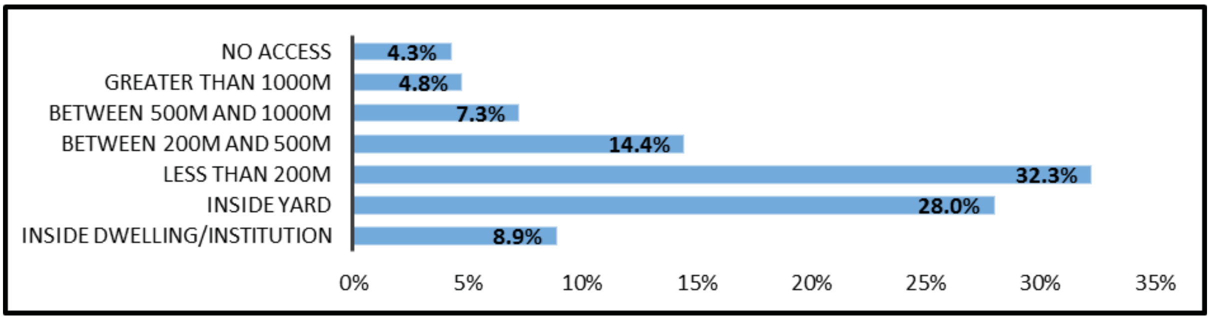

Figure 7-69: Water access demographic of households in the Shingwedzi Sub-Catchment (Census 2011).

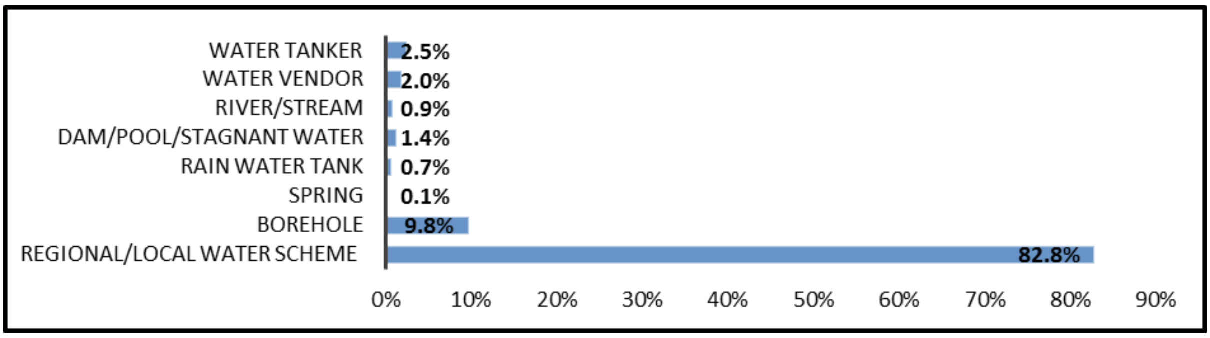

Figure 7-70: Source of water of households in the Shingwedzi Sub-Catchment (Census 2011).

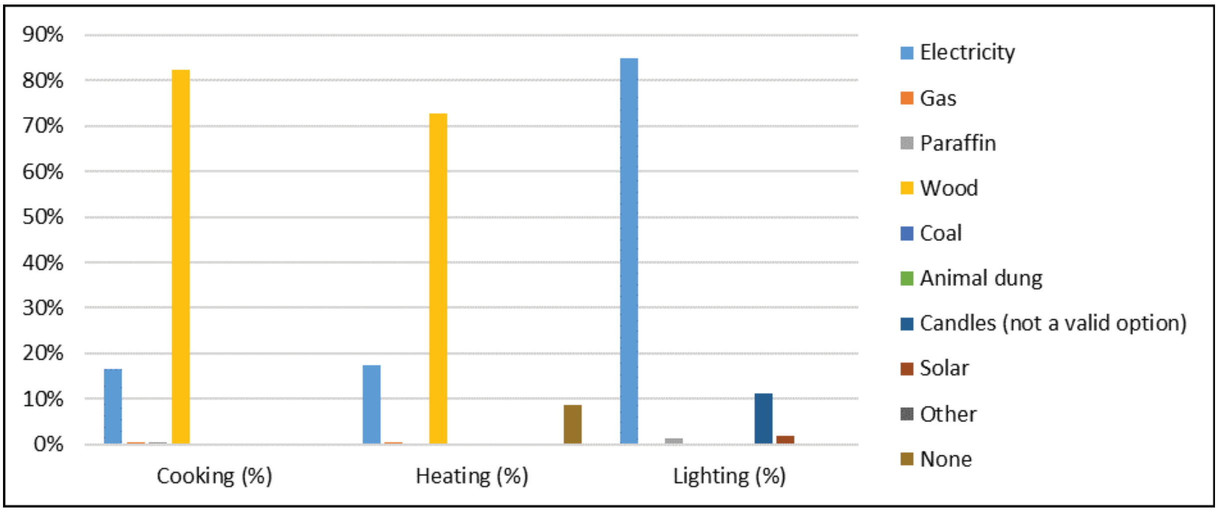

Figure 7-71: Energy type and use of households in the Shingwedzi Sub-Catchment (Census 2011).

7.1.1.2 Ecosystem services hotspts

Ecosystem service hotspots needed to be identified (Figure 7-72 and Figure 7-73) through broadly investigating the presence of ecosystem services across the catchment. The identification and qualitative descriptions of each is the first step towards understanding the patterns of ecosystem service use across the catchment. This provided a broad baseline for the appropriate selection of ecosystem services from which the use of aquatic ecosystem services will be described in Task 4.

A starting point included a master list of ecosystem services provided in literature (MEA, TEEB) and eliminate or select the services appropriate to the areas investigated.

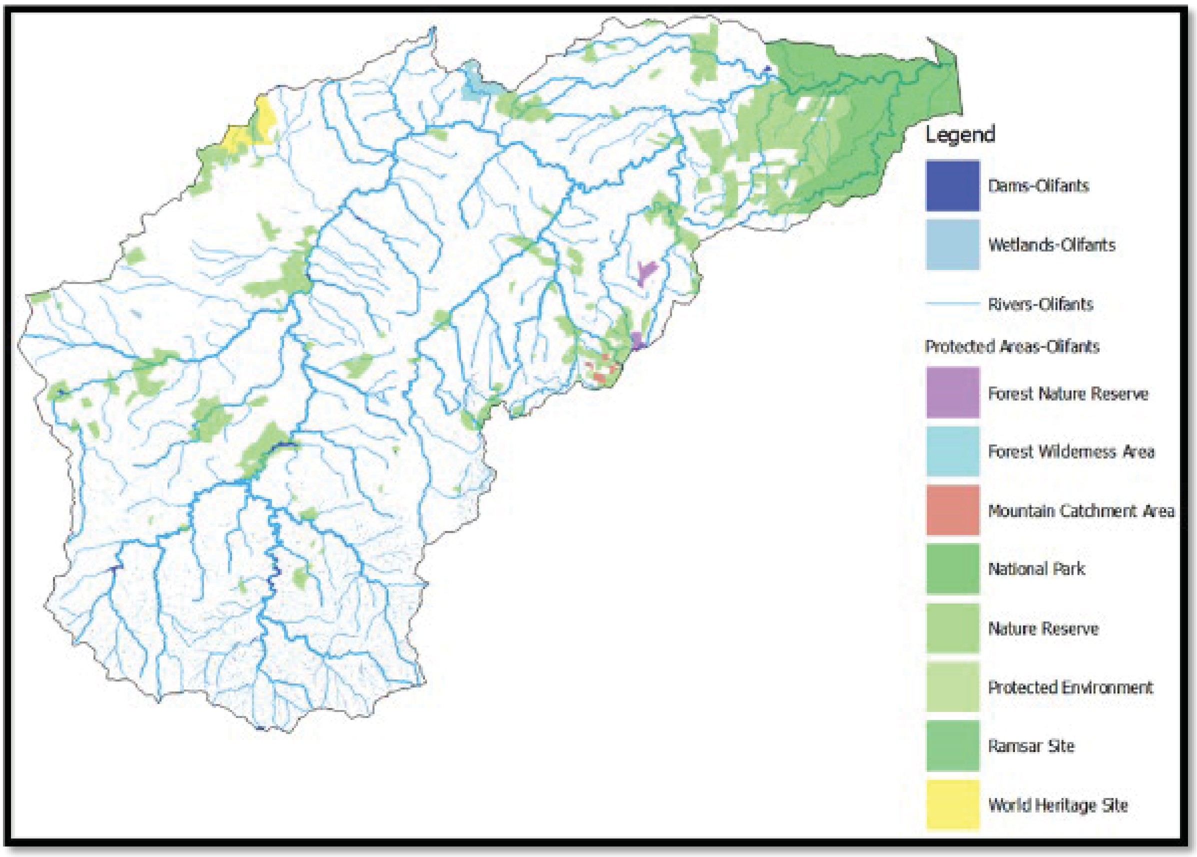

Figure 7-72: Olifants WMA protected Areas

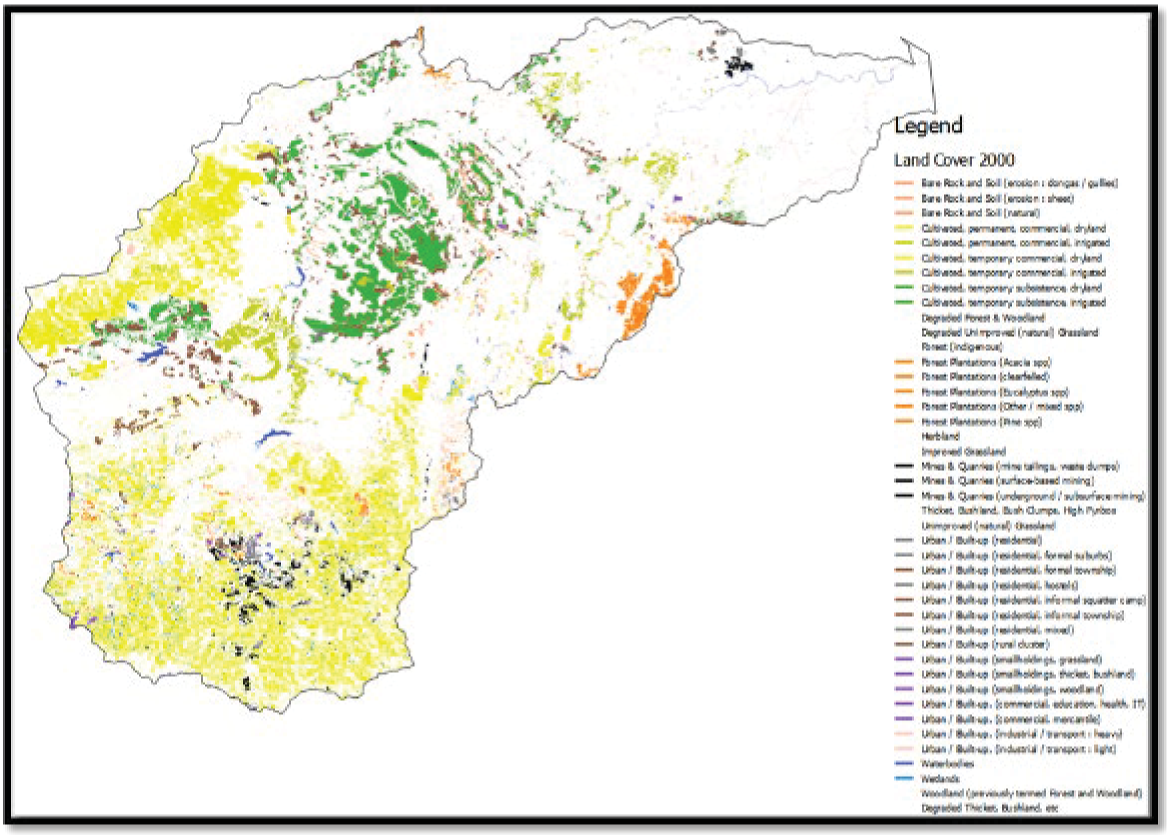

Figure 7-73: Land Cover of Olifants WMA

7.1.2 Action 2. Socio-Economic Zones (SEZ)

Spatial considerations for SEZ determination included results of Action 1 and information of land tenure, land use type (broad categorisation), aquatic resources present and other significant variables that indicate the extent of relationship between communities and associated ecosystems i.e. Tourism.

In consultation with experts, four broad socio-economic zones were developed for the Olifants WMA, namely Rural Agriculture, Energy, Conservation and Plantation, and Metallic Minerals Zones.

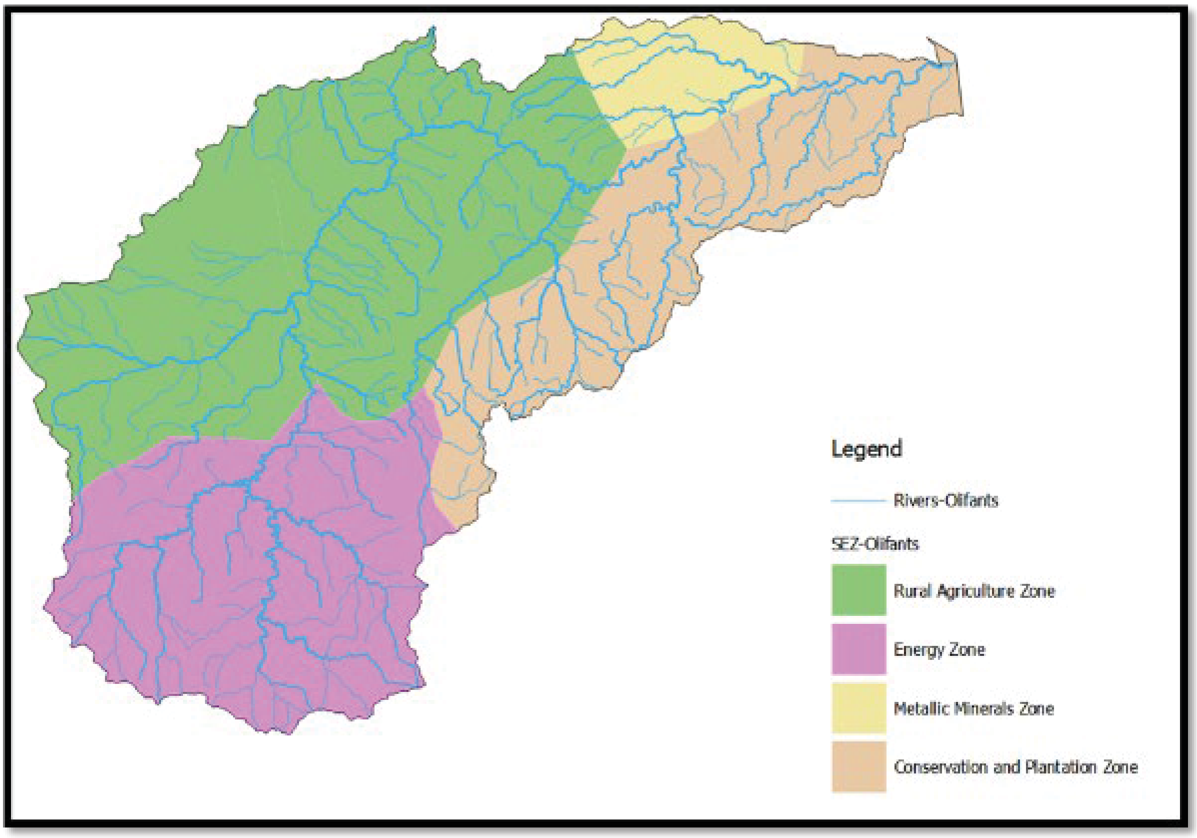

Figure 7-74: Socio-economic zones in the Olifants WMA

The SEZ developed in the figure above during the socio-economic evaluation of the catchment are used in the larger classification process to develop Integrated Units of Analysis (IUAs).

7.1.3 Action 3. IUA delineation

The delineation of Integrated Units of Analysis (IUAs) involved the collation of the SEZ, catchment boundaries and results of the ecological classification studies up to this point (end of Step 1-definition of IUA action) (DWAF 2007b). Biophysical nodes were identified and are used to retrieve ecological data that is relevant to the socio-economic characteristics of each IUA.

This process occurred in a workshop environment with all relevant stakeholders contributing their findings and agreeing on the proposed IUA delineations (Figure 7-75)

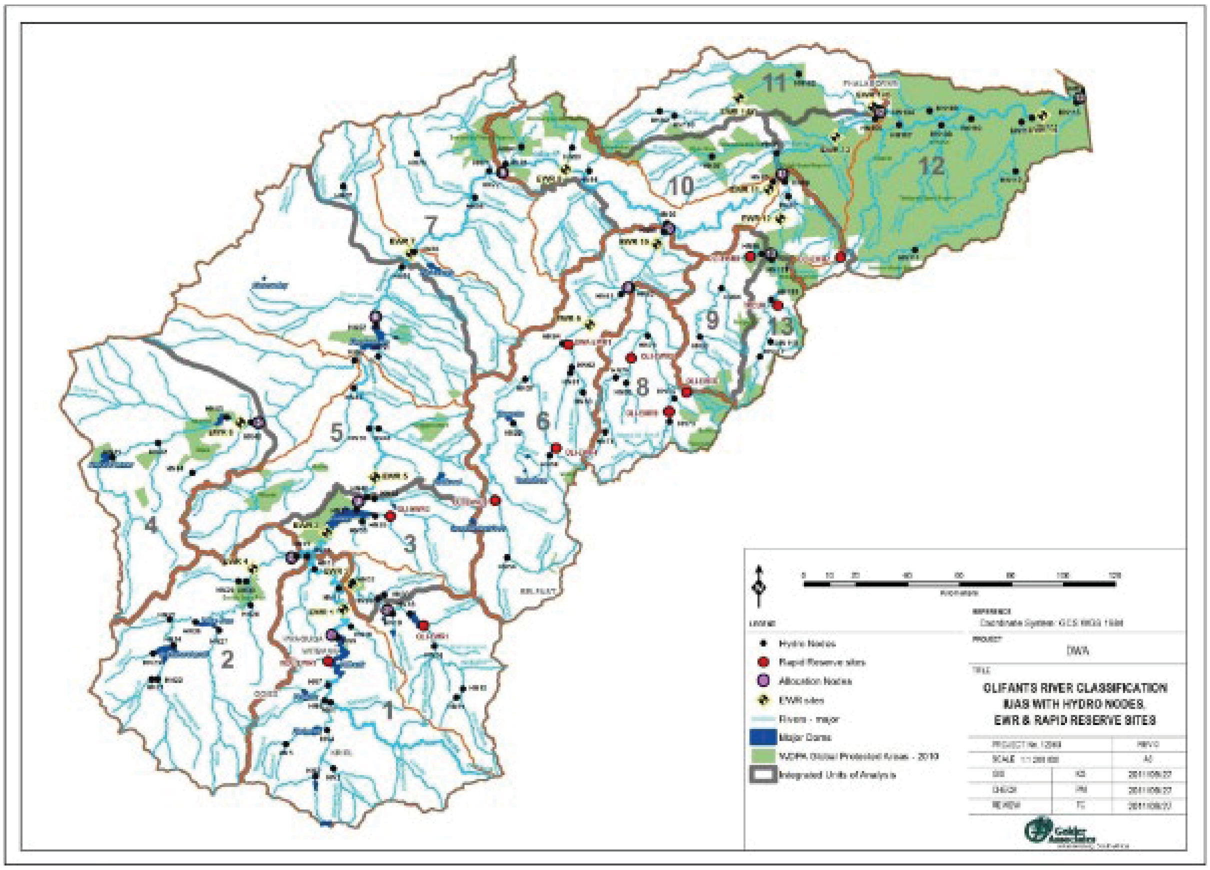

Figure 7-75: IUAs in the Olifants WMA

7.2 Task 2. Describe Communities and their Wellbeing

The well-being of communities was described using various indicators of financial, physical, human, social and natural capital assets available to communities. The process included the construct of an index of wellbeing which were used together to determine a Social Wellbeing Score (SWS). The approach taken was based on the approach toward classifying social wellbeing in DWAF 2007c.

7.2.1 Action 4. Describe communities

The descriptions required spatial manipulation to apportion the indicator data to IUA boundaries. Recommended categories and indicators included household income, access to water and sanitation and education level.

Table 7-1: Description of communities in each IUA

IUA	IUA Description
1	This IUA principally includes the local economy of eMalahleni (Witbank) and includes the towns of Middelburg, Hendrina, Douglas, Kriel and Kinross. The southern border of the IUA is located just north of Evander, Secunda and Bethal. The IUA includes the upper Olifants River and the Klein Olifants, Witbank Dam, Middelburg Dam and the Klipspruit. The IUA is characterized by intensive coal mining and an associated energy and manufacturing economy. The IUA is highly used and impacted. The population of IUA 1 is approximately 369 808 (Census 2001) with approximately 104 648 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
2	The Wilge River catchment principally includes the towns of Bronkhorstspruit and Delmas as well as the Ezemvelo Game Reserve to the north. The town of Ogies is located on the border of the Wilge River IUA and the Upper Olifants IUA (IUA 1). The town of Cullinan is located on the border of the IUA 2 and IUA 4. The IUA includes the Wilge River and tributaries. The economy of IUA 2 is dominated by mixed coal mining and dryland agricultural activities, supported by local economies around the key towns. The population of IUA 2 is approximately 146 647 (Census 2001) and has approximately 38 227 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
3	IUA 3 includes the Loskop Dam and its surrounding protected area. The IUA starts below the confluence of the Olifants and the Wilge Rivers and also includes the Selons River and Kruis rivers. The IUA includes a Section of the lower Klein Olifants between Mhluzi and the Doornkop protected area. The IUA has a largely natural and rural character and the agriculture Sector is an important source of employment. The population of IUA 3 is approximately 42 682 (Census 2001). The IUA has approximately 11 347 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
4	IUA 4 includes the town of Cullinan in the South, Kwamahlanga, the Rust De Winter Dam, and the rural settlements (Siyabuswa) around the Mkhombo Dam. Bela-Bela (Warmbaths) falls outside of the IUA on the western boundary. The IUA includes the Elands, Kameel and Mkhombo Rivers. The IUA includes the Dinokeng protected area and Mdala Nature Reserve. The Elands River is mainly rural in the upper reaches with impacts from agriculture, dams and settlements in the lower reaches of the catchment. The population of IUA 4 is approximately 164 250 (Census 2001) and has approximately 38 772 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
5	IUA 5, the Middle Olifants up to Flag Boshielo area includes the towns of Marble Hall, Groblersdal and Roedtan. The IUA contains the Flag Boshielo Dam, the Bloed, Klipspruit and Grass Valley Rivers. Several protected areas occur within the IUA and include Mbusa, Moutse, Kwaggavoetpad and Schuinsdraai Nature Reserves. The population of IUA 5 is approximately is 366 051 (Census 2001) and has approximately 81 474 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).

IUA	IUA Description
6	IUA 6 follows the Steelpoort River valley, starting from the Grootspruit River in the south; up to its confluence in the north with the Olifants River mainstem. It includes the towns of Belfast in the south, Steelpoort in the north and Stoffberg. The IUA includes a Section of the Verloren Vallei Nature Reserve near Dullstroom. The population of IUA 6 is approximately 37 958 and has approximately 8 489 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
7	IUA 7 consists primarily of dryland agriculture and rural subsistence farmers. It encompasses the Local Municipalities of Polokwane, Lepele-Nkumpi, Fetakgomo Makhuduthamaga. Some platinum mining occurs within the IUA. The population of IUA 7 is approximately 550 871 and has approximately 123 234 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
8	IUA 8 comprises the Spekboom catchment area. It includes the town of Mashishing (Lydenburg) in the south and Burgersfort in the north. Several protected areas occur within the IUA and include the Sterkspruit and Gustav Klingbiel Nature Reserves. The population of IUA 8 is approximately 30 026 and has approximately 9 029 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
9	IUA 9 includes the town of Ohrigstad and comprises the Ohrigstad river catchment area. The Blyde Nature Reserve is located in the lower reaches of this IUA. The population of IUA 9 is approximately 16 527 and has approximately 5 201 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
10	The IUA includes the town of Hoedspruit and the semi-urban areas of Hlohlokwe, Sofaya and Mahlomelong. The Lower Olifants IUA contains several conservation areas, which include the Bewaarkloof Nature Reserve, the Wolkberg Wilderness area and a portion of the Blyde River Canyon catchment area. Important water resources include the Olifants River and the lower Blyde and Mohlapitse tributaries. The population of IUA 10 is approximately 25 430 with approximately 5 665 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).
11	The IUA includes the towns of Phalaborwa, Gravelotte and Mica, and is bordered by the Kruger National Park to the west and other conservation areas to the east. The Ga-Selati IUA also encompasses the semi-urban areas of Ga-Mashishimale and Namakgale. Important water resources include the Ga-Selati River. The population of IUA 11 is approximately 134 894 and has approximately 33 156 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2012b).
12	The IUA incorporates the lower Olifants catchment area. This area is largely a protected area with a high conservation status. It includes the world-renowned Kruger National Park. The Olifants River especially in these lower reaches contains important natural heritage. These areas are water-dependent and play an important role in the tourism economy of the region. The IUA incorporates the Olifants main stem river and Klaserie, Tsiri, Timbavati, Tshutsi and Hlahleni tributaries. The population of the IUA is approximately 7 721 and has approximately 2 471 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).

IUA	IUA Description
13	The IUA incorporates the town Pilgrims Rest and contains the upper portions of the Blyde and Treur Rivers. The IUA is predominately rural in nature and is relatively undisturbed with a small area of forestry in the upper reach of the Treur River. The population of the Blyde River IUA is approximately 8 260 with approximately 2 600 households. The large majority of the households fall within the very poor and poor income categories (DWA, 2011b).

7.2.2 Action 5. Wellbeing index scoring

Wellbeing scoring is an approach whereby multiple indicator of wellbeing are integrated, resulting in an overall Social Wellbeing Score (SWS). This approach ideally gives a score between 0 and 100 where 0 is the lowest and 100 is the highest level of social wellbeing. The use of this scale allows for percentages to be used in the determination of the SWS. Indicators of wellbeing were categorised and an average score of wellbeing was determined. The overall score was the weighted average score among categories (Table 7-2).

Table 7-2: Social wellbeing score per IUA

IUA	SWS
1	81
2	76
3	78
4	71
5	69
6	56
7	62
8	78
9	57
10	57
11	74
12	61
13	71

7.3 Task 3. Describe the Use and Value of Water

The objective of this task was to describe the way in which water is used on an IUA level, and to estimate the value generated by that use

7.3.1 Action 6. Physical water account

Statssa and the Water Research Commission (WRC) are currently (2017) developing Physical Water Flow Account on national and WMA level. The project team analysed the Olifants WMA physical water account Figure 7-76.

Physical units (Million m3/a)	Environment	Inland water resources: Surface water	Inland water resources: Groundwater	Transfers in: TCTA LHWP	Distributors: DWS	Distributors: Water Boards	Distributors: Other water service providers	Distributors: Municipalities	Industry Groups: Agriculture	Industry Groups: Mining and bulk industries	Industry Groups: Electricity	Industry Groups: Other	Industry Groups: Domestic	Rest of the country: Limpopo (WMA 1)	Rest of the country: Olifants (WMA 2)	Rest of the country: Inkomati-Usuthu (WMA 3)	Rest of the country: Pongola-Umzimkhulu (WMA 4)	Rest of the country: Vaal (WMA 5)	Rest of the country: Orange (WMA 6)	Rest of the country: Mzimvubu-Tsitsikamma (WMA 7)	Rest of the country: Breede-Gouritz (WMA 8)	Rest of the country: Berg-Olifants (WMA 9)	Rest of the World: Botswana	Rest of the World: Lesotho	Rest of the World: Mozambique	Rest of the World: Namibia	Rest of the World: Zimbabwe	Return to sea	Residual
Environment: Collection of precipitation		3,409	971	0																									
Environment: Inland water Yield: Surface water					3,409																								
Environment: Inland water Yield: Groundwater					971																								
Transfers in: TCTA: LHWP																													
Distributors: DWS						511	21	142	1,011	95	182														2,418				
Distributors: Water Boards								353																					157.56
Distributors: Other Water Service Providers								21																					
Distributors: Municipalities	153											144	371																
Industry Groups: Agriculture	1,011																												
Industry Groups: Mining and bulk industries	95							0																					
Industry Groups: Electricity	145							36																					
Industry Groups: Other	112							33																					
Industry Groups: Domestic	288							84																					
Rest of the country: Limpopo (WMA 1)																													
Rest of the country: Olifants (WMA 2)																													
Rest of the country: Inkomati-Usuthu (WMA 3)																													
Rest of the country: Pongola-Umzimkhulu (WMA 4)																													
Rest of the country: Vaal (WMA 5)																													
Rest of the country: Orange (WMA 6)																													
Rest of the country: Mzimvubu-Tsitsikamma (WMA 7)																													
Rest of the country: Breede-Gouritz (WMA 8)																													
Rest of the country: Berg-Olifants (WMA 9)																													
Rest of the World: Botswana																													
Rest of the World: Lesotho																													
Rest of the World: Mozambique																													
Rest of the World: Namibia																													
Rest of the World: Zimbabwe																													
Return to sea																													

Figure 7-76: Physical water account of the Olifants WMA

7.3.2 Action 7: Water quality account

Statssa and the Water Research Commission (WRC) are also developing water quality account on national and WMA level. These accounts will update on an annual basis a national water quality account which will be updated on an annual basis. Figure 7-77 is water quality account of Olifants WMA.

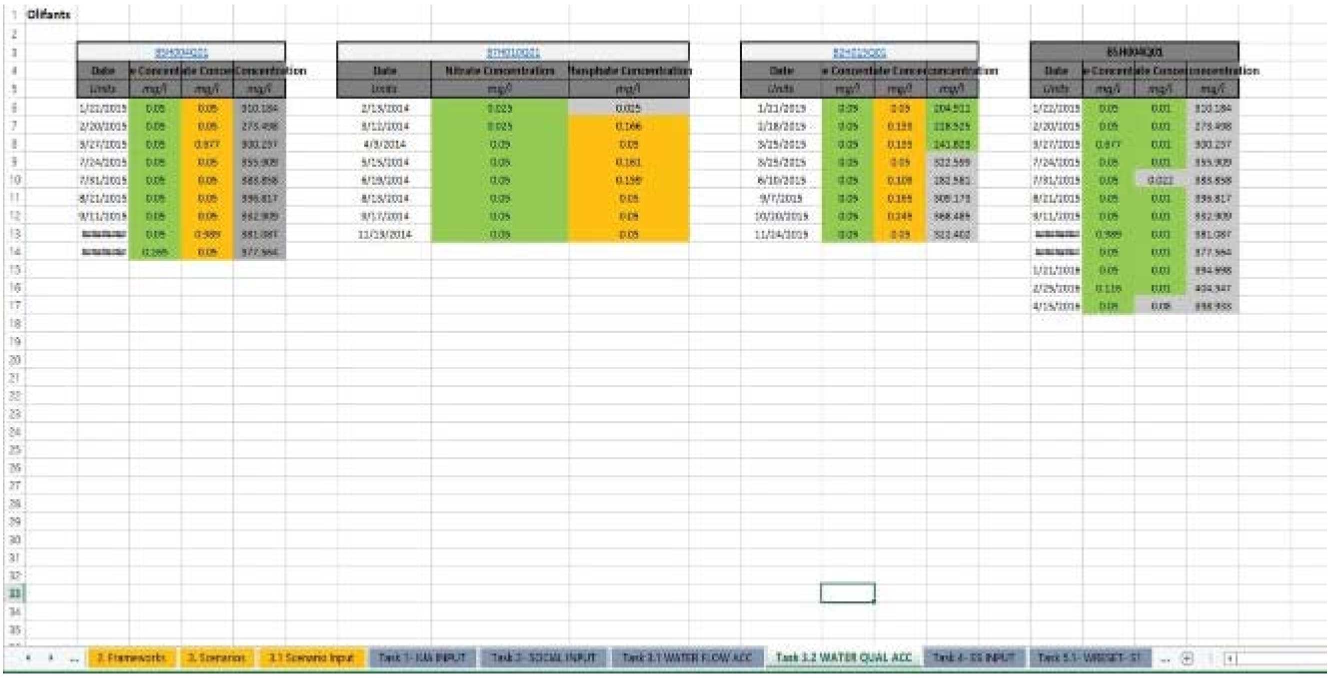

Figure 7-77: Water quality account of the Olifants WMA

7.4 Task 4. Develop an Inventory of Aquatic Ecosystem Services

Following on from Action 1, the purpose of this step was to identify the ecosystem services (ES) within the catchment at an IUA level and develop an idea of the demand of these services by communities and the economic sectors that utilize them.

7.4.1 Action 8. Identify the relevant ecosystem services within each IUA within the catchment

TEEB (2010) classification system was used to list relevant ecosystem service to be assessed Table 7-3.

Table 7-3: List of ecosystem services to be assessed

IUA	Beneficiary (12 Sectors)	Description of Benefit	Ecosystem Service (Teeb 2013)
6	Households	Use of raw materials for building	Raw Materials
6	Households	Informal grazing of cattle	Food
7	Agriculture	receive water from the wetland system	Fresh Water
2	Mining	Require relatively clean water for processes	Water Quality Regulation
2	Households	Grazing provided to local livestock owners	Food
2	Households	The collection of reeds and grasses for building and crafting purposes	Raw Materials
3	Households	The provisioning of water for use by households	Fresh Water
3	Households	The maintenance of water quality for household use	Water Quality Regulation
3	Tourism	The source of recreational activities for visitors	Ecotourism Recreation
6	Households	Use of raw materials for building	Raw Materials
6	Households	Informal grazing of cattle	Food
8	Society	The support of habitats and species especially within protected areas	Habitats for species

IUA	Beneficiary (12 Sectors)	Description of Benefit	Ecosystem Service (Teeb 2013)
8	Households	The provisioning of fresh water by local communities	Fresh Water
8	Society	The support of habitats and species especially within protected areas	Habitats for species
10	Tourism	Ecotourism provided to tourists by the numerous protected areas	Ecotourism Recreation
10	Society	The support of habitats and species in protected areas	Habitats for species
12	Society	The support of habitats and species especially within the Kruger National Park	Habitats for species
12	Tourism	The support of habitats and species especially within protected areas	Ecotourism Recreation
13	Finance, real estate and business services	The aesthetic value of the Blyde River Canyon increases property prices	Ecotourism Recreation
13	Households	Households benefit from the regulation of water quality	Water Quality Regulation

7.4.2 Action 9. Identify the ecological Infrastructure & supply of ecosystem services

The aim of this step was to identify the ecological infrastructure, which in turn supplies the flow of ecosystem services identified in Action 1. The output was a list of relevant ecological infrastructure to be assessed.

IUA	Resource Unit/Description	Ecological Infrastructure
1	Upper Olifants River:	River
	Upper Olifants River:	Wetland
		Lake
		GroundWater
2	Upper Olifants River: Segment 14 (Doringpoort	River
		GroundWater
		Wetland
		Lake
3	Upper Olifants River	River
	Klein Olifants river	Wetland
		GroundWater
4	Klein Olifants river- Segment 5	River

Figure 7-78: List of Ecological infrastructure per Resource Unit

7.4.3 Action 10: Ecosystem services are defined as the benefits that society receives from ecosystems

The identification of beneficiaries of ecosystem services was conducted at a desktop level in conjunction with relevant experts and using tools such as Google Earth and aerial photography (Table 7-4). This action would draw heavily on the outcomes of Task 2 and Task 3.

Table 7-4: List of beneficiaries of ecosystem services

1	Fresh Water	Mining	water use in coal mining
		Manufacturing	water use in Manufacturing
		Electricity and Water	water use in power production
		Households	People use water from catchment
	Food	Households	Harvesting from wetlands, grazing for cattle
	Raw Materials	Households	Collection of materials to construct homes
2	Fresh Water	Mining	Coal mining
		Agriculture	Dryland agriculture-low water use
		Households	Mostly poor households
	Food	Households	Grazing and harvesting service
3	Fresh Water	Agriculture	Highly rural catchment with high subsistence agriculture
		Households	Highly poor subsistence
	Food	Households	Harvesting and collection from Loskop dam (fishing)
	Raw Materials	Households	Collection of reeds and grass for crafts
	Medicinal Resources	Households	Collection of the devils claw
4	Fresh Water	Agriculture	Highly rural catchment with high subsistence agriculture
		Households	Highly poor subsistence household densities
	Ecotourism Recreation	Tourism	The Dinokeng and other reserves form a major tourism attraction

		Households	Local communities benefit through the tourism economy
	Raw Materials	Households	Raw materials are used to make crafts and art in the tourism industry

7.5 Task 5 Evaluate Scenarios

The objective of this task is to evaluate the selected scenarios within the socio-economic framework (Table 7-5).

Table 7-5: Selected Scenarios of Olifants WMA

Scenario		Description
1	Ecological Base Case	• The Present Ecological State (PES) was used as the ecological category • PES EWR low and maintenance flows were applied.
2	Recommended Ecological Reserve	• The recommended ecological category (REC) • REC EWR low and maintenance flows
3	Maximum use	• An ecological category of D • EWR low and maintenance flows.

7.5.1 Action 11: Comparative risk assessment

Through the CRA process, a list of ecosystem services at risk from the scenario would was generated (Table 7-6). The prioritised list contained a descriptive chain of causality for each ecosystem service/scenario interaction.

Table 7-6: List of ecosystem services at risk per scenario

Sc	IUA	Environmental Effect Statement
2	6	A reduction in PES will unlikely influence the mining Sector negatively. It is assumed that water allocations will remain constant thus not altering production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
2	6	A reduction in PES and corresponding decreased flow volumes will result in a reduced ability of rivers to provide raw building materials to communities. The Umvumvulu community is well known to source from local riparian systems.
2	6	It is unlikely that a drop in PES influence the tourism service provided by wetlands in Verloren Vallei Nature Reserve having a minor influence on the local economy and social wellbeing.
2	6	It is unlikely that reduced available water would impact on the irrigation of crops, however similarly to the mining Sector, it is assumed that water use is allocated for these purposes. Thus the consequences of the expected water loss (8%) would be minor.
2	6	Although it is possible that an 8% reduction in flow will negatively influence this service, the consequences will be minor as grazing is relatively localised to riparian zones.
2	6	Although it is possible that an 8% reduction in flow will negatively influence this service, the consequences will be moderate (higher than a river system) as grazing areas would be distributed over a larger area.
2	7	0
3	2	The flow for this scenario has been shown to almost double thus will not influence this Sector. A subsequent reduction in PES will unlikely influence the mining Sector negatively. It is assumed that water allocations will remain constant thus not altering production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	2	The flow for this scenario has been shown to almost double thus will not influence this SectCTor. A subsequent reduction in PES will unlikely influence the mining Sector negatively. It is assumed that water allocations will remain constant thus not altering production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	2	A twofold category drop in PES for wetlands will result in a substantial impact on water quality in the catchment, this will likely have an impact on the water used by the mining Sector of which consequences will be moderate.
3	2	The flow for this scenario has been shown to almost double and thus will not influence this Sector. The reduction in PES will unlikely influence the energy production Sector negatively. It is assumed that water allocations to this Sector will remain constant thus not altering production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	2	Grazing quality of riparian zones is highly dependent on the resilience and health of a system. A twofold drop in PES will likely have a major impact of the ability for river systems to provide this service. The high density of informal settlements in the region, especially those along the Wilge River, will be directly impacted.
3	2	A reduction in PES will result in a reduced ability of rivers to provide raw materials to communities. The communities along the Wilge River are known to source materials from corresponding wetlands for use in building and creation of products.

3	3	A twofold reduction in PES will unlikely influence agricultural crop irrigation negatively. It is assumed that water allocations will remain constant and even though there will be a reduction in flow this will not alter production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	3	The provisioning of water for informal use is highly dependent on the quantity of water available. A decrease inflow and subsequent twofold drop in PES will likely have a major impact of the ability for river systems to provide this service. The characteristic rural demographic with high density of poor to very poor communities residing in the region, will be directly impacted.
3	3	The regulation ability of water quality for informal use is highly dependent on the health of a system. A decrease inflow and subsequent twofold drop in PES will likely have a major impact of the ability for river systems to provide the water quality regulating service. The characteristic rural demographic with high density of poor to very poor communities residing in the region, will be directly impacted.
3	3	The storage of water in the dam will provides q water quantity service providing water throughout the year. A decreased flow would mean the maximum volume available would decrease. It is assumed that water allocations will remain constant and even though there will be a reduction in flow this will not alter production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	3	A twofold drop in PES at the Loskop Dam would have likely impacts on tourism of which the consequences would be major. A loss in ecosystem health would result in decreased visitors due to a loss of aesthetic and recreational ability.
3	6	A reduction in PES will unlikely influence the mining Sector negatively. It is assumed that water allocations will remain constant thus not altering production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	6	A reduction in PES will unlikely influence the mining Sector negatively. It is assumed that water allocations will remain constant thus not altering production. We assume that the size of the Sector remains unchanged therefore their demand for water remains constant.
3	6	A reduction in PES and corresponding decreased flow volumes will result in a reduced ability of rivers to provide raw building materials to communities. The Umvumvulu community is well known to source typha from local riparian systems.
3	6	It is unlikely that a drop in PES influence the tourism service provided by wetlands in Verloren Vallei Nature Reserve having a minor influence on the local economy and social wellbeing.
3	6	It is unlikely that reduced available water would impact on the irrigation of crops, however similarly to the mining Sector, it is assumed that water use is allocated for these purposes. Thus the consequences of the expected water loss would be minor.
3	6	Although it is possible that a 27% reduction in flow will negatively influence this service, the consequences will be minor as grazing is relatively localised to riparian zones. The subsequent loss in PES would also influence the health and productivity of the system.
3	6	Although it is possible that a 27% reduction in flow will negatively influence this service, the consequences will be major (higher than a river system) as grazing areas would be impacted over a larger area. The subsequent loss in PES would also influence the health and productivity of the system.
3	8	A drop in PES category and 26% drop in flow will possibly result in a moderate impact on the ability for rivers to support habitats and species. The Sterkspruit and Gustav Klingbiel Nature reserves will receive the bulk of these impacts.

3	8	There is a large proportion of households which fall into the poor to very poor demographic and are thus highly dependent on the water from associated rivers. A drop in ecosystem health and 26% decrease in flow will possibly impact these communities having major effects on the service.
3	8	A drop in PES category and 26% drop in flow will possibly result in a major impact on the ability for wetlands to support habitats and species. The Sterkspruit and Gustav Klingbiel Nature reserves will receive the bulk of these impacts.
3	8	Although a drop in PES category will possibly have an effect on medicinal plant provisions, the impacts will be minor as there is access to clinics in the region for local dependent communities.
3	10	It is unlikely that reduced available water would impact on the irrigation of crops, however it is assumed that water use is allocated for these purposes. Thus the consequences of the expected water loss on irrigation would be minor.
3	10	A drop in PES category and 38% drop in flow will likely result in a major impact on the ability for rivers to support habitats and species. The Bewaarkloof Nature Reserve and Wolkberg Wilderness Area will receive the bulk of these impacts.
3	10	A 38% drop in flow and subsequent reduction in PES will possibly result in a reduced ability of the system to support habitats and species. This reduction would have major impacts on the health of such a system especially within the protected areas of Bewaarkloof Nature Reserve and Wolkberg Wilderness Area.
3	12	This IUA is essentially a protected area (Kruger National Park). The reduction of river PES with therefore have a major effect on the support of habitats and species. This will influence the health of the system and thus influence dependent natural systems.
3	12	It is possible that a drop in PES will influence the tourism service supported by rivers in Kruger National Park having a moderate influence on the state of dependent ecosystems and wildlife. Visitors to the Kruger National Park are dependent on the aesthetic and wildlife viewing experience of which would be altered with altering state of the system.
3	13	The value of real estate along the Blyde River catchment is dependent on the aesthetic and quality of the associated system. A twofold drop in PES of the incoming river system would possibly have a major effect on property prices. This is especially true for real estate with a direct view of the catchments river systems.
3	13	A twofold category drop in PES for wetlands will result in a substantial impact on water quality in the catchment, this will possibly have an impact on the water used by dependent households of which consequences will be moderate.

7.5.2 Action 12: Link ecosystem services to socio-economic well-being

Economic analyses was used to estimate the relative economic changes (differences) that will be caused by the identified scenarios on a catchment and macro-economic scale (Table 7-7).

Table 7-7: Economic analyses per scenario

Scenario		Description	GDP Impact (%)
1	Ecological Base Case	• The Present Ecological State (PES) was used as the ecological category • PES EWR low and maintenance flows were applied.	0.00%
2	Recommended Ecological Reserve	• The recommended ecological category (REC) • REC EWR low and maintenance flows	-4.60%
3	Maximum use	• An ecological category of D • EWR low and maintenance flows.	4.59%

7.6 Summary

The final objective was to evaluate the selected scenarios within the socio-economic framework. These changes were compared per scenario through use of the SeCT. In the pilot, the three scenarios were on two main indicators, GDP Impact and Ecosystem Services Risks (Table 7-8).

Table 7-8: Summary of economic analysis and ecosystem at risk per scenario

Scenario		Description	Ecosystem Services Risks	GDP Impact (%)
1	Ecological Base Case	• The Present Ecological State (PES) was used as the ecological category • PES EWR low and maintenance flows were applied.	0	0.00
2	Recommended Ecological Reserve	• The recommended ecological category (REC) • REC EWR low and maintenance flows	13%	-0.05
3	Maximum use	• An ecological category of D • EWR low and maintenance flows.	73%	0.05

The Ecological Base Case, as would be expected, results in no change to the socio-economic system. The Recommended Ecological Reserve scenario, through its improvement the ecological system, would have negative impacts on the economy (reduced water to sectors) as well as slightly reduced ecosystem services to the socio-economy. The Maximum Use scenario results in a larger economy as measured by GDP through the increased economic activity supported by water use. In turn, the scenario also has the largest Ecosystem Services Risk because over the decreased water flow as well as water quality and ecological states.

This information is then available for use in Step 5 of the classification process, which is “Evaluate scenarios within the integrated water resource management process”. In this consultative process economic, social and ecological trade-offs will be made within existing lawful use and with consideration of equity.

8 APPENDIX 2: DETAILED STEPS IN THE 7-STEP CLASSIFICATION PROCEDURE

GNR 810 prescribes a 7-step procedure to recommending the MC of a resource (the outcome of the Classification Process). The seven steps and their sub-steps are (DWS, 2007a):

Step 1: Delineate units of analysis and describe the status quo; including:

a) Describe present socio-economic status of the catchment.
b) Divide catchment into socio-economic zones.
c) Identify a network of significant resources, describe water resource infrastructure and identify water user allocations.
d) Define a network of significant resources and establish biophysical nodes.
e) Describe communities and their wellbeing.
f) Describe and value the use of water.
g) Describe and value the use of aquatic ecosystems.
h) Define Integrated Units of Analysis (IUAs).
i) Develop and/or adjust the socio-economic framework and the decision-analysis framework.
j) Describe present-day community wellbeing within each IUA.

Step 2: Link value and condition; including:

a) Rationalize the choice of ecosystem values to be considered based on ecological and economic data.
b) Describe the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and the Sectoral use of water.
c) Define the scoring system for scenario evaluations.

Step 3: Quantify Ecological Water Requirements (EWRs) and changes in nonwater quality Ecosystem Goods, Services and Attributes (EGSAs); including:

a) Identify nodes to which Resource Directed Measures (RDM) data can be extrapolated and extrapolate.
b) Develop rule curves, summary tables and modified time series for nodes for all categories.
c) Quantify the changes in relevant ecosystem components, functions and attributes for each category for each node.

Step 4: Set Ecological Sustainability Base Configuration (ESBC) scenario and establish starter configurations; including:

a) Set ESBC scenario and screen for water quantity, quality and ecological feasibility.
b) Incorporate planning scenarios (future use, equity considerations, existing lawful use, etc.).
c) Establish RDM catchment configuration scenarios.

Step 5: Evaluate scenarios within the Integrated Water Resource Management (IWRM) process

Steps 5 and 6 form part of the 'Larger Process' where the economic, social and ecological trade-offs will be made. Trade-offs will also need to be made between existing lawful use.

(ELU) and equity considerations. Emerging from this 'Larger Process' will be the recommended MC, RQOs and Reserve, CMS, allocation schedule, modelling system and the monitoring, auditing and compliance strategy. A number of key questions will need to be addressed in this 'Larger Process'. These include:

- at what level will the trade-offs be negotiated?
- in what institutional setting will they be negotiated?

- what types of scenarios will inform the process of negotiation?; and
- the recommended MC, Reserve, RQOs, CMS and allocation schedule will impact on specific groups of people, so the key question will be who benefits and who pays the social and economic cost?

These key questions should be framed (and assessed) in the context of equity, efficiency and sustainability as required by the NWA, and by the core objectives of the present government which are, amongst others, to '…halve poverty and unemployment by 2014', reduce the regulatory burden on small and medium businesses and eliminate the second economy[1]. Step 5 should therefore contribute to meeting government's objective of '…reduce(ing) inequality and virtually eliminating poverty'[2]. Step 5 will therefore include:

a) Run yield model for ESBC and Other catchment configuration scenarios and adjust if necessary.
b) Assess water quality implications (fitness for use) for all users.
c) Report on ecological condition and aggregate impacts per IUA for each scenario.
d) Value changes in aquatic ecosystems and water yield.
e) Describe macro-economic and social implications of different catchment configuration scenarios.
f) Evaluate overall implications at an IUA-level and a regional-level.
g) Select a subset of scenarios for stakeholder evaluation.

Step 6: Evaluate scenarios with stakeholders; including:

a) Stakeholders evaluate scenarios and agree on short-list.
b) DWS recommends IUA classes.

Step 7: Gazette class configuration; including:

a) Populate summary template and present to Minister or delegated authority.
b) Minister decides on IUA classes, nested category configurations, Reserve(s), allocation schedule(s) and Catchment Management Strategy (CMS).
c) Recommend Resource Quality Objectives (RQOs).
d) Gazetted IUA classes and nested category configurations and RQOs.

Develop plan of action for implementation of recommended scenario.

9 APPENDIX 3: SOCIO-ECONOMIC WRCS STUDIES

(Available from DWS website (DWS, 2015))

Olifants Water Management Area

- Economy of the Olifants WMA – May 2011
- Socio-Economic Framework – July 2011 [PDF - 5.2 MB]
- Report on the Socio-Economic Evaluation and the Decision Analysis Framework – July 2011 [PDF - 5.2 MB]

Vaal Water Management Areas (Upper, Middle and Lower)

- None

Olifants Doorn Water Management Area

- Socio Economic Impact on Irrigation – April 2012
- Olifant Doorn Socio Economic Report – April 2012 (sic)
- Socio econ [PDF - 7 MB]

Letaba Project

- Socio-economic flow scenarios

Letaba Water Management Area

- Economic Status
- EGSA Status
- Letaba Catchment: Macro Economic
- Overview of the Multi-Criteria Decision Support System to evaluate scenarios and identify draft Management Classes

Mokolo/Matlabas Catchment: Limpopo WMA and Crocodile (West) Marico WMA

- Appendix C – Socio-economic Modelling
- Appendix E – Scenario Evaluation

Mvoti-Umzimkulu WMA

- EGSA Consequences
- Macro-Economic Consequences
- Ecosystem Services Consequences
- Economic Consequences
- Ecosystem Services
- Economic Consequences
- Mvoti Ecosystems Services Consequences Report

Inkomati Water Management Area

- Socio-econimics Presentation (sic)
- Ecosystem Services Consequences
- Economic Consequences

Breede-Gouritz WMA and Berg Catchment

- None

10 APPENDIX 4: ECOSYSTEM SERVICES

The MEA (2010) and TEEB (2013) define ecosystem services as the direct and indirect contributions of ecosystems to human well-being. They distinguish between four types of ecosystem services: provisioning, cultural, regulating and supporting services.

Provisioning services describe the material or energy outputs from ecosystems. Cultural services include the non-material benefits people obtain from contact with ecosystems. Regulating services are the services that ecosystems provide by acting as regulators. They control and normalise ecosystem functioning and thus insures the benefits supplied by ecosystems (MEA 2005; Barbier *et al.* 2009, Barbier *et al.* 2011).

Regulating services play an indirect role in the economy, and mitigate environmental risk. Supporting services underpin almost all other services through its function of providing living spaces for humans, plants and animals. Examples of these services, relevant to aquatic ecosystems, may include:

- Climate regulation. Ecosystems influence climate both locally and globally. For example, at a local scale, changes in land cover can affect both temperature and precipitation. Wetland or estuarine ecosystems can act as carbon sinks. At the global scale, ecosystems play an important role in climate by either sequestering or emitting green-house gases.
- Water regulation. The timing and magnitude of runoff, flooding, and aquifer recharge regulate water provisioning in a system.
- Erosion control. Vegetative cover plays an important role in soil retention and the prevention of landslides.
- Water purification and waste treatment. Ecosystems can be a source of impurities in fresh water but also can help to filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems.
- Regulation of human diseases. Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes.
- Biological control. Ecosystem changes affect the prevalence of pests and diseases.
- Pollination. Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators.
- Storm protection. The presence of coastal ecosystems such as mangroves and coral reefs can dramatically reduce the damage caused by hurricanes or large waves.

Supporting services are those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. Some examples of supporting services are primary production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.

The key benefit of the MEA/TEEB framework is that it allows investigators to systematically unpack a development problem into its ecosystem attributes and the ecosystem services dependent on them.

10.1.1 Ecosystem services, biodiversity and ecological infrastructure

Another important aspect of the MEA framework of ecosystem services is that it implicitly links biodiversity to the economy and to human well-being. The term ecosystem has been defined as a natural unit consisting of all plants, animals and micro-organisms (biotic components) in an area functioning together with all of the non-living physical (abiotic) factors of the environment (Christopherson 1996). Biodiversity is the living component of the ecosystem. Accordingly, the ecosystem is interpreted in the MEA to represent a portfolio of abiotic and biotic assets that produce a specific set of ecosystem services, which are of benefit to human well-being. Biodiversity is described by Noss (1990) more than simply the number of genes, species, ecosystems, or any other group of things in a defined area. Noss (1990) rather favors a characterization of biodiversity that identifies the major components at several levels of organization which includes composition, structure, and function.

The valuation of biodiversity-based services thus requires more than the valuation of the diversity itself, as for instance in the case of ornithological or botanical tourism, or bio-prospecting. In most cases the value of biodiversity is indirect, or embedded in the provisioning or cultural services that are ultimately consumed (Kinzig *et al.* 2007). Water resources is a form of ecological infrastructure. The South African National Biodiversity Institute (SANBI, 2014) describes ecological infrastructure as a network of natural assets "*that conserve ecosystem values and functions and provide associated benefits to society*".

Thus, if we are to understand and enhance the resilience of such coupled systems we need robust models of the linkages between ecological infrastructure, biodiversity and ecosystem services and between biodiversity change and human well-being (Kinzig *et al.* 2007).

10.1.2 The Economics of Ecosystems and Biodiversity (TEEB)

TEEB is an international initiative to draw attention to the benefits of biodiversity. It focuses on the values of biodiversity and ecosystem services, the growing costs of biodiversity loss and ecosystem degradation, and the benefits of action addressing these pressures. The TEEB initiative has brought together over five hundred authors and reviewers from across the continents in the fields of science, economics and policy (TEEB 2013).

The TEEB initiative can be viewed as the next step in ecosystem service understanding and builds on the MEA by providing a focussed approach for dealing with the costs of biodiversity loss and how this impacts society.

10.1.3 Final Ecosystem Goods and Services Classification System (FEGS-CS)

The Final Ecosystem Goods and Services Classification System (FEGS-CS) was developed by the US Environmental Protection Agency (US EPA) towards providing a comprehensive framework for the evaluation of ecosystem services (Macnair et al., 2014). The FEGS-CS builds on the MEA and TEEB, similarly defining Final Ecosystem Goods and Services FEGS as "components of nature that are directly enjoyed, consumed, or used to yield human well-being." The goal of FEGS-CS is to "Identify, measure, and quantify FEGS in a scientific, rigorous, and systematic way that can be aggregated from local to regional and national scales" (Macnair et al., 2014). In other words, it attempts to accurately identify and value contributions of ecosystem services toward economic well-being. To this end, FEGS-CS takes one step forward from the MEA as it classifies natural resources into FEGS which have corresponding environmental classes (which indicate the source components of nature) and beneficiary classes (which indicate the beneficiaries of well-being). Various combinations of these classes depending on the beneficiary will result in 358 unique FEGS codes which will ultimately all be valued, thus identifying an ecosystems contribution towards a range of specific beneficiaries. The premise is that specific Sectors can be attributed with the benefits received from ecosystems and these benefits be quantified and valued. This would allow for the understanding of environmental contributions toward socio-economic wellbeing.

The operation of the SeCT required identification of ecological infrastructure and its corresponding ecosystem services. For these purposes a framework linking ecological infrastructure to ecosystem services was derived from TEEB (2013) and FEGS-CS (2013) shown in (Table 10-1). This framework is included as a guide in the SeCT.

Table 10-1: Ecosystem services with corresponding water resources as defined by FEGS and TEEB 2013)

Category	Ecosystem Services (TEEB 2013)	FEGS (2013) TEEB (2013)	Water Resource- As defined by NWA Act 36 of 1998					
			Waterway (River/Strea	Wetland	Aquifer	Surface Water (Dam/	Estuary and near coastal	Open oceans and seas
Provisioning	Food	Fauna	x	x		x	x	x
		Flora						
	Fresh Water (Water quantity)	Water	x	x	x	x		
	Raw materials	Fibre	x	x		x	x	x
		Natural materials						
	Medicinal resources	Flora	x	x		x	x	x
		Fauna						
Regulating	Climate/climate change regulation	Carbon sequestration/storage	x	x			x	x
		Microclimate regulation						
	Water quantity regulation	Floods	x	x	x	x	x	x
		Droughts						
	Water purification & waste management:	Water purification	x	x		x	x	x
		Waste assimilation						
	Erosion control/ Soil stability	Erosion control	x	x		x	x	x
		Soil fertility maintenance						
	Biological control	Pests and disease	x	x		x	x	x
Support	Habitats for species	Habitats for species	x	x		x	x	x
	Maintenance of genetic diversity	Maintenance of genetic diversity	x	x		x	x	x
Cultural	Landscape & amenity values	Presence of environment	x	x		x	x	x
		Viewscapes						

Category	Ecosystem Services (TEEB 2013)	FEGS (2013) TEEB (2013)	Water Resource- As defined by NWA Act 36 of 1998					
			Waterway (River/Strea	Wetland	Aquifer	Surface Water (Dam/	Estuary and near coastal	Open oceans and seas
	Ecotourism & recreation	Presence of environment	x	x		x	x	x
		Fish						
		Water						
	Educational values and inspirational services	Presence of environment	x	x		x	x	x
		Sounds and scents						
		Natural materials						