DEVELOPMENT OF A SYSTEM DYNAMICS MODEL FOR THE IMPLEMENTATION OF IWRM IN SOUTH AFRICA: PHASE I – DERIVING PERFORMANCE INDICATORS FOR IWRM IMPLEMENTATION ON A CATCHMENT SCALE

Report to the
Water Research Commission

by

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List of Acronyms

BID	Background Information Document
BMR	Baviaanskloof Mega Reserve
C.A.P.E	Cape Action for People and the Environment
CMA	Catchment Management Agency
CMC	Catchment Management Committee
CMF	Catchment Management Forum
CMP	Catchment Management Plan
CMS	Catchment Management Strategy
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EC DWAF	Eastern Cape Department of Water Affairs
ECPB	Eastern Cape Parks Board
ERI	Ecological Reserve Implementation
FOBWA	Friends of the Baviaanskloof Wilderness Area
GIB	Gamtoos Irrigation Board
ICM	Integrated Catchment Management
IEWA	International Environmental for Water Allocation
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resources Management
MOU	Memorandum of Understanding
NGO	Non-governmental Organisation
NWA	National Water Act: Act 36 of 1998
NWRS	National Water Resource Strategy
PES	Payment for Ecosystem Services
PMS	Performance Management System
PRESENCE	Participatory Restoration of Ecosystem Services & Natural Capital, Eastern Cape
RDM	Resource Directed Measures
RPMS	Regulatory Performance Management System
RQO	Resource Quality Objectives
RWU	Regulating Water Use
SANBI	South African National Biodiversity Institute
SDC	Source Directed Controls
SDM	Source Directed Measures
SMME	Small, Medium & Micro Enterprises
SSM	Soft Systems Modelling
WAP	Water Allocation Plan
WMA	Water Management Area
WRC	Water Research Commission
WRP	Water Resource Protection
WRSA	Water Resource Situation Assessment
WSDP	Water Services Development Plan
WUA	Water Users Association

1 INTRODUCTION

Jeffares & Green (Pty) Ltd has been appointed by the Water Research Commission of South Africa to undertake the Development of a System Dynamics Model for the Implementation of IWRM in South Africa (WRC project number K5/1911). The first Phase of the overall three Phase project commenced on 1 April 2009 and will terminate on 31 May 2010. This Phase of the project involves the Deriving of Performance Indicators for IWRM Implementation on a catchment scale. The catchment that was chosen as a case study area is the Baviaanskloof Mega Reserve (BMR) area.

The key project focus in Phase I was to gather all existing data and information on river catchments within the Baviaanskloof Mega Reserve case study area, to identify key stakeholders and to engage active participation from willing collaborators able to assist in developing a comprehensive catchment management model for the area. The model needs ultimately to serve the purpose of identifying key performance indicators that are easily measurable for the purposes of long term sustainable management of the Baviaanskloof Mega Reserve catchment. It is envisioned that the project would contribute greatly to the establishment of an integrated Catchment Management Strategy and Plan to be implemented by Irrigation Board(s) and/or WUA[1] as well as the future CMA.

The Baviaanskloof Mega Reserve was selected as a study area based, amongst other reasons, on the fact that a project of this nature should preferably be launched at a Water Management Area (WMA) or Catchment Management Agency (CMA) scale. Furthermore it is advantageous to initiate the project in a catchment for which ample information is available and/or where various synergistic projects and/or activities are already in progress with which to collaborate. The Jeffares & Green (Pty) Ltd study team have recently (July 2009) completed an Ecological Reserve Determination study in the Baviaanskloof Mega Reserve area for the C.A.P.E. Ecological Reserve Implementation (ERI) programme and during this study a fair amount of current and historical information was collected. (See picture: J&G team together with members from EC DWAF and EC Parks). In addition to the information gathered, a number of active role players, projects and programmes were identified which are synergistic to the current project.

2 PURPOSE OF THIS DOCUMENT

This Final Report aims to present the final results of Phase I of the project as well as suggestions for the way forward in Phase II. The final report will integrate the results that were presented in Deliverables 1-8.

3 MOTIVATION FOR THE PROJECT

The National Water Resources Strategy (NWRS, DWAF, 2004a) states that *"The need for an integrated approach to water resources management is discussed in the National Water Policy. It is also explicitly acknowledged in the Preamble to the Act, which recognises that water occurs in many different forms which are all part of a unitary, inter-dependent cycle. The Preamble also recognises the need for the integrated management of all aspects of*

[1] The Gamtoos Irrigation Board has been in the process of establishing a WUA. This process is still ongoing to the best of our current knowledge. To date no CMA has been established for the WMA, only a proto-CMA.

water resources." It goes further to say that *"There is increasing understanding internationally that water resources can be successfully managed only if the natural, social, economic and political environments in which water occurs and is used are taken fully into consideration."*

According to the NWRS (DWAF, 2004a) integrated water resources management (IWRM) can be defined as *"a process which promotes the co-ordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."* This means that IWRM therefore aims to strike a balance between the use of resources for livelihoods and conservation of the resource to sustain its functions for future generations. It also means that the implementation of IWRM promotes social equity, environmental sustainability and economic efficiency which form the basis of sustainable development. It therefore seems pertinent that, to adhere to stated requirements of the National Water Act as well as the concept of sustainability as an environmentally sound principle, an integrated approach to water resources management is essential.

3.1 Why is there a lack of integrated water resources management in SA?

IWRM is a logical and intuitively appealing concept. At its core lies the appreciation that the many different uses of our finite water resources are highly interdependent and that the sustainable development, allocation and monitoring of water resource use needs to take into account social, economic and environmental objectives. Then why, if IWRM makes such logical sense and is seemingly applied so widely, do we not see the results in the water sector that we might have envisaged.

The answers to this question are many and varied, however it has been proposed countless times that non-optimal water governance and lack of integration are key issues of concern with far reaching impacts on all aspects of IWRM. Sectoral approaches to WRM still often prevail, which leads to fragmented and uncoordinated development and management of our valuable water resources. Barriers to the successful implementation of IWRM include amongst others the following key concepts which have particular relevance to the proposed study:

- Failure of individual water use sectors to engage meaningfully with other sectors
- Models for integration are not based on a systemic approach / "big picture" view
- Lack of integration in tools, policy and systems to implement IWRM optimally
- Conflict between decentralisation and the desire to maintain central power
- Difficulty of getting large, diverse stakeholder groups to interact meaningfully

3.2 Why use systems modelling as an approach to optimise IWRM in SA?

Freshwater ecosystems are complex ecological systems that comprise a number of highly interdependent components all linked in a continuous cycle, namely the hydrological cycle.

Not only is each component of the freshwater ecosystem therefore able to exert an influence on any other component, but freshwater as a system also interacts with other systems. Human activities such as land use, waste disposal and air pollution can have major impacts on the quantity and quality of water available for human use, while the abstraction and storage of water and the discharge of waste into water resources can impact on the quality of the natural environment. This multitude of interacting components as well as the potential interactions between them must be considered and addressed holistically by water resource

managers. Water must also be managed with its crucial social, political and economic importance in mind. The complexity of managing water resources is further compounded by the large number of domestic and international institutions and organisations involved in the administration and management of the various systems. (DWAF, 2007)

It is therefore clear that water resource systems consists of a number of individual entities, all connected to each other in various ways and that the behaviour of the system can only be understood when considering it as a whole, i.e. all the individual entities together with all their interrelationships. It is also necessary to manage the constituent biophysical, socio-political and economic sub-systems of a water resource in a sustainable integrated manner (Campbell *et al*., 2001). Systems modelling and Systems Thinking has in recent times seen the integration of so-called "hard" with "soft" sciences. This allows for its application to all aspects of IWRM, which includes both "hard" sciences such as ecosystem structure and function as well as "soft" sciences such as institutional arrangements, legal instruments, poverty alleviation, and gender equity. A further aspect of Systems Modelling that sets it apart from most other methods of IWRM optimisation is that it can accommodate the intrinsic dynamicity that forms part of all integrated management systems and which is especially relevant to IWRM in SA.

Furthermore optimal water resource management requires the ability to measure performance in a system. To achieve this, key system variables indicative of the behaviour of the overall system need to be identified. These key variables may be referred to as performance indicators (Campbell *et al.,* 2001). In terms of performance indicators IWRM initiatives in SA currently focus on the derivation of ecosystem health indicators (RQOs) as management tools. They are especially popular due to their ease of use and the ease with which results of ecosystem (health) assessments may be conveyed to resource managers. However, recent thinking suggests that the best approach for deriving comprehensive indicator sets (a set of indicators that maximally describes the behaviour of the system), involves developing systems models (Bossel, 2001).

Finally, where most approaches to optimising IWRM take into account the most obvious components of a system, i.e. the direct observables or distinct entities comprising it they often do not adequately consider the relationships between these entities, which are critical to the behaviour of the system as a whole. The entities within e.g. an IWRM system are greatly interconnected, such that an impact on any component of the system registers as an impact on the entire system, being all the other components and their relationships. It is therefore necessary to implement an approach that can accommodate such complexity and system dynamics modelling (SDM) is advocated here as such an approach.

As indicated above, to understand a system, it has to be viewed in its entirety. While this may be impractical in the "real" world, it is entirely possible to achieve a functional representation of a system through a process called Systems Modelling. In this process, the techniques of Systems Thinking are used in order to develop a Systems Diagram. Systems Diagrams are representations of systems that aid in the qualitative understanding of impacts on a system by perturbations. Systems Diagrams also act as functional templates for the development of System Dynamics Models that are used in the more accurate prediction of impacts through scenario development.

In addition to the mentioned virtues of SDM in the optimisation of IWRM, there are other less obvious intrinsic benefits of using the proposed approach which relates to stakeholder involvement, "buy-in" and sense of ownership. Soft systems modelling (SSM) which is an approach that will be implemented extensively, particularly in the initial stages of the project, greatly facilitates the constructive participation of stakeholders from all sectors and levels of society, which has also been flagged as a major challenge within IWRM in SA.

4 PROPOSED BENEFITS OF THE PROJECT

The proposed project ultimately aims to produce a systems-based decision support tool for optimising the implementation of IWRM in a manner that delivers the results that are implicitly expected and explicitly required in order to maintain the ecosystem goods and services as well as the water-use demands by current and future generations. The following has been identified as potential benefits ensuing form the execution of the project as it relates to each of the main contributing elements to sustainability in the water sector:

4.1 Society

Optimisation of IWRM implementation has wide reaching social impact since water is a critical component of society in innumerable ways including but not limited to, health and wellbeing, peace and prosperity, as well as culture and religion. Successful implementation of IWRM is critical to the maintenance of all manner of societal structures and has special relevance in water-scarce and developing countries such as South Africa. The underlying concept of sustainability on which the proposed approach is based explicitly addresses the relevant societal aspects within the ambit of the project.

4.2 Economy

All economies of the world are intricately enmeshed with water. No economy can survive and/or prosper without it. Successful implementation of IWRM is of particular importance in water-stressed and developing countries. Managing the quality and quantity of South Africa's water in a holistic and sustainable way has become critical and urgent and there is an indisputable need for new and/or improved approaches to IWRM implementation. As with societal aspects, economy is included explicitly as part of the sustainability triangle.

4.3 Health

Water is key to human health and existence. In South Africa this aspect is addresses explicitly through the concept of "water for basic human needs" (which translates to 25 litres of water per capita per day) that is included in the National Water Act. It has also been found in various social impact studies that providing less than the basic human need in water, leads to various related health problems in the relevant communities. These health issues in turn translate into huge amounts of capital losses due to all manner of medical expenditure and incapacitation. Due to the integrative approach proposed for successfully addressing IWRM, human health aspects are implicitly included.

4.4 Environment

The fundamental premise on which the project is based is that of Integrated Natural Resources Management which has as its primary objective, the protection of the environment from which society receives certain ecological goods and services. The primary project objective is to optimise the integration of all aspects of water-use and protection within the project environment and in so doing ensure the sustainable utilisation of our country's scarce and valuable freshwater resources.

Another key benefit of the proposed approach is that it aims to ultimately facilitate the integration of all relevant existing national systems, tools, information, knowledge, data, etc. into a centralised (electronic) system in order to optimise coordination and synergy between this multitude of IWRM-related activities.

5 AIM OF THE STUDY

The following aims have been identified for Phase I of the overall study:

- Optimisation of the approach to Integrated Water Resource Management
- Fostering of successful co-operative governance in the study area
- Synergising existing research and other related initiatives within the study area
- Development of a comprehensive stakeholder/information database for the study area
- Derivation of a preliminary set of IWRM performance indicators and/or criteria
- Initiation of a performance management system for IWRM in the study area
- Information dissemination and knowledge creation in the study area
- Establishing a firm foundation for the development of an integrated CMS

6 STUDY AREA

6.1 Study area selection

It is advisable to launch a project of this nature at a Water Management Area (WMA) or Catchment Management Agency (CMA) scale and preferably in a fairly small catchment. Furthermore it is advantageous to initiate the project in a catchment for which ample information is available and/or where various synergistic projects and/or activities are already in progress with which to collaborate. The study team have recently completed an ecological Reserve determination study in the Baviaanskloof Mega Reserve area. During this study a fair amount of current and historical information was collected and a number of issues that are negatively impacting on the health and management of the area's water resources were identified. These largely centred around issues related to poor catchment management and over allocation and use of water.

In addition, a number of active role players, projects and programmes were identified which are synergistic to the current project. For these reasons it was decided to use the Baviaanskloof Mega Reserve area as the study area for the project.

6.2 Study area description

Baviaanskloof means "Valley of Baboons" and is situated between the Baviaanskloof and Kouga mountain ranges in the western region of the Eastern Cape (Boshoff, 2005). The Baviaanskloof area is an ecosystem hotspot containing seven different biomes, namely: Fynbos, Subtropical Thicket, Nama-karoo, Succulent Karoo, Grassland, Savanna and Forest (ECPB, 2007). The Baviaanskloof area contains a cluster of formal protected areas including the Baviaanskloof Nature Reserve. This reserve is the third largest protected area in South Africa and was awarded World Heritage Site status in 2004 because of its rich biodiversity (Boshoff, 2005).

The Baviaanskloof Nature Reserve itself has more than 1100 species of plants with 20 of those known to be endemic and 52 species been listed as Red Data species (ECPB, 2007). The Baviaanskloof Mega-Reserve (BMR) Project came into being in 2002 (Boshoff, 2005). A mega reserve is a landscape wide conservation initiative that covers an area large enough

to encompass landscape scale climatic gradients and topographical variations and a wide range of habitat types or biomes. A mega reserve would also include whole or large portions of river catchments so that water and soil resources could be conserved at a landscape scale (Anonymous, 2004).

According to Boshoff (2005) it is envisioned that the Baviaanskloof Mega Reserve would encompass the following:

- A gradient from the arid Nama-karoo to moist fynbos and forest
- Much of the Groot-Baviaanskloof-Kouga riverine (migratory) corridor
- Habitats such as grassland and moist subtropical thicket that is restricted to the eastern sector of the Cape Floristic Region

The aim of the BMR project is to (Boshoff, 2005):

- Conserve the areas biodiversity.
- Protect its critically important role of providing water.
- Promote sustainable economic development opportunities based on the natural assets of the area.

The objectives set to reach these goals include the following (Boshoff, 2005):

- Securing a large consolidated core formal protected area.
- Establishing a multi-owner contractual reserve network around the core area in which different land-use patterns and forms of conservation status are reconciled and aligned with biodiversity conservation initiatives.
- Managing the mega-reserve network through a partnership between government, the private sector and civil society.
- Realising prospects for improving the livelihoods of people living in the rural parts of the region.
- Exposing people to sustainable ways of using the area's natural resources, and incentivising their adoption.

It is envisioned that the mega-reserve will cover an area of approximately around 500 000 ha comprising the cluster of state-owned protected areas within a network of private and communal land. The private land owners that are included within the mega-reserve will have to align their land-use activities with the principles and practices of biodiversity conservation (Boshoff, 2005).

Another objective of the mega reserve is to establish a biodiversity corridor that links the mountains to the sea. The Kouga, Baviaanskloof and Groot Rivers meet to the south-east of the Baviaanskloof to form the Gamtoos River which meanders across the coastal plain towards the sea.

This Gamtoos Valley forms a natural link between the mountains in the interior and the coast. The conservation of this valley would allow for the conservation of animals and plants and allows for their movement in response to climate changes (Boshoff, 2005).

The irrigation and land-use occurring within the Gamtoos River basin can be divided into three catchments namely: the Groot River catchment, the Kouga River catchment and the Gamtoos River catchment.

The Groot River catchment lies entirely in the Karoo and therefore the main land use is rough grazing for sheep with some irrigation occurring for crops being grown. (DWAF, 2002)

In contrast, the Kouga River catchment rises in the Langkloof where the fertile valley floor has soils that are intensively cultivated, mainly for deciduous fruit orchards. The Baviaanskloof River is the main tributary of the Kouga River and the upper portion of this valley is a nature reserve. Some land in this area is irrigated mainly for pasture. (See picture).

Within the Gamtoos River Catchment, various crops are grown, such as vegetables, citrus, lucerne and tobacco. Approximately 56 km2 of land in this river valley downstream is irrigated from canals which carry water from the Kouga and Loerie Dams. (See pictures).

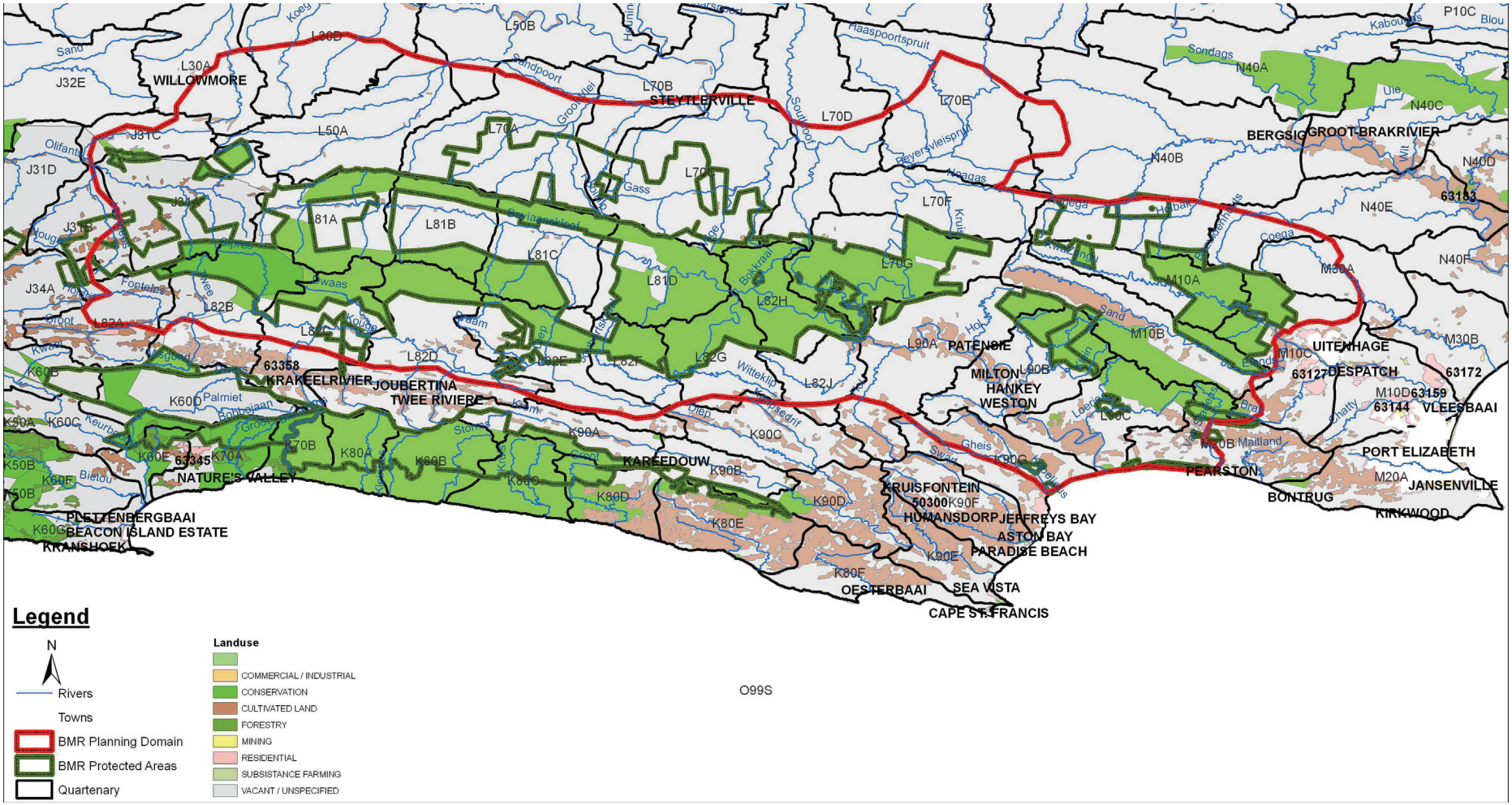

Figure 1: Study area showing the boundaries of the proposed Baviaanskloof Mega Reserve as well as formal protected areas and other landuses

7 APPROACH

Integrated Water Resources Management should progress through a number of stages and although the process is more iterative than sequential, the following broad stages have been identified within in the full process (reference is made specifically to the steps involved in developing and implementing catchment management in SA as legislated by the NWA):

Stage 1 involves identifying where we are (structuring the problem situation), where we want to be (developing scenarios for improving the problem situation), what the road signs are (defining performance measures such as indicators of *Effectiveness* – Are we doing the right things?, *Efficacy* – Is what we are doing working?, and *Efficiency* – Are we using the minimum amount of resources to get things done?) and what we need to do to get there (defining the changes needed to improve the problem situation {e.g. a CMS})

Stage 2 entails how we are going to do what is needed to get where we want to be (defining the actions needed to improve the problem situation {e.g. a CMP or WAP}).

Stage 3 is about taking action (e.g. compulsory licensing, catchment restoration and/or rehabilitation, water use registration, etc.) through implementing the WAP and/or CMP in order to improve the problem situation.

Stage 4 involves how we now when we get where we want to be (measuring indicator compliance to criteria {e.g. RQOs} through monitoring resource status).

Stage 5 is about ensuring that once we reach our goal we stay where we wanted to be (ensuring indicator compliance to criteria {e.g. RQOs} through monitoring compliance).

The overall project is aimed at explicitly addressing *Stage 1* of the IWRM process[2] with the main objective of assisting the proto-CMA and/or CMA to develop a Catchment Management Strategy and Plan for the purposes of successful IWRM implementation.

According to the NWA a catchment management strategy (CMS) is established in a phased and progressive manner and in separate components over time (DWAF, 2007). The project is therefore conducted in a phased manner of which this study forms Phase 1. The overall project will entail *three phases* namely:

I. Deriving performance indicators for IWRM implementation on a catchment scale
II. Pilot implementation and design of the Performance Management System (PMS)
III. Integration of national information management systems with the PMS. (Please note that this Phase is dependent on the progress of implementation of national management systems and may not be possible in the short term. As a result, the team will not submit a Phase III proposal in 2010, but will assess the status of national systems during the course of Phase II and possibly amend Phase III if necessary.)

These phases are however not completely distinct as aspects of the pilot programme and the PMS will be initiated during Phase I. This inception report will focus on the detailed approach for Phase I of the project, which is divided into three stages:

1. Stakeholder engagement and establishing collaborations
2. Model design and development
3. Preliminary identification of performance indicators and design of a PMS

[2] A model for the implementation of IWRM was developed by the author based on all 5 Stages (see **Error! Reference source not found.**)

The following sections provide detail on how each of these stages in Phase1 is addressed in the current project. The approach is combined from a broad spectrum of systems modelling literature (see References) as well as the Catchment Management Strategy Guidelines developed by DWAF (2007).

7.1 Overall approach

For the purposes of coherence within the water resources management sector (which is one of the ultimate aims of the project) every effort was made to align the proposed approach with that developed by DWAF for integrated water resources management. These include primarily the approaches from the CMS guidelines (DWAF, 2007) as well as from other strategic planning instruments such as the NWRS (DWAF, 2004a) and the WMA specific ISP (DWAF, 2004b). In addition, the requirements of the NWA (Act 36 of 1998) forms the underlying framework or guideline on which all approaches proposed are based.

In essence the aim of the project is that the outcome (systems model) would constitute the first iteration of a Catchment Management Strategy (CMS). DWAF has developed a number of guidelines aimed at facilitating the implementation of Integrated Water Resources Management amongst others the "Guidelines for the development of Catchment Management Strategies in South Africa" (DWAF, 2007). This guideline draws on all aspects of IWRM and presents an overview of the implementation of IWRM on the level of WMA. These guidelines were therefore used to guide the information gathering and design phases of the project. According to DWAF (2007) a CMS needs to consider the status quo and future scenarios, as well as what vision stakeholders hold for the future of the catchment and finally strategic ways of realising this future vision (Figure 2). Aspects of the aforementioned approach will be incorporated in establishing the current and future scenarios as well as the catchment vision. Furthermore the requirements for a CMS as stated in the Guidelines (DWAF, 2007) will be adhered to in terms of the model design and the resultant catchment management model will therefore:

- not be in conflict with the NWRS;
- be reviewed from time to time;
- take into account all matters relevant to the:
- protection,
- use,
- development,
- conservation,
- management, and
- control of water resources

Essentially the NWRS (DWAF, 2004a) provides the basis for the Catchment Management Strategies (CMS) and thus forms a key source document for the model design process. Added to this, is the information provided through the Internal Strategic Perspective[3] for the WMA (DWAF, 2004b). In addition, there are certain fundamental principles associated with all water resources management policies and legislation in South Africa and the model design will aim to adhere to these, namely (DWAF, 2007):

"Sustainability: in recent times there has been an increasing realisation of the critical interdependence between human systems and ecosystems and that the more we

[3] DWAF. 2004. Fish to Tsitsikamma Water Management Area: Tsitsikamma to Coega Internal Strategic Perspective. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resources Planning. DWAF Report no.: P WMA 15/000/00/0304.

compromise our natural environment (including the quality and quantity of available water) the more we compromise our own livelihoods. There has also been the realisation that current generations have an obligation to future generation to protect the natural environment (including water resources). With respect to water resources it is therefore imperative that the concept of sustainability be incorporated explicitly in all aspects of IWRM.

Equity: Historically only a minority of South Africans had adequate access to water. A current cornerstone in our transformation process is the requirement to ensure equitable access to water resources for all. This also applies to neighbouring countries with which we share water resources. It is therefore imperative that the concept of equity be incorporated explicitly in all aspects of IWRM.

Efficiency: South Africa is a water-scarce country and vulnerable to floods and droughts. It is therefore essential that we use water efficiently and in the best interests of all users. The aim of promoting efficiency of water use in IWRM is to optimize the beneficial use of water in terms of a broad range of uses in a variety of sectors including the economic, social and environmental sectors."

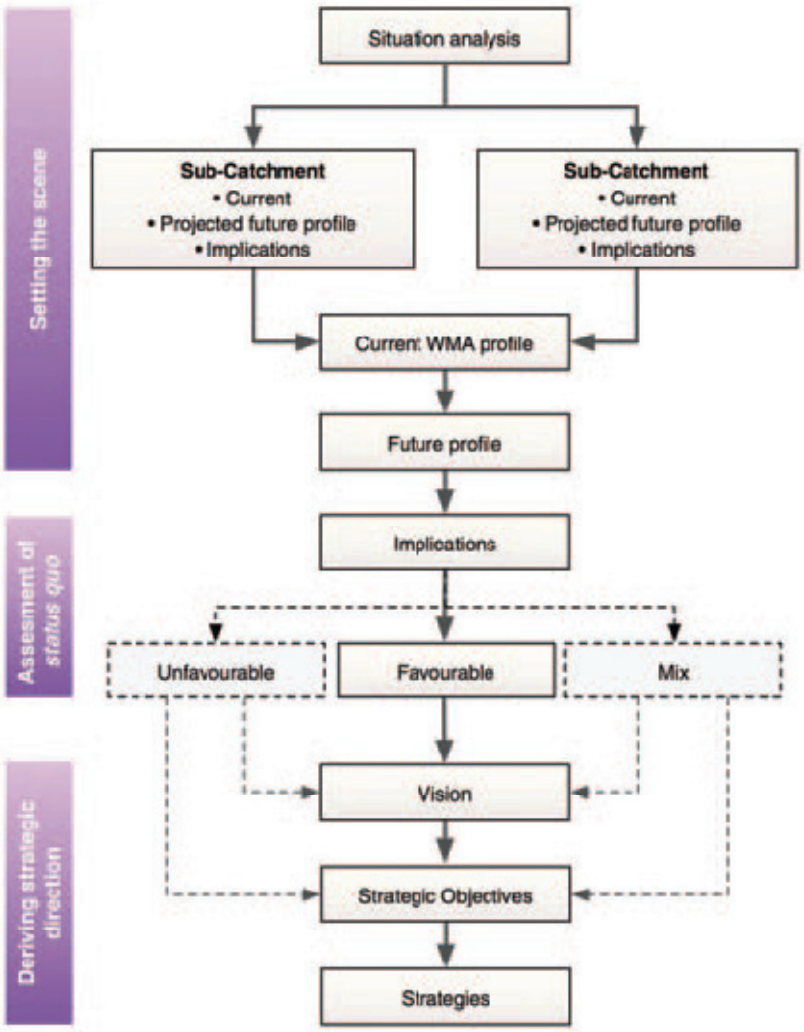

Figure 2: Overview of the development of a CMS (DWAF, 2007)

Other supporting principles as identified by DWAF (2007) that will be incorporated in the model design through a range of soft system methodologies (SSM[4]) include:

"Coherence of management strategies: Alignment must be sought to achieve coherence between national and local water-resource related strategies and plans (instruments) such as the CMS (WMA), the NWRS (national) and Water Service Development Plans (Sectoral).

Collaboration and stakeholder engagement: The success of a CMS depends upon collaboration between relevant key institutions and with its stakeholders and beneficiaries. The vision and objectives set for the CMS should be inclusive, and should reflect the principles of IWRM.

Transparency and "buy-in": Engaging key stakeholders very early on in the process of developing a CMS will encourage "buy-in" due to the inherent transparency of the approach. Active stakeholder participation will foster co-operation and support for difficult decisions and necessary trade-offs, which always form part of IWRM."

According to DWAF (2007) a CMS should also be based on certain generic "design criteria" or elements of design which will be taken into account when developing the current catchment management model. For the purposes of this study *no new data* on the listed criteria will be generated and information will be obtained only from existing data sources. These design elements/criteria include amongst others the following (DWAF, 2007):

- The Ecological Class of the Water Resource
- The Resource Quality Objectives or specific catchment objectives
- The Ecological Reserve and/or Basic Human Needs Reserve
- Obligations between countries/provinces/WMAs with shared water resources
- Consistency with the most recent National Water Resources Strategy

Strategies, objectives, plans, guidelines and procedures for protection, development, use, conservation, management and control of water resources within the WMA

- Geology, demography, land use, climate and vegetation within the WMA
- Water works, dams, and other water related infrastructure in the WMA
- Water Allocation Plan(s) for the WMA
- Water Conservation & Demand Management Plans for the WMA
- Needs and expectations of existing and potential water users in the WMA

IWRM in South Africa is conceptualised as four clusters (A to D; Figure 3) which represent core sub-strategies that together comprise the CMS (DWAF, 2007). The project will aim to address these core strategies where applicable during the design of the model. According to DWAF (2007) the four sub-strategies can be described as:

"Cluster A comprises a holistic assessment of the status quo and potential future scenarios of a WMA, against the background of water availability versus water requirements (reconciliation), and the vision for the WMA. Part A thus provides an overview (Figure 3-6.1) and assessment of the current and future situation (Figure 3-6.2 and 6.3) as well as a vision (Figure 3-6.4) for the future and essentially involves the gathering of data as a foundation for the development of the CMS. A substantial amount of relevant information is contained in the NWRS as well as WMA-specific studies such as the Water Resources Availability and Utilisation, Water Resources Situation Assessment and the Internal Strategic Perspectives.

[4] A soft systems model was designed by the author to facilitate stakeholder engagement in IWRM (Annexure 1)

Additional information, such as demographics, agricultural development, etc. is available from the relevant institutions (e.g. Statistics South Africa).

Cluster B comprises two key strategic areas namely water resources protection (Figure 3-6.5) and the regulation of water use (Figure 3-6.6) which apply to both surface water and ground water resources, and to issues of quantity and quality. Resource Directed Measures (RDM) and Source Directed Controls (SDC) are the overarching strategies for IWRM in South Africa. The RDM are directed at protecting the water resources base (6.5) whilst SDC are controls for water use (6.6).

Cluster C comprises the strategies and plans for stakeholder engagement and communication (Figure 3-6.7), information management and monitoring (Figure 3-6.8), as well as finances (Figure 3-6.9) without which the intentions of IWRM cannot be realised.

Cluster D comprises collaboration and integration strategies (Figure 3-6.10) for the multitude of institutions and initiatives engaged in IWRM. This includes strategies for inter-basin and international collaboration within shared catchments."

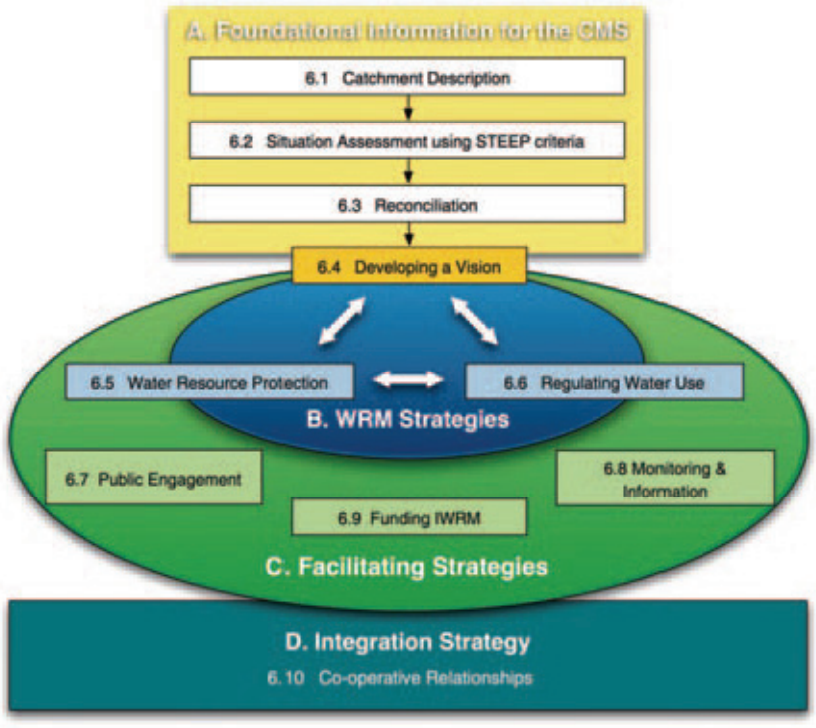

Figure 3: Four cluster (A-D) framework for IWRM (and CMS design) in South Africa (DWAF, 2007)

The above framework illustrates that the steps of IWRM are not sequential but rather iterative. The CMS guidelines thus suggest the use of a Strategic Adaptive Management or "learning-by-doing" approach for the implementation of IWRM. A critical component of this approach is that it is *adaptive* for in complex systems such as catchments the setting of rigid management strategies is very unlikely to succeed. This is due to multiple external factors such as changing political and/or social values, unpredictability and the fact that management actions themselves bring about change, which mean that one is managing a moving target. Adaptive management approaches start with a foundation of best available information (Cluster A) and iteratively grows in from there. This requires an attitudinal shift in accepting that not all the answers (data) are needed before developing the first iteration of CMS. (DWAF, 2007).

Adaptive learning (management) approaches involve a continuous process of interrogation aimed at sequentially validating and calibrating initial assumptions. The use of systems modelling, a highly iterative process whereby there is a tight feedback loop between model validation and calibration in a continuous model building exercise, is thus uniquely suited to the development of a CMS.

Central to the adaptive management process is also a clear catchment (WMA) vision which must be translated into management objectives and ultimately management actions and end points. Translating this vision into practice is often highly challenging. One model for translating the vision into strategic objectives and finally into management measures (or performance indicators) is presented in Figure 4 (DWAF, 2007).

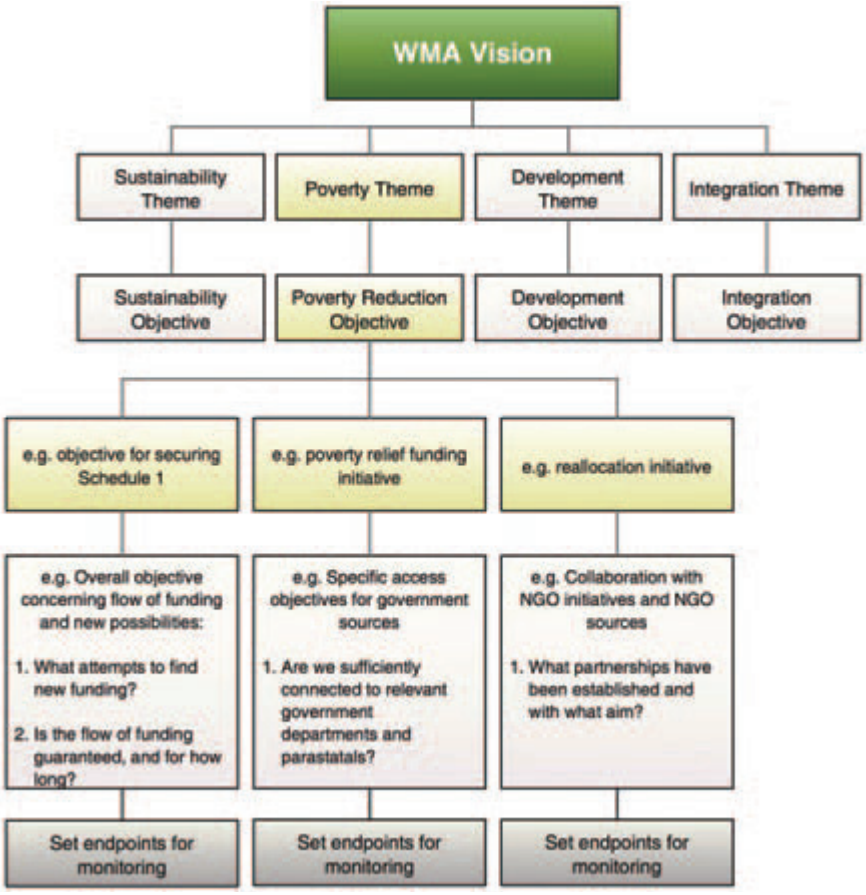

Figure 4: Example of an objectives hierarchy for translating a vision into management measures

NOTE: DWAF (2007) also states that as a result of the iterative nature of CMS development not all issues can be developed as part of the first CMS. It is therefore important to understand that the catchment management model that will be designed in this phase of the project will not address all aspects of IWRM or of the CMS, but will serve as a first iteration of an ongoing process of development and refinement.

The following sections deal with the approach to the systems modelling aspects of the project in more detail.

7.2 Soft Systems Modelling

SSM[5] which remains the most widely used and practical application of systems thinking is primarily employed in the analysis of complex situations where there are divergent (world) views about the definition of the problem in other words "soft problems." IWRM which involves both “hard” and “soft” issues is a perfect example of such a complex “problem” and is ideally suited to analysis by SSM. In such complex situations (as IWRM) even the actual problem to be addressed may not be easy to agree upon. Thus, in order to facilitate the solving of such complex “problems” the SSM approach uses the notion of a "system" as an interrogative device that enables organised debate amongst concerned parties. SSM is also renowned for fostering “buy-in” amongst stakeholders, under otherwise difficult or complex circumstances.

In its classic form the methodology consists of seven steps, with initial appreciation of the ‘problem situation’ leading to the modelling of several ‘human activity systems’ that might be thought relevant to the problem situation. By discussions and exploration of these, decision makers may arrive at accommodations (or, exceptionally, at consensus) over what kind of changes may be systemically desirable and feasible in the situation (www.wikipedia.org). This earlier, classical view of SSM is most widely used in practice and is the method that will primarily be employed as a framework during the modelling phase of the project. The classical 7-stage representation of SSM is as follows:

1. Enter situation considered problematic (Section 7.2.1)
2. Express the problem situation (Section 7.2.2)
3. Formulate root definitions of relevant systems of purposeful activity (Section 7.2.3)
4. Build conceptual models of the systems named in the root definitions (Section 7.2.4)
5. Comparing models with real world situations (Section 7.2.5.3)
6. Define possible changes which are both possible and feasible (Section 7.2.5.4)
7. Take action to improve the problem situation (Sections 7.2.5.5 and 7.2.5.6)

IMPORTANT: It must be understood that implementing the SSM approach can create tension between the competing demands of ‘comprehensiveness’ and ‘comprehensibility’. Comprehensiveness demands the inclusion of all relevant factors while comprehensibility demands simplification, in order to make the model understandable. The solution to this tension is to see the resultant systems model(s) as an aid to thinking and conceptualisation about the ‘problem situation(s)’, rather than as faithful representations of an ‘objective reality’. A truly comprehensive model of a complete system would be just as complex as that system and just as inscrutable. “The art of model building is knowing what to cut out, and the purpose of the model is to act as the logical knife.” (Sterman, 1991)

7.2.1 Identifying the “Problem Situation”

The first part of the modelling exercise essentially starts with the proposal phase when the “Problem Situation[6]” is identified. The “Problem Situation” can be defined as a situation considered problematic e.g. the implementation of the National Water Act (no 36 of 1998) or more specifically Integrated Catchment Management within the ambit of the NWA. It can also be described as the *reason for the initiation of the analysis* or *a general feeling of uneasiness of the “Problem Owner”*.

[5] “Soft Systems is a branch of systems thinking specifically designed for use and application in a variety of real-world contexts. Rather than SSM models attempting to map the real world – impossible because there are multiple candidates for what counts as the real world in complex situations – the models are devices for learning about the real world. In short, SSM becomes a process of inquiry, a learning system.” (www.wikipedia.org).

[6] Terms indicated in parenthesis refers to systems modeling language

During this initial phase of the project it is determined what information is available, who the potential stakeholders are and how communication will take place, followed by a process of defining the problem (system) boundaries. That is the boundaries (environmental constraints) within which the "Problem Situation" is to be addressed. In the case of the implementation of the National Water Act (or specifically ICM), non-allocatable water such as water for inter-basin transfers, servicing international obligations and/or providing the Ecological Reserve and/or the Basic Human Needs Reserve, present such unchangeable boundaries or environmental constraints. Following the initial data collection and stakeholder identification as well as the definition of system (problem) boundaries the "Problem Owner" now has an unstructured "Problem Situation" which needs to be transformed into a structured "Problem Situation" through a situation analysis or "Rich Picture" phase during which identified stakeholders are actively engaged from the start.

7.2.1.1 Gathering existing information[7]

An extensive information gathering phase is initially conducted during which all relevant systems, tools, policies, strategies, institutions, legal instruments, stakeholders, water use sectors, projects, programmes, software, etc. are identified and investigated. This is followed by a facilitated workshop amongst key stakeholders during which a Soft Systems Modelling approach is followed to, amongst others: i) decide on a common catchment vision, ii) determine catchment objectives, iii) identify issues of concern, iv) identify management strategies, v) categorise the different role players, their roles and actions and vi) determine the environmental constraints or system boundaries of the project. This process will contribute to the establishment of an updated situation profile[8] of the WMA (or in this case the Baviaanskloof Mega Reserve catchment area) as a basis for strategic planning (CMS/P). According to DWAF (2007) "*the objective of describing the status quo is to provide a holistic contextual profile of the key characteristics of the WMA (biophysical, social, technical, economic, political and institutional), as related to water, and the likely future profile, in order to provide a sound basis for the development of appropriate and effective strategic direction*".

As a result one would have an up-to-date synopsis (situational profile) of the best available information on key characteristics of the WMA[9] as well as the likely future scenarios to be assessed for the purposes of developing the CMS and ultimately the CMP. Development of a situational profile is and ongoing iterative process and not a once-off exercise since changes in management actions are reflected in the status quo of the WMA and vice versa.

An integrated and holistic assessment of the current situation is required for the purposes of successful IWRM and a useful framework to guide this process is presented in the Guidelines for CMS Development (DWAF, 2007), namely the "STEEP" framework which aims to integrate Social, Technical, Ecological, Economic and Political characteristics (Figure 5). There is close correlation between the application of this "STEEP" approach and the process of formulating "Root Definitions" (Section 7.2.3).

[7] The pilot phase will in essence already be initiated during this stage

[8] A situation assessment for the WMA was conducted in 2002 (Department of Water Affairs and Forestry, South Africa. 2002. *Fish to Tsitsikamma Water Management Area:* Water Resources Situation Assessment. Prepared by Ninham Shand on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0101) and updated in 2004 (Department of Water Affairs and Forestry, South Africa. 2004. *Fish to Tsitsikamma Water Management Area: Tsitsikamma to Coega Internal Strategic Perspective*. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0304).

[9] When reference is made to WMA it refers to the BMR catchment area (or study area)

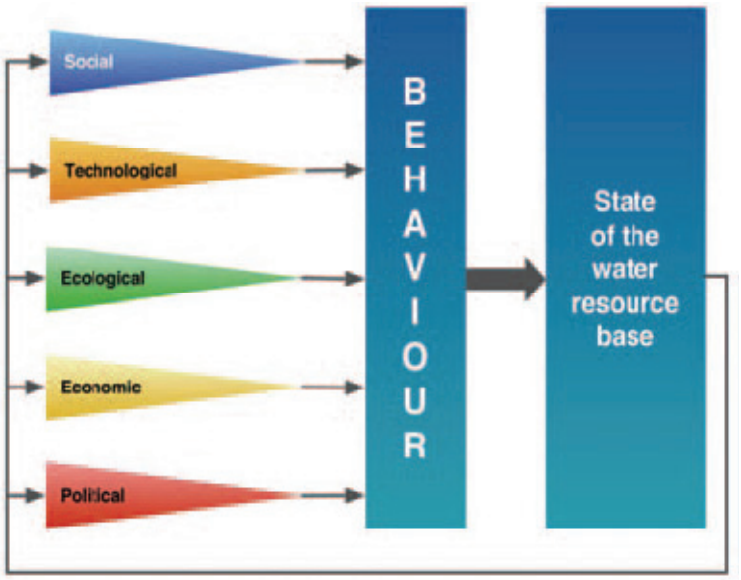

Figure 5: STEEP framework for situation assessment and selection of criteria (DWAF, 2007)

Status quo assessment does not require the collection of large quantities of *new* information or data, but rather the collation and synthesis of available data and information such as to provide a firm foundation for strategic planning within the WMA. Essentially it entails a gap analysis and the prioritisation of key issues. Relevant WMA information is available through amongst others the DWAF Water Resources Situation Assessment (WRSA) Studies[10], National Water Resources Strategy (NWRS)[11], Internal Strategic Perspectives (ISPs[12]), Water Services Development Plans (WSDPs[13]) and various other documents within provincial and local government. When the status quo has been established a potential future catchment profile or future scenario(s) for the WMA must be established by asking relevant questions about where things are going and what the situation will be in some defined future time. The study will investigate scenario development as part of the modelling phase (Sections 0 to 7.2.5.5).

7.2.1.2 Stakeholder engagement and establishing collaborations

Integrated water resources management is a complex undertaking that needs to rely on input and active participation form a number of relevant sectors, government departments, institutions, organisations and civil society groups.

7.2.1.2.1 Stakeholder engagement

Each of these role-players has their own expectations, interests and agendas which may or may not overlap. This presents a challenge in establishing collaboration and cooperation between different stakeholder groups.

The ultimate aim of stakeholder engagement in the IWRM process is to minimise conflict and maximise overlap in needs and expectations. Active participation from the very

[10] Department of Water Affairs and Forestry, South Africa. 2002. *Fish to Tsitsikamma Water Management Area:* Water Resources Situation Assessment. Prepared by Ninham Shand on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0101

[11] Department of Water Affairs and Forestry, South Africa. 2004. *National Water Resources Strategy:* Directorate National Water Resources Planning.

[12] Department of Water Affairs and Forestry, South Africa. 2004. *Fish to Tsitsikamma Water Management Area: Tsitsikamma to Coega Internal Strategic Perspective*. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0304

[13] A WSDP is available for the Baviaans Local Municipality's Adopted IDP 2007-2008

beginning will engender a sense of ownership and enhance understanding of the process and the objectives of the project. This will foster the much needed "buy-in" and promote smooth transition between the design (CMS) and implementation (CMP) phases of the project. If 'buy-in' occurs early on in the process stakeholders will be less likely to contest the final outcome of the process. The proposed approach (soft systems modelling) to stakeholder engagement takes these issues explicitly into account since the success of the project is highly dependent on active stakeholder participation and collaboration with relevant role-players.

The NWA also clearly stresses the need for consultation with various role-players and stakeholders in the development of the CMS. The CMA (or proto-CMA) is therefore required to seek co-operation and agreement on water related matters from the various stakeholders and interested persons. According to DWAF (2007), the three main platforms available for stakeholder engagement in IWRM are Catchment Management Committees, Catchment Management Forums, and Water User Associations (Figure 6). Since the establishment and maintenance of catchment stakeholder platforms is the responsibility of the CMA (or in this case the proto-CMA), the head[14] of the proto-CMA was engaged from the very start of this Stage of the project. The aim is to establish close collaboration with the proto-CMA in order to i) optimise adaptive learning and ii) optimise resource utilisation with respect to amongst others the establishment and maintenance of the stakeholder database.

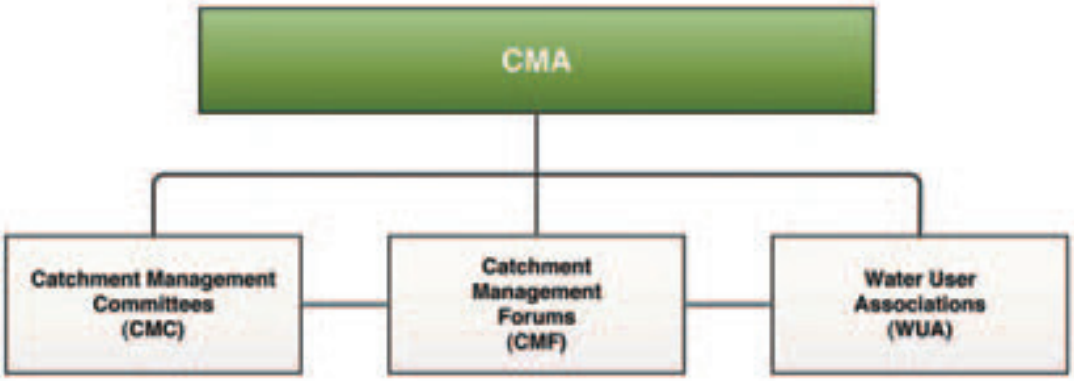

Figure 6: Three main platforms available for stakeholder engagement in IWRM (DWAF, 2007)

The stakeholder engagement stage was initiated by developing a comprehensive list of key stakeholders that were identified based on the preceding information gathering phase. Identified stakeholders are then contacted preferably telephonically or alternatively by email correspondence if no contact can be established. A Background Information Document on the project is compiled at the same time and sent to all stakeholders following the initial establishment of contact. A Microsoft Access stakeholder information database is initiated concomitantly and maintained for the duration of the study.

7.2.1.2.2 Establishing collaborations

In addition to the collaborations established during the foregoing stakeholder engagement processes, close collaboration is also established with a number of relevant Jeffares & Green lead projects, including but not limited to the following:

[14] Ms Bolekwa Kama; Catchment Manager; DWAF East London; Tel: 043 701 0221; email: kamab@dwaf.gov.za

- Regulatory Performance Measurement System. Department of Water Affairs' project conducted by Jeffares & Green (Pty) Ltd and currently in the pilot implementation phase.
- Baviaanskloof Mega Reserve River ecosystem monitoring and ecological Reserve assessment. An Ecological Reserve Implementation (ERI) project led by CapeNature through the C.A.P.E. partnership programme with South African National Biodiversity Institute (SANBI) and the Department of Water Affairs and Forestry (DWAF). Conducted by Jeffares & Green (Pty) Ltd and associates.
- Implementation of a conceptual framework model for the regulation of water quality in an integrated, preventative management approach. WRC project lead by Golder in association with Jeffares & Green (Pty) Ltd).

Information and experience (adaptive learning) gained in the above mentioned projects are incorporated in the current project in order to optimise synergy and resource allocation. In addition the extensive investigation into all relevant institutional (universities), government and public sector projects, programmes, research endeavours, etc. conducted during the information gathering stage of the project is aimed at fostering synergistic collaboration with these initiatives[15].

7.2.2 Developing the "Rich Picture"

The next level of stakeholder engagement is a series of expertly facilitated stakeholder workshops during which SSM concepts are employed. The first of these workshops is aimed at developing the "Rich Picture" which can be defined as an expression of "Problem Situation" (e.g. lack of IWRM implementation) that allows for the selection of relevant[16] (to debate) systems of purposeful activity (any group of activities that from a purposeful whole, e.g. agriculture, conservation, tourism, etc.).

The "Rich Picture" must include all the elements of the CATWOE (where C = Client; A = Actor; T = Transformation; W = World view or Weltanchauung; O = Owner; and E = Environmental constraints) and more. This phase of the SSM process is initially characterised by an 'explosive' divergence, of which the aim is find out who is involved (clients and owners), what the culture of the problem is, what activities are taking place and in what political framework these activities take place in order to make sure that no important hidden issues are left out of the process. When it is certain that all the important and relevant issues are on the table, convergence takes place where the key issues, key stakeholders, main objectives, etc. (often different for different stakeholder groups) are distilled and grouped into systems of purposeful activity (or human activity systems[17]).

Divergence essentially takes place as a brainstorming event between a small group of key stakeholders in a facilitated workshop environment which includes cognitive mind maps aimed at identifying the dimensions of the problem by asking the following key questions: What are the 1) issues of concern, 2) objectives, 3) strategies, 4) vision[18], 5) constraints, and 6) who are the relevant stakeholders (Checkland, 1981). In essence this process provides a

[15] To date numerous such collaborations have been established (see K5-1911 Stakeholder Engagement Report for detail on these collaborative initiatives).
[16] "Using SSM, no choice of the most relevant of Possible `relevant systems' is made from the beginning, as is the case with hard systems thinking, where the `system of concern' is taken to be obvious. In SSM the `relevance' is determined in the course of the whole problem-solving process, as the problem-solvers gradually gain insight into the problem situation by passing through the various stages of SSM. (Checkland and Tsouvalis 1996)
[17] "In SSM, enquiry into a real-world situation in which people are trying to take would-be purposeful action is structured by setting the perceived situation against a number of purposeful `holons'. These purposeful holons, or, as they are called in SSM, `human activity systems', are defined and modelled in such a way that they provide a source of questions which can be asked of the problem situation. Answering these questions enables an understanding of the situation to be gained and leads to the emergence of a structured and coherent debate about intended change." (Checkland and Tsouvalis 1996)
[18] See pg 63 to 66 in the CMS guidelines (DWAF, 2007) for detail on visioning procedures.

framework for a holistic assessment of the current situation[19] and likely future scenarios in terms of biophysical, social, economic, political and institutional aspects relevant to the "Problem Situation."

Following this explosive divergence one enters a *convergence* process, namely the formulation of "Root Definitions" that involves the active facilitation of maximal overlap between defining characteristics[20] (indicators/criteria) of different systems of purposeful activity (ideally between 5 and 9)[21].

The outcome of this 1st stakeholder workshop is a structured "Problem Situation" which constitutes a number of systems of purposeful activity (sectors within the study environment) from which relevant (to debate) systems can be selected.

7.2.3 Formulate "Root Definitions"

"Root Definitions" are, in essence, systems of purposeful activity (water related sectors and/or initiatives) that contain all the elements (components) of the conceptual model. "Root Definitions" are formulated by categorising the different systems of purposeful activity in terms of groups of defining characteristics using the CATWOE protocol. Each "Root Definition" must have a pure Weltanchauung[22]. In other words it must be contained in an environment with a specific viewpoint or world view. E.g. a system of purposeful activity such as agriculture can have different "Root Definitions" for different stakeholder groups (e.g. farmers and conservationists) based on the specific world view each of these groups hold regarding the activity.

This process ideally takes place in a facilitated workshop environment with key stakeholders and would constitute the 2nd stakeholder workshop. The optimal sequence in which the systems of purposeful activity should be defined is as follows: T - W - E - O - A - C. The process must be facilitated such that the defining characters (indicators or criteria) of the different "Root Definitions" have maximal overlap. The output of this process is a number of "Root Definitions" (with maximally overlapping defining characteristics) that will serve as inputs to (or elements of) a conceptual model.

The CATWOE protocol is defined as follows:

Customers/beneficiaries: Who are the stakeholders (or who can benefit or lose from the process), e.g. DWAF, farmers unions, water boards, rural communities, industry, urban communities, habitat and biota (environment).

Actors/agents: Who takes the action (or who has the mandate for transformation), e.g. DWAF or the CMA.

Transformation process: What are the transformation processes (or activities that will bring about the desired change), e.g. compulsory licensing, registration of water use, determination of the ecological and/or basic human needs Reserve.

Weltanchauung: What are the different world views (or perceptions of the world/project environment) by different stakeholder groups, e.g. what view has the local municipality that is charged with amongst others the provision of water for human development vs. nature conservation that has the mandate to protect water resources from over allocation?

[19] See pg 51 to 55 in the CMS guidelines (DWAF, 2007) for detail on developing a situation assessment.
[20] Aspects or resource economics e.g. may be investigated as a method of facilitating maximal overlap.
[21] See annexure 3 for the diagrammatic representation of the sub-model for managing divergence.
[22] "Any system chosen as `relevant' is selected by the problem solver in accordance with a particular image of the world, a world view, or Weltanchauung. Since one observer's `terrorist' is another's `freedom fighter', there will always be multiple possible interpretations of purposeful activity. (Checkland and Tsouvalis 1996)

Owner: Who can stop the process (or who is ultimately responsible and accountable), e.g. the Minister of the Department Water Affairs and Forestry.

Environmental constraints: What are the constraints in the system environment (or what are the boundaries or unchangeables of the system or project environment), e.g. the Basic Human Needs Reserve, and/or Ecological Reserve, and/or International Obligations.

Checkland and Wilson (1980) identified two different kinds of "Root definitions", namely primary task root definitions and issue based root definitions. According to their definition, primary task root definitions "express a notional human activity system whose system boundary might be expected to coincide with real-world organisational boundaries". Primary task root definitions, therefore, most closely resemble (though, being notional, they are not the same as) the kind of systems defined by hard systems[23] methods.

The second kind of root definitions are issue based. According to Checkland and Wilson (1980) "issue based root definitions' boundaries do not in general coincide with real-world manifestations; that is, they do not define a task which has been institutionalised." These root definitions are generally used to define soft systems[24].

7.2.4 Conceptual model design

In order to understand any system, it has to be viewed in its entirety. This is made possible by constructing a functional representation of a system (or conceptual model) through the processes of Systems Thinking[25] (the mental discipline used for characterising complex systems and finally identifying the key drivers of such systems) and Systems Modelling (a technique for predicting the behaviour of complex systems under different scenarios). The purpose of the conceptual model is to accomplish on paper (or in theory) what has been defined during the formulation of the "Root Definitions".

According to Checkland and Tsouvalis (1996) a root definition (being a description of purposeful human activity conceived as a transformation process) always embodies a particular world-view and is an account of `what the system is'.

The conceptual model on the other hand "is an account of `what the system must *do* in order to *be'* the system described in the root definition" (Checkland 1981). The relationship between the root definition and the conceptual model in SSM is therefore a relationship between a `being' and a `doing' or between the structure of the system and the function of the system (Checkland and Tsouvalis 1996).

Designing the conceptual model is therefore based on the root definitions and thus the CATWOE elements. Model construction is essentially initiated by allocating verbs to the activities described in the root definitions and by structuring these activities in terms of their logical dependencies. There are various ways of constructing conceptual models however some may lead to undesirable inconsistencies. Checkland in association with Scholes

[23] Hard systems are defined as involving simulations, often using computers and the techniques of operations research. Useful for problems that can justifiably be quantified. However it cannot easily take into account unquantifiable variables (opinions, culture, politics, etc), and may treat people as being passive, rather than having complex motivations.

[24] Soft systems are systems that cannot easily be quantified, especially those involving people holding multiple and conflicting frames of reference. Useful for understanding motivations, viewpoints, and interactions and addressing qualitative as well as quantitative dimensions of problem situations. Soft systems are a field that utilizes foundation methodological work developed by Peter Checkland, Brian Wilson and their colleagues at Lancaster University. Morphological analysis is a complementary method for structuring and analysing non-quantifiable problem complexes.

[25] Systems thinking can be defined as an approach to problem solving based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation. Systems thinking attempts to illustrate that events are separated by distance and time and that small catalytic events can cause large changes in complex systems. Acknowledging that an improvement in one area of a system can adversely affect another area of the system, it promotes organizational communication at all levels in order to avoid the silo effect. Systems thinking techniques may be used to study any kind of system including natural, scientific, engineered, human, or conceptual.

(1990) employ the following approach which aims to avoid these inconsistencies. Their approach consists of the careful modelling of the transformation process (T) of each root definition in such a way as to fulfil the following five criteria:

- Effectiveness (is the transformation process the right thing to be doing[26]?);
- Efficacy (do the means selected work?);
- Efficiency (is the transformation process being done with minimum resources?)
- Ethicality (is the transformation process a moral thing to do?); and
- Elegance (is the transformation process aesthetically pleasing?)

A conceptual model will go through a number of information gathering iterations in order to fill any gaps in the understanding of the system under investigation. Systems Diagrams[27] will be implemented to achieve this. Although various approaches exist with which to accomplish this, System Diagrams are particularly well suited to identifying the component elements of a system as well as the relationships between these elements.

Systems Diagrams (see Figure 7 for an example of a basic Systems Diagram) in essence, provide functional representations of systems that aid in the qualitative understanding of the impact on a system of perturbations affecting any component of the system and as such, act as templates for the development of System Dynamics Models. The latter are used for more accurate prediction of impacts during scenario manipulation.

7.2.5 System dynamics modelling

A System Dynamics[28] Model is then created based on the Systems Diagram constructed during the conceptual modelling stage using a computer programme (iThink 9.1.3). This process is initiated in Phase I and continued in Phase II.

[26] Taking into account long-term-aims

[27] The process of constructing qualitative Systems Diagrams require that hidden assumptions in tacit mental models are made explicit, in order to represent the relationships between processes in a schematic diagram. This process allows scrutiny by others and provides a visual representation that aids exploration of the (problem) situation, as well as communication and critique. Critique by others e.g. can result in changes to the conceptualisation of some relationships. Conceptual clarification is thus facilitated by a visual medium for sharing and testing the concepts within the mental model(s). (Sterman 1991)

[28] System dynamics is an approach to understanding the behaviour of complex systems over time. It deals with internal feedback loops and time delays that affect the behaviour of the entire system. What makes using system dynamics different from other approaches to studying complex systems is the use of feedback loops and stocks and flows. These elements help describe how even seemingly simple systems display baffling nonlinearity. System dynamics is an aspect of systems theory as a method for understanding the dynamic behaviour of complex systems. The basis of the method is the recognition that the structure of any system (the many circular, interlocking, sometimes time-delayed relationships among its components) is often just as important in determining its behaviour of the system as the individual components themselves. It is also claimed that because there are often properties-of-the-whole which cannot be found among the properties-of-the-elements, in some cases the behaviour of the whole cannot be explained in terms of the behaviour of the parts.

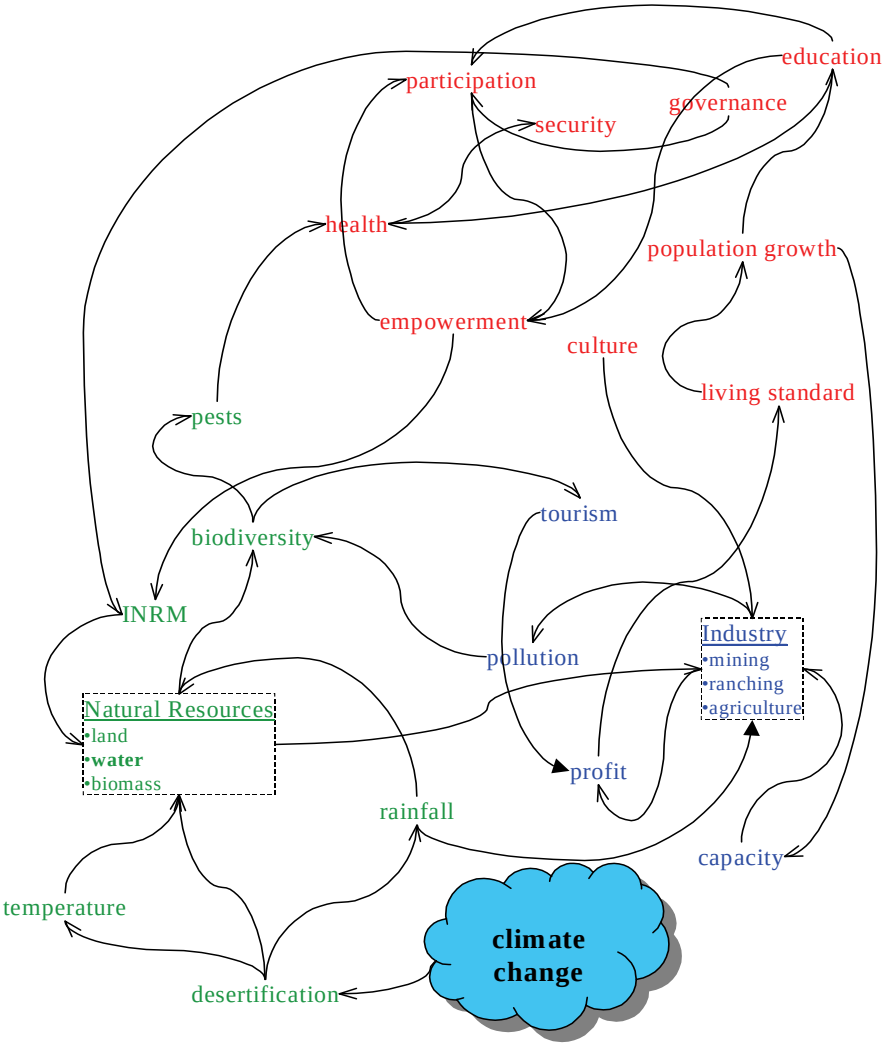

Figure 7 A Systems Diagram showing catchment components and their inter-relationships

Briefly the process involves the following steps:

7.2.5.1 Unpack root definition (see Section 7.2.3 and 7.2.4)

Each model component must relate to a particular word or phrase in the Root Definition. The activities implicit in the Root Definition are described by the "verbs" of the modelling language and the "verbs" are structured together according to logical dependencies. The aim is to have no more than 9 different systems of purposeful activity.

7.2.5.2 Translate TOC into model components (see Section 7.2.4)

By employing the technique of Causal Loop Diagrams (Vinnex group model building) the “unpacked” root definitions can be structured into a conceptual model which includes activities (verbs) linked by logical dependencies. Even in these early phases of model construction the performance measures (indicators and criteria) should be identified in terms of efficacy, efficiency and effectiveness to assess the performance of each system of purposeful activity.

7.2.5.3 Validate model behaviour (see Section 7.2)

By investigating the validity of the logic relationships between the activities (verbs) of the model it can be assessed whether or not the model is "doing the right things". It is beneficial to make this a stakeholder participation process in order to optimise “buy-in” and a sense of ownership of the process. This step will thus constitute the 3rd Stakeholder Workshop[29].

7.2.5.4 Calibrate model assumptions (see Section 7.2)

By checking the output of the model or model results against real world situations or actual historical data, the model can be calibrated to ensure that the assumptions made by the model conforms to reality. Again, it is beneficial to make this a stakeholder participation process to optimise “buy-in” and a sense of ownership of the process. This step will thus constitute the 4th Stakeholder Workshop.

A systems model can be defined as a functional representation of scenarios, where scenarios correspond to different values on axes of input parameters, with intangibles ranked e.g. as H, M, or L. E.g. if for instance in the Systems Diagram of Figure 7 there is no mining, ranching or tourism in the catchment, the values of these variables would be set to zero for simulation purposes. Thus, for the purpose of management of the catchment, impacts on the system may be quantified by running a simulation of different scenarios and observing the behaviour of key variables in the model that correspond to performance indicators, which could be either health indicators of sustainability indicators. Figure 8 shows as an example of the output of the computer programme (iThink™ – HP, 1997), a System Dynamics Model for the biophysical component of the catchment.

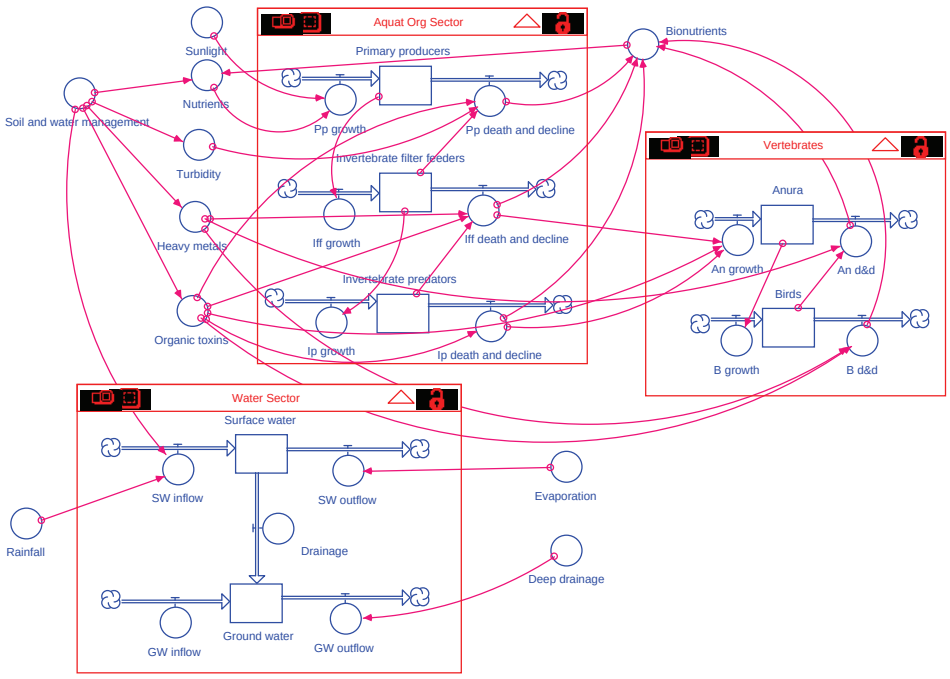

Figure 8: System Dynamics Model of the biophysical component of the catchment (iThinkTM)

[29] It is important to note that these stakeholder workshops involve only key stakeholders and not the general public. The requirement for participation is that people have knowledge of the study area and understand the need and requirements of establishing a catchment management plan.

7.2.5.5 Defining performance measures

One of the important outcomes/functions of the System Dynamics Model is to yield 'indicators of performance' for the pilot catchment (Phase II). Successful management of any complex system (such as the BMR catchment) requires the correct description of the system in terms of these critical variables, performance indicators. The correct derivation of performance indicators is therefore key to the entire process. Two main categories of methods exist to identify indicators namely ad-hoc methods and system dynamics modelling (Bossel, 2001).

Many approaches for deriving indicator sets involve ad-hoc methods that involve choosing from a great wealth of possible indicators, typically as in MCDA. These methods however often involve the selection of indicators by experts (those who are available), and by stakeholders (whose interests might be traded off in some mechanisms of stakeholder management). According to Campbell *et al.* (2001) there is consequently the danger of bias being incorporated into the indicator selection mechanism. Campbell *et al.* (2001) has therefore developed a method for comprehensive indicator set selection termed the "Sustainable Livelihoods" approach which integrates social, economic and ecological dimensions, and leads to effective selection of indicator sets for the assessment of system performance. The STEEP method (Figure 5- Section 7.2.1.1) has certain similarities to the aforementioned approach and is suggested in the CMS guideline document (pg 52) for the derivation of Performance Indicators.

System dynamics modelling (SDM) on the other hand presents an approach for comprehensive unbiased indicator-set selection whereby a model is developed and then sequentially and iteratively calibrated and validated as more information becomes available and the design is enhanced through adaptive learning (in particular during the pilot implementation, monitoring and refinement phase of the project – Phase II).

In South Africa, performance measures have been developed under the ambit of two broad strategies, namely: Water Resource Protection (WRP)[30] and Regulating Water Use (RWU)[31]. To this end each of these strategies are given effect through a set of statutory measures respectively termed Resource Directed Measures (RDM)[32] and Source Directed Controls (SDC)[33]. Each of these sets of measures includes a number of indicators[34] and criteria[35] aimed at measuring the performance of these two strategies in achieving their stated objectives[36].

The process of defining performance measures (indicators and criteria) is a highly iterative process that is, in essence, initiated in Section 7.2.1.1 and since Phase I is aimed at only providing a preliminary set of indicators all of the above methodologies may be investigated as an approach to performance indicator selection.

The preliminary set of performance indicators that are identified during the Phase I will from part of the design and development of the Performance Management System (PMS) which mainly takes place in Phase II of the overall project.

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[30] See pg 65 to 73 of the CMS Guidelines (DWAF2007) for detail on the WRP strategy.
[31] See pg 74 to 88 of the CMS Guidelines (DWAF2007) for detail on the RWU strategy.
[32] See pg 69 of the CMS Guidelines (DWAF2007) for a summary of the Resource Directed Measures.
[33] See pg 86+87 of the CMS Guidelines (DWAF2007) for a checklist of what a SDC strategy must address.
[34] Definitions of an indicator:
1) A meter or gauge
2) An index periodically measures that reveal the direction of change with respect to a criterion
3) In chemistry – a substance used to indicate concentration or the degree of a reaction
4) In ecology – a plant or animal whose presence is indicative of some specific environment
5) In economics – a measure, such as unemployment rate, which can be used to predict trends
[35] Definition of criterion: A standard or test by which individual components of a system may be compared
[36] See pg 66 of the CMS Guidelines (DWAF, 2007) for WRP objectives and pg 75 for RWU objectives.

7.2.5.6 Preliminary PMS design

This stage of the process will start concurrently with the SDM phase. A consistent tight feedback loop between model development and PMS design will be maintained since the one will inform the other in an iterative and adaptive manner. Jeffares & Green (Pty) Ltd has extensive experience in designing computerised information management systems and will implement the learning acquired from, in particular the DWAF regulatory performance management system (RPMS) project, in the current project. Since the PMS design forms part of a separate project the approach will not be detailed here. Collaboration MOU has already been agreed to by the relevant team members.

The conceptual model that is developed in Phase 1 will be iteratively refined throughout Phase 2 during the pilot implementation phase. The refined model will then be systematically interrogated to develop a number of protection-use scenarios for the pilot catchment and then finally employed to aid in the selection of desirable and feasible protection-use scenarios as part of the final stages of CMS development.

Phase 3 will build on the foundational development in Phase 1 and 2 to culminate in the establishment of a comprehensive Performance Management System to be implemented as part of the Catchment Management Plan.

8 METHODOLOGY

8.1 INFORMATION GATHERING & STAKEHOLDER ENGAGEMENT

8.1.1 Information gathering

In order to establish who the key stakeholders are and what collaborative initiatives exist in the study area, an extensive information gathering process was conducted at the outset of the stakeholder engagement stage. This included the identification of all relevant systems, tools, policies, strategies, institutions, legal instruments, projects, programmes, stakeholders, water use sectors, etc. This process contributed to the establishment of an updated situation profile[37] of the Baviaanskloof Mega Reserve catchment area as a basis for the future development of a Catchment Management Strategy (CMS) and Plan (CMP). According to DWAF (2007) "*the objective of describing the status quo is to provide a holistic contextual profile of the key characteristics of the WMA (biophysical, social, technical, economic, political and institutional), as related to water, and the likely future profile, in order to provide a sound basis for the development of appropriate and effective strategic direction*".

Development of a situational profile is an ongoing iterative process and not a once-off exercise since changes in management actions are reflected in the status quo of the catchment area and vice versa. Status quo assessments do not require the collection of large quantities of *new* information or data, but rather the collation and synthesis of available data and information. Essentially it entails a gap analysis and the prioritisation of key issues.

The relevant information was gathered through amongst others the DWAF Water resources Situation Assessment (WRSA)[38], NWRS[39], ISP[40], Water Services Development Plan (WSDP[41]) and various other key documents.

The information gathering stage was followed by the stakeholder engagement process during which series of focus group meetings and facilitated workshops were held amongst key stakeholders. The process also involved a number of awareness creation activities and the establishment of collaborative partnerships.

8.1.2 Development of a stakeholder database

The stakeholder engagement stage was initiated by developing a comprehensive list of key stakeholders that were identified based on the preceding information gathering phase. Identified stakeholders were contacted telephonically or alternatively by email correspondence if no contact could be established. A Microsoft Access stakeholder information database was initiated concomitantly and is maintained for the duration of the study.

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[37] A situation assessment for the WMA was conducted in 2002 (Department of Water Affairs and Forestry, South Africa. 2002. *Fish to Tsitsikamma Water Management Area:* Water Resources Situation Assessment. Prepared by Ninham Shand on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0101) and updated in 2004 (Department of Water Affairs and Forestry, South Africa. 2004. *Fish to Tsitsikamma Water Management Area: Tsitsikamma to Coega Internal Strategic Perspective*. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0304).

[38] Department of Water Affairs and Forestry, South Africa. 2002. *Fish to Tsitsikamma Water Management Area:* Water Resources Situation Assessment. Prepared by Ninham Shand on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0101

[39] Department of Water Affairs and Forestry, South Africa. 2004. *National Water Resources Strategy:* Directorate National Water Resources Planning.

[40] Department of Water Affairs and Forestry, South Africa. 2004. *Fish to Tsitsikamma Water Management Area: Tsitsikamma to Coega Internal Strategic Perspective*. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resources Planning. DWAF Report no. P15/000/00/0304

[41] A WSDP is available for the Baviaans Local Municipality's Adopted IDP 2007-2008

8.1.3 Project awareness creation

A Background Information Document on the project was compiled and distributed to all stakeholders following the initial establishment of contact.

A presentation on the project was delivered at the FOBWA Workshop on the 23rd October 2009 for the purposes of introducing the project and to create awareness amongst potential stakeholders and collaborators. This initial establishment of contact with the relevant role-players was also specifically aimed at gaining support for future workshops and to establish firm collaborations with key individuals and/or relevant projects or other initiatives.

Further awareness creation was achieved at the International Environmental Water Allocation (IEWA) Conference held in February 2009 where a poster entitled "Development of a Systems Dynamic Model for the Implementation of IWRM in South Africa" was presented.

8.1.4 Establishing collaborations

In addition to the collaborations established during the foregoing stakeholder engagement and awareness creation processes, close collaboration was also established with a number of relevant J&G projects, including but not limited to the following:

- Regulatory Performance Measurement System (Department of Water Affairs and Forestry project conducted by Jeffares & Green (Pty) Ltd and currently in the pilot implementation phase).
- Baviaanskloof Mega Reserve River ecosystem monitoring and ecological Reserve assessment (an Ecological Reserve Implementation (ERI) project led by CapeNature through the C.A.P.E. partnership programme with South African National Biodiversity Institute (SANBI) and the Department of Water Affairs and Forestry (DWAF).
- Implementation of a conceptual framework model for the regulation of water quality in an integrated, preventative management approach. This is a WRC project being undertaken by Golder Associates in association with Jeffares & Green (Pty) Ltd). Phase 1 of the project is complete with Phase 2 underway, using the Breede River Catchment, between Slanghoek and Bonnievale, as the case study area.

Information and experience (adaptive learning) gained in the above mentioned projects are incorporated in the current project in order to optimise synergy and resource allocation. In addition the extensive investigation into all relevant institutional (universities), government and public sector projects, programmes, research endeavours, etc. conducted during the information gathering stage of the project is aimed at fostering synergistic collaboration with these initiatives.

During the FOBWA workshop the project team was invited to attend a workshop hosted by the Living Lands on the 5th-6th November 2009, of which the aim was to facilitate dialogue around proposed measures and incentives for landscape and/or catchment restoration (e.g. Payments or Rewards for Ecosystem Services schemes (PES/PWS)) in and around the Baviaanskloof Mega-Reserve. This workshop was attended by national and international specialists conducting research in the study area as well as representatives from local and provincial government, farmers and other key stakeholders from amongst others the tourism sector. Living Lands have initiated the PRESENCE (Participatory Restoration of Ecosystem Services & Natural Capital, Eastern Cape) on-line portal l[42] for all research initiatives

[42] http://www.livinglandscapes.co.za/

conducted within the BMR study area in an attempt to strategically coordinate research efforts.

8.1.5 Focus group meetings

Focus group meetings were held with key individuals identified during the aforementioned processes in order to further gather information and establish collaborations. The first focus group meeting was held with the head of the proto-CMA, Ms Bolekwa Kama[43] on the 21st October 2009. The purpose of the meeting was:

- To establish collaboration with the CMA Division with regards to the development of a CMS for the Baviaanskloof Mega Reserve study area;
- To assess the current status quo with regards to the establishment of the CMA and CMS for the study area;
- To assess what data, current and future projects, new strategies and or tools and or instruments are in place or being developed by DWAF for CMA implementation;
- To establish the current status quo in terms of water resources protection and use in the BMR study area.

The second focus group meeting was held on the 22nd October 2009 with Mr Dana Grobler[44]. Mr Grobler has 20 years experience specialising in water resource management and monitoring. He is also the C.A.P.E ERI task team co-ordinator and is an advisor for the eWISA website as well as the facilitator of the subsequent catchment management workshops arranged by the project team with a core team of key stakeholders. The purpose of the meeting was to determine if all key role players in the catchment have been identified as well as discuss some of the key catchment issues.

A third focus group meeting was held on the 3rd November 2009 with Mr Dana Grobler, Mr Willie Enright and Mr Pierre Joubert. Mr Enright has 35 years of experience, specialising in water resources and water services management. He has been part of several separate task teams assisted to drafting and developing the National Water Act, National Water Resources Strategy and the Guideline for Catchment Management Strategies. He has also been a leader in transformation of irrigation boards into Water User Associations and in the establishment of the Breede-Overberg, Gourits, Olifants-Doorn and Berg CMAs. The purpose of this focus meeting was to prepare for the first Catchment Management Workshop.

8.1.6 Catchment management workshop

The next level of stakeholder engagement is a series of expertly facilitated stakeholder workshops during which soft systems modelling concepts are employed. The first catchment management workshop was held on the 4th of December 2009 at the Gamtoos Irrigation Board in Patensie. This first catchment management workshop was aimed at developing a “Rich Picture” of the BMR catchment.

This workshop was initially characterised by an "explosive" divergence, of which the aim was to find out who was involved (clients and owners), what the culture of the problem was, what activities were taking place and in what political framework these activities take place, in order to make sure that no important hidden issues were left out of the process. When it was certain that all the important and relevant issues were on the table, convergence took place where the key issues, key stakeholders, main objectives, etc. (often different for

[43]Catchment Manager; DWAF East London; Tel: 043 701 0221; email: kamab@dwaf.gov.za
[44] Blue Science, Tel: 021 887 7161; website: www.bluescience.co.za

different stakeholder groups) were distilled and grouped into systems of human activity (e.g. agriculture).

Following this explosive divergence a *convergence* process (formulation of Root Definitions) took place that involved the active facilitation of maximal overlap between defining characteristics (indicators/criteria) of different systems of human activity. "

The outcome of this 1st catchment management workshop was a "structured problem situation" which constituted a number of systems of human activity (or sectors within the study "environment") from which relevant (to debate) systems could be selected. After review of these results it became apparent that another workshop was needed to refine the results. A 2nd catchment management workshop was held on the 16th March 2010 at the Gamtoos Irrigation Board in Patensie. At this workshop the vision of the catchment was revised, new systems of human activity were determined as well as transformation processes. This new structured problem situation formed the basis of the conceptual catchment management model.

8.2 INFORMATION DATABASE

The Information Database was designed using Microsoft Access. Stakeholder information was categorised into 6 tables in MS Access as follows:

- Category_Type
- Contacts
- Documents
- Document_Type
- Organization Type List
- Organization List

Links were designed within each table so that information in one table could be linked to information in another table with the use of a drop-down menu for the selection of the preferred link. This enables the user to coordinate and link information while working in one table, to information in another table without having to manually open the other table. Information in the tables that have been created can be amended and refined to suit the needs of the person working with the table. Additional information can be added, existing information can be edited and information that is no longer required can be deleted without compromising the basic layout of the table.

It is important to note that the design of the database must be flexible to the needs of the project as it develops. What has been designed to date is expected only to form the foundation of a stakeholder management system which can develop as the catchment management model develops.

8.3 PERFORMANCE MANAGEMENT SYSTEM

The human activity systems that were determined during the workshops were then analysed in terms of the STEEP approach and divided into social, technological, ecological, economic and political categories. A desktop analysis based on Chapter 6 of the CMS guidelines - Sub-strategies of the CMA (Pgs 47-126; DWAF, 2007) was subsequently undertaken to review the various results from the workshops. *Issues* identified during the workshops were categorised as sub-systems under each human activity system. Results from the workshops were then used to derive the *Objectives* for each sub-system. Measurable indicators were assigned to objectives so that they can be monitored to determine if the objectives have been reached. The indicators were determined by reviewing the CMS

guidelines (DWAF, 2007), the workshop notes and other documentation from the information database.

8.4 CONCEPTUAL MODEL

The conceptual catchment management model was compiled by conducting internal workshops with the project team. The transformation processes that were identified during the catchment management workshops were linked to the systems of human activities and to their subsystems. Similar transformation processes were identified and grouped together and the links between the transformation processes were also identified. Owners[45] were also allocated to each system of human activity and the actors[46] were allocated to each subsystem. The management objectives were derived through categorizing the activities which arose from the transformation processes and assessing the performance indicators. As a result of this analysis, twelve broad-scale management objectives were identified. It must be noted that these are preliminary, and the sub-objectives under these broad objectives will be identified in consultation with the catchment stakeholders during Phase 2 of the project.

8.5 SYSTEMS DYNAMIC MODEL

A System Dynamics Model was created using a computer programme known as iThink™ system dynamics modelling software. The SDM was created based on the Systems Diagram constructed during the conceptual modelling stage. The Transformational Processes as well as the Systems of Human Activity that had been identified in the development of the Conceptual Model were used as the basis for formulating the elements of the system. These Transformational Processes and Systems of Human Activity were formulated following the workshops held with stakeholders on the 16 and 17 March 2010. The system of Baviaanskloof Mega Reserve was divided into 5 sectors, namely:

- Water
- Environment
- Institutional sector
- Human activities
- Funding and investment

Within each of the five sectors, stocks were identified, as well as the associated flows and converters that link to each other. The stocks were what could be termed sub-components of each sector. These were aspects that defined those sectors. For example within the Environmental sector, the stocks were environmental matters such as biodiversity, aesthetics, alien vegetation and habitat. The linkages within the system were not limited within each sector for each sector only, but were also cross-sectoral. This means that, for example, a flow within one sector could link to a flow within the same sector, and / or a flow in another sector. The same applied to converters. One converter could link to another converter, whilst linking to a flow in another sector.

[45] Owner: Who can stop the process (or who is ultimately responsible and accountable), e.g. the Minister of the Department Water Affairs and Forestry.
[46] Actors: Who takes the action (or who has the mandate for transformation), e.g. DWAF or the CMA.

9 OUTCOMES

9.1 INFORMATION GATHERING & STAKEHOLDER ENGAGEMENT

9.1.1 Information gathering

The list of data and information gathered thus far in respect of the Baviaanskloof Mega Reserve study area include:

1. Strategic Management Plan Baviaanskloof Cluster, Draft 1, February 2007 (Eastern Cape Parks Board 2007).
2. Fish/Tsitsikamma Water Management Area. Tsitsikamma to Coega Internal Strategic Perspective. Version 1. 2004. DWAF Report No: PWMA 15/000/00/0304 (DWAF. 2004b).
3. Fish/Tsitsikamma Water Management Area. Water Resources Situation Assessment. Main Report Vol. 2: APPENDICES. 2002. DWAF Report No: P15000/00/0101 (DWAF, 2002).
4. Department of Water Affairs and Forestry. 2004. National Water Resource Strategy. First Edition. Appendix D. Pretoria (DWAF, 2004a).
5. A macroinvertebrate biomonitoring investigation using SASS5 index, in the Gamtoos River (Eastern Cape), undertaken in the context of the River Health Programme. (Coetzee 2004).
6. Kirkman, K.E. 2006. Baviaans Conservancy Feasibility Study: Feasibility study to investigate the conversion of land-use from domestic stock farming to sustainable biodiversity-based ventures.
7. Joubert, A. Smith, B. & Neke, K. Preliminary assessment of the proposed consolidation and expansion of the western sector of the Baviaanskloof Wilderness Area.
8. Baviaans Municipality. Final Integrated development Plan 2007-2012. Reviewed 2008.
9. Wilson, L.S. & Smith, N. 2002. Changing land use trends in the thicket biome: Pastoralism to game farming. Terrestrial Ecology Research Unit. Report No. 38.
10. Cumming, T.L. 2007. Conservation initiative for private commercial farmers in the ticket biome, Eastern Cape, South Africa. Masters of Science, Rhodes University.
11. Baviaanskloof Mega Reserve Project Management Unit. 2004. Baviaanskloof Mega Reserve (EC), Conservation Strategy 2004-2007. Third Draft.
12. Constitution and minutes of meetings for the Baviaanskloof Steering Committee.
13. Sue Matthews. 2008. Kouga Catchment enters rehab. Water Wheel Article January / February 2008.
14. Department of Water Affairs and Forestry. 2000. Implementation guidelines for water conservation and water demand management in agriculture. Development of irrigation water management plans.
15. Department of Water Affairs and Forestry. 2004. National water conservation and water demand management strategy.
16. Department of Water Affairs and Forestry. 2004. Water conservation and water demand management strategies for the agricultural sector.
17. Department of Water Affairs and Forestry. 2004. Water conservation and water demand management strategies for the industry, mining and power generation sectors.
18. Department of Water Affairs and Forestry. 2004. Water conservation and water demand management strategies for the water services sector.
19. Water Research Commission. Guidelines for catchment management to achieve integrated water resources management in South Africa. Part I & II.

20. Department of Agriculture. 2002. National guideline for the integrated management of agricultural water use.
21. Department of Water Affairs and Forestry. 2006. Resource Directed Management of Water Quality: Management Instruments. Edition 2. Water Resources Planning Systems Series.
22. Historical flow and water quality data from the DWAF weir on the Groot (L7H006) and Kouga (L8H005) Rivers.
23. EarthCollective (eds). 2008. PRESENCE Seed Phase: Workshop Outcomes. Patensie, South Africa and Wageningen, The Netherlands.
24. Noirtin E. 2008. Analysis of stakeholder interactions and involvement in thicket restoration, Western Baviaanskloof, South Africa: Who is willing to restore and why? MSc thesis. Wageningen University, The Netherlands. Commissioned by the PRESENCE learning network. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=10
25. Lorencová. E. 2008. Exploring the organizational institutional capacity of the carbon sequestration projects in South Africa: A comparison between Clean Development Mechanism (CDM) and voluntary carbon offset schemes; Case study of the Subtropical Thicket restoration in Baviaanskloof, the Eastern Cape MSc thesis. Wageningen University, The Netherlands. Commissioned by the PRESENCE learning network. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=9
26. De la Flor Tejero, I. 2008. Valuation of the Goods and Services provided by the Thicket Ecosystem in the Western Baviaanskloof, South Africa MSc thesis. Wageningen University, The Netherlands. Commissioned by the PRESENCE learning network. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=11
27. Jansen. K. 2008. The relevance of socio-cultural values of ecosystem services to restoration planning and implementation in the Baviaanskloof. MSc thesis Wageningen University, The Netherlands. Commissioned by the PRESENCE learning network. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=12
28. Van der Burg, L. 2008. Valuing the benefits of restoring the water regulation services, in the subtropical thicket biome: a case study in the 'Baviaanskloof-Gamtoos watershed', South-Africa MSc thesis. Wageningen University, The Netherlands. Commissioned by the PRESENCE learning network. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=14
29. Powell, M. 2009. Restoration of degraded subtropical thickets in the Baviaanskloof Mega Reserve, South Africa – The role of carbon stocks and Portulacaria afra survivorship. MSc thesis. Department of Environmental Science, Rhodes University. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=33
30. Jansen, H.C. 2008. Water for food and ecosystems in the Baviaanskloof Mega Reserve. Land and water resource assessment in the Baviaanskloof, Eastern Cape Province, South Africa. Alterra Report 1812-ISSN1566-7197. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=22
31. De Palio, G. 2008. River system restoration for a sustainable land and water management in the Baviaanskloof Mega Reserve. Preliminary assessment of the opportunities and challenges to the creation of a payment for watershed services scheme. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=16
32. Ali Javed, H. 2009. Investigating the Institutional Arrangements Required to Implement Payment for Environmental Services (PES): A Case Study in Baviaanskloof Watershed, South Africa MSc thesis. Wageningen University, The Netherlands. Commissioned by the PRESENCE learning network. http://www.livinglandscapes.co.za/forum/downloads.php?do=file&id=15

9.1.2 Stakeholder engagement

A list of key stakeholders were identified within the various sectors involved in the BMR study area and from these stakeholders a core of key role players were identified and invited to the first facilitated catchment management workshop (Table 1). This group of key stakeholders (henceforth called the Core Team) will play an important role in the strategic management of the BMR catchment in future. The ECDWAF Catchment Management Division that has been engaged at the start of the project is on board and enthusiastic about collaborating with the Core Team (lead by the CEO of the Gamtoos Irrigation Board – Pierre Joubert) in designing a CMS for the BMR study area.

Table 1: Key stakeholders that participated in the catchment management workshops

Name	Affiliation	Role in Organisation
W Erlank	ECPB	
P Joubert	Gamtoos Irrigation Board (GIB)	CEO
VDM du Preez	GIB	Treasurer
M Brouard	FOBWA	Chairperson of the FOBWA.
L Matyana	DWA – Port Elizabeth	Working for Water
S Ngilana	DWA – Port Elizabeth	Chief development expert
M Sitole	DWA – East London: Institutional Development and Support	Principal Community Development Officer
D van den Broeck	Living Lands	PRESENCE Enabler: Ecosystem Management & Restoration
G Shaw	ECPB	Reserve Manager; Cockscomb Section, Baviaanskloof Nature Reserve
T Steyn	ECPB	Coordinator: Baviaanskloof Mega Reserve
S Blie	DWA	Water Allocation Reform
J Buckle	SANBI	Working for Wetlands
P Kruger	Baviaans Landebou	Farmer
H Bateman	TerraPi	Managing Director of TerraPi

The 1st workshop discussed the issues of concern for the catchment and which included the following:

- Climate change,
- Value of water,
- Legal issues
- Livelihood alternations,
- Population control
- Ignorance, awareness and compassion
- Riparian channel degradation
- Institutional issues
- Socio-economic issues

The 1st workshop also provided a vision for the catchment as well as a list of systems of human activity within the catchment. During the 2nd workshop, the vision (Table 2) and systems of human activity (Table 3) were revised and refined. Various transformation processes for each system of human activity were then identified by the stakeholders during the 2nd workshop and these were refined during the design of the conceptual model. The actors and owners for each system of human activity were also identified (Table 4).

Table 2: Vision for the catchment

Vision for the catchment	
1st Workshop	**2nd Workshop**
Holistic management (IWRM) based on the sustainability triad	Holistic sustainable management
Mega Reserve	Biosphere reserve
World Heritage Site	Accountable, responsible cooperative governance
Integrated Management Corridors	Foster social cohesion through social marketing
Wilderness	Integrated restoration strategy
	Equitable distribution of resources
	Self sustaining financial entity
	Foster a paradigm shift in all aspects

Table 3: Systems of Human Activity

Systems of Human Activity	
1st Workshop	**2nd Workshop**
Quality of Life	Legal compliance and enforcement
Production & Economics	Social marketing
Social & Culture	Catchment Management funding and administration
Water utilisation	Tourism
Land use	Agriculture
Legislation	Conservation
	Human settlement
	Other commercial activities (Industry, mining & business)

Table 4: Owners and actors for each System of Human Activity.

System of human activity	Owner	Actor
Legal compliance and enforcement	DWA & ECPB	Green scorpions, EMI
Social marketing	DWA & ECPB	Living lands
Catchment Management funding and administration	DWA & CMA	GIB
Tourism	ECPB	Farmers, ECPB, Gamtoos tourism board, TerriPi, FOBWA, tourism liaison board
Agriculture	Dept of Agriculture	GIB, Farmers
Conservation	ECPB	ECPB, farmers, NGO's (TerriPi)
Human settlement	Department of Housing & Development, district and local municipalities	Land owners, urban and rural communities, commercial enterprises
Other commercial activities (Industry, mining & business)	Dept of Minerals and Energy, Department of Trade and Industry	Juice factory, quarry, SMME's, businesses

9.2 INFORMATION DATABASE

Six tables were created in the Microsoft Access Information Database and these included:

- Category type
- Contacts
- Documents
- Document type

- Organization type list
- Organization list

The preliminary design for the Microsoft Access Information Database is provided in Figure 9.

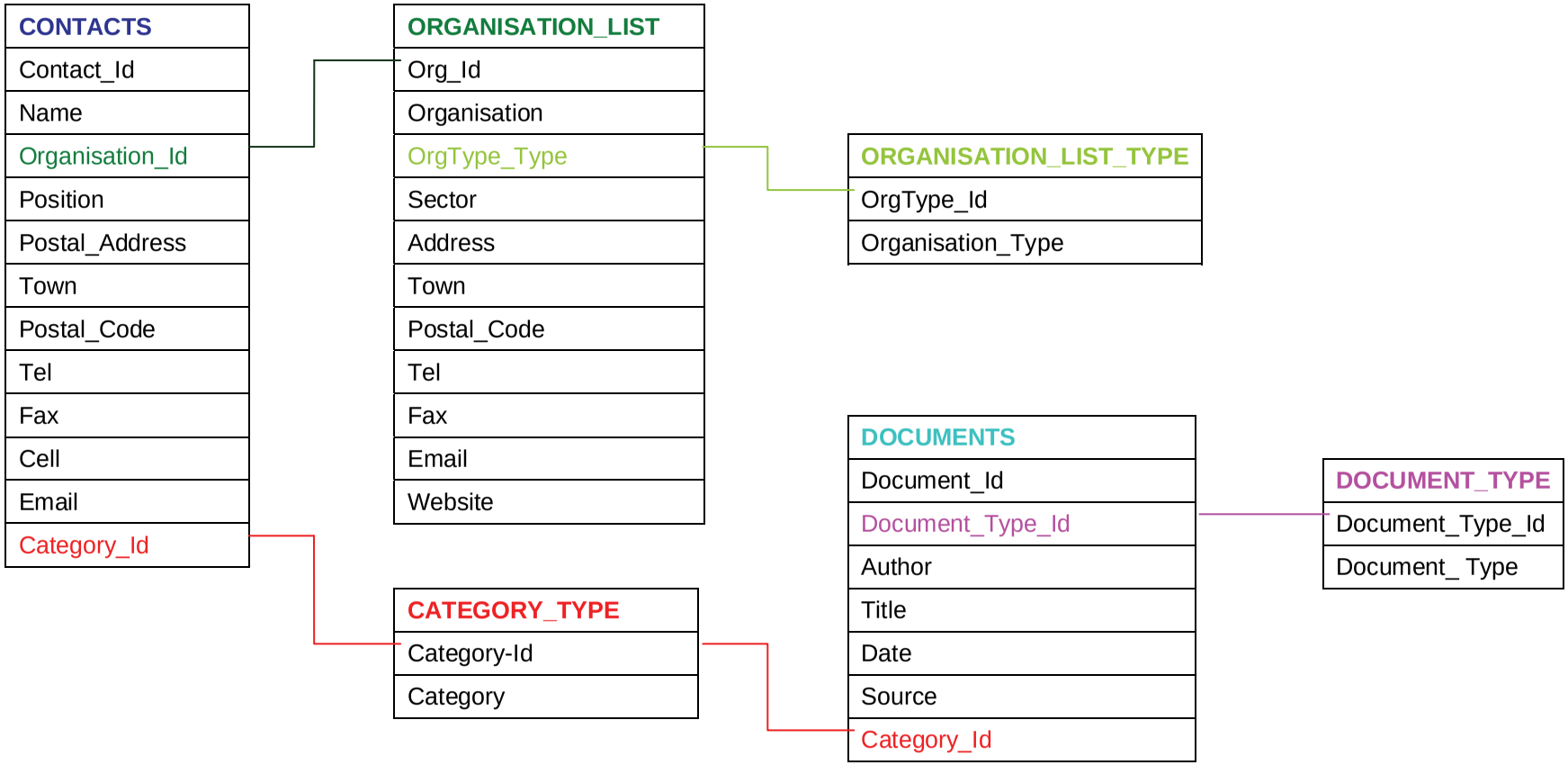


Figure 9: Preliminary design of the Microsoft Access Information database

9.2.1 Category_Type

This table lists the five different categories (Table 5) under which the organizations, research material and persons can be classified. These categories include Social, Technological, Ecological, Economic and Political. This is the STEEP concept, as has been indicated in the DWAF guidelines for Catchment Management Strategies (DWAF, 2007).

Table 5: Category types listed in the Information Database.

Category_ID	Category
1	Social
2	Technological
3	Ecological
4	Economic
5	Political

9.2.2 Contacts

This table provides a comprehensive list of the stakeholders identified thus far, the organization to which they belong, and their contact details (Annexure 4). The stakeholders have also been placed into the relevant category type, as according to the STEEP concept. An example of the Microsoft Access Contact table is provided in Figure 10.

9.2.3 Documents

This table provides a comprehensive list of all documentation that has been sourced during Phase I of the project (Annexure 5). The documents table includes the name of the article, the author, date of publication, and in addition to that the various documents have been categorized as according to the STEEP concept. An example of the Microsoft Access Document table is provided in Figure 11.

9.2.4 Document_Type

The document_type indicates the format in which the captured document is captured. The different document types are listed in Table 6.

Table 6: Microsoft Word table illustrating the document type list

Document_Type_Id	Document_Type
1	PDF
2	Word
3	Excel
4	Power point
5	Hard Copy

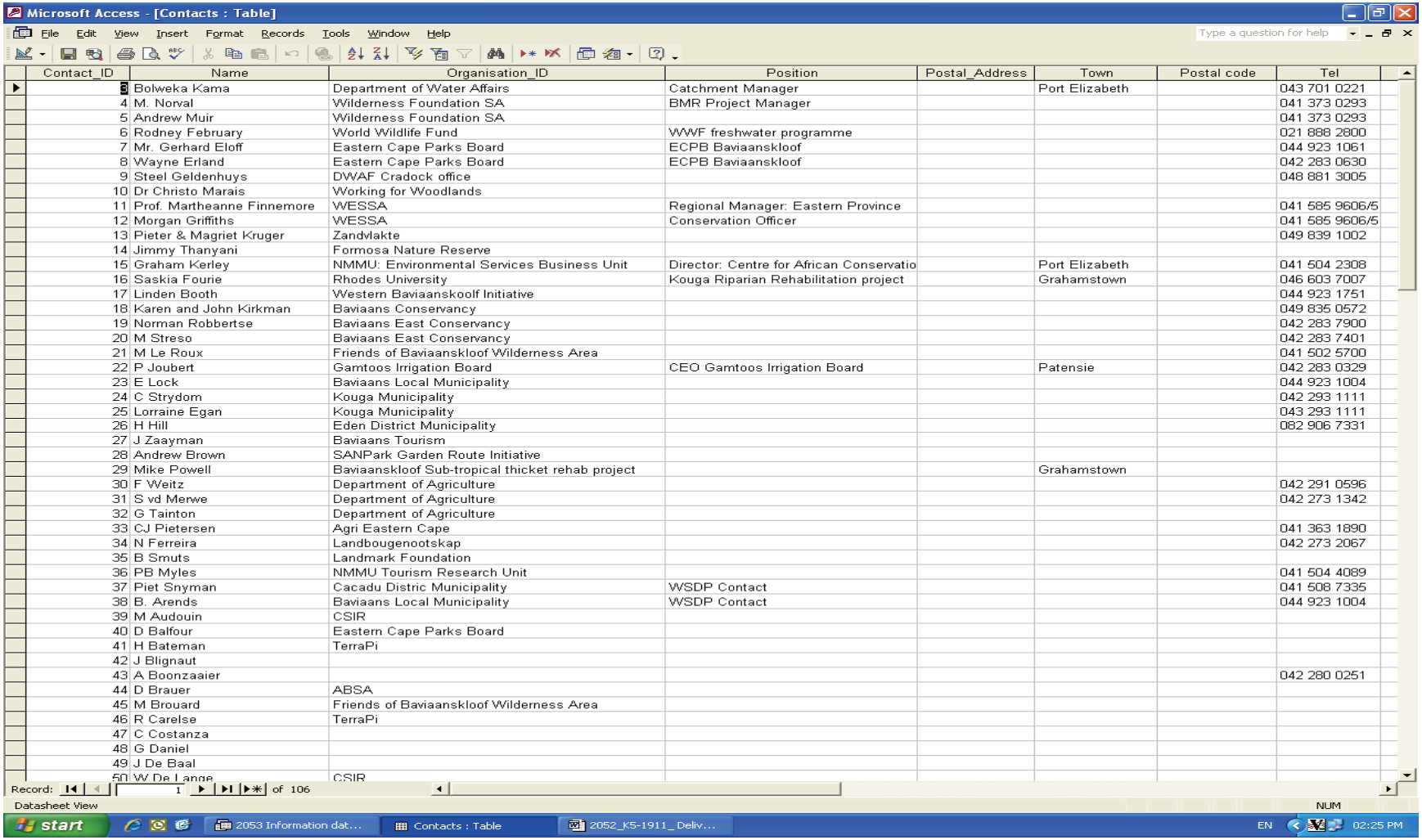
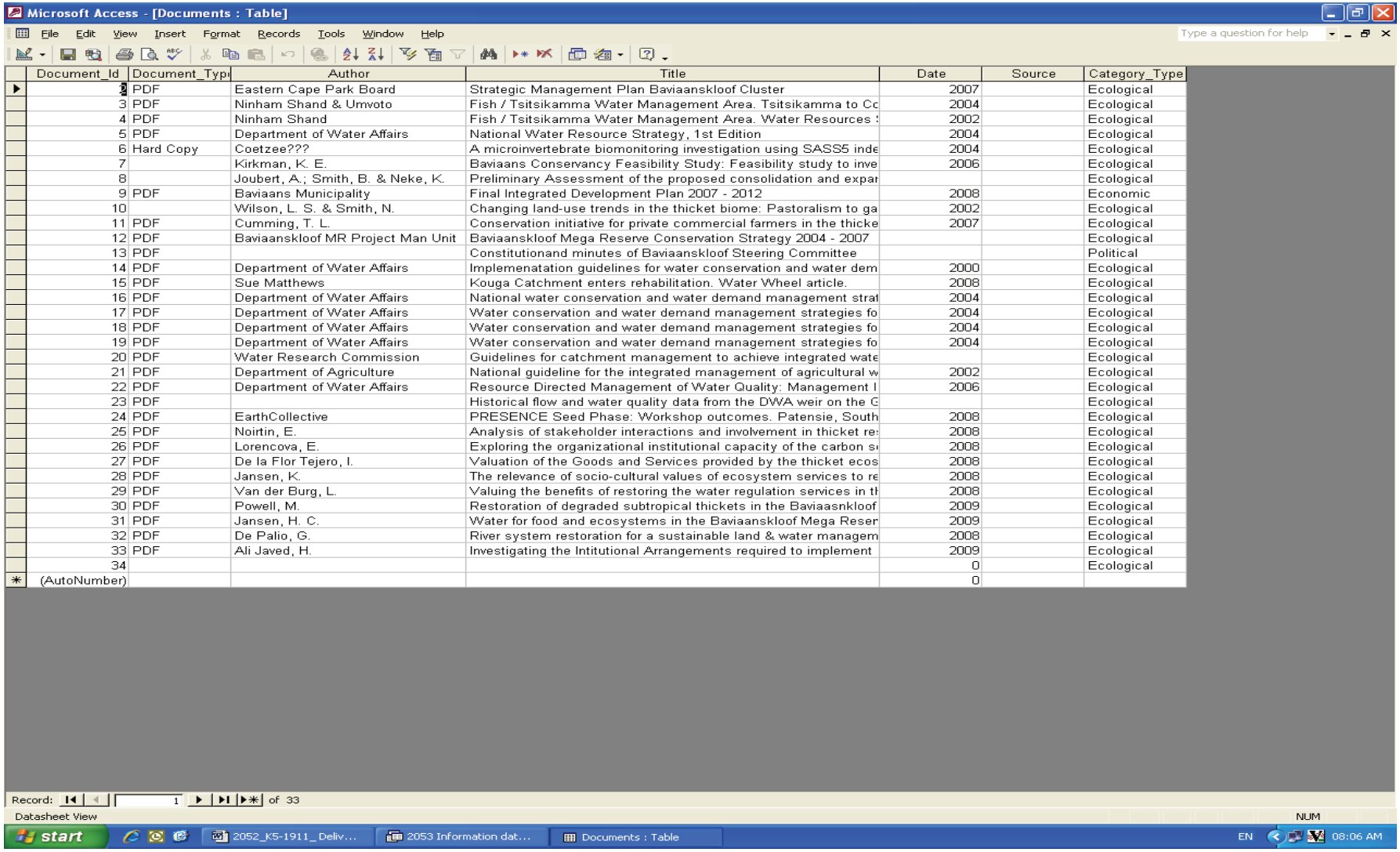


Figure 10: Example of the Microsoft Access Contact table



Document_Id	Document_Typ	Author	Title	Date	Source	Category_Type
2	PDF	Eastern Cape Park Board	Strategic Management Plan Baviaanskloof Cluster	2007		Ecological
3	PDF	Ninham Shand & Umvoto	Fish / Tsitsikamma Water Management Area. Tsitsikamma to Cc	2004		Ecological
4	PDF	Ninham Shand	Fish / Tsitsikamma Water Management Area. Water Resources :	2002		Ecological
5	PDF	Department of Water Affairs	National Water Resource Strategy, 1st Edition	2004		Ecological
6	Hard Copy	Coetzee???	A microinvertebrate biomonitoring investigation using SASS5 inde	2004		Ecological
7		Kirkman, K. E.	Baviaans Conservancy Feasibility Study: Feasibility study to inve	2006		Ecological
8		Joubert, A.; Smith, B. & Neke, K.	Preliminary Assessment of the proposed consolidation and expar			Ecological
9	PDF	Baviaans Municipality	Final Integrated Development Plan 2007 - 2012	2008		Economic
10		Wilson, L. S. & Smith, N.	Changing land-use trends in the thicket biome: Pastoralism to ga	2002		Ecological
11	PDF	Cumming, T. L.	Conservation initiative for private commercial farmers in the thicke	2007		Ecological
12	PDF	Baviaanskloof MR Project Man Unit	Baviaanskloof Mega Reserve Conservation Strategy 2004 - 2007			Ecological
13	PDF		Constitutionand minutes of Baviaanskloof Steering Committee			Political
14	PDF	Department of Water Affairs	Implemenatation guidelines for water conservation and water dem	2000		Ecological
15	PDF	Sue Matthews	Kouga Catchment enters rehabilitation. Water Wheel article.	2008		Ecological
16	PDF	Department of Water Affairs	National water conservation and water demand management strat	2004		Ecological
17	PDF	Department of Water Affairs	Water conservation and water demand management strategies fo	2004		Ecological
18	PDF	Department of Water Affairs	Water conservation and water demand management strategies fo	2004		Ecological
19	PDF	Department of Water Affairs	Water conservation and water demand management strategies fo	2004		Ecological
20	PDF	Water Research Commission	Guidelines for catchment management to achieve integrated wate			Ecological
21	PDF	Department of Agriculture	National guideline for the integrated management of agricultural w	2002		Ecological
22	PDF	Department of Water Affairs	Resource Directed Management of Water Quality: Management I	2006		Ecological
23	PDF		Historical flow and water quality data from the DWA weir on the G			Ecological
24	PDF	EarthCollective	PRESENCE Seed Phase: Workshop outcomes. Patensie, South	2008		Ecological
25	PDF	Noirtin, E.	Analysis of stakeholder interactions and involvement in thicket re:	2008		Ecological
26	PDF	Lorencova, E.	Exploring the organizational institutional capacity of the carbon s	2008		Ecological
27	PDF	De la Flor Tejero, I.	Valuation of the Goods and Services provided by the thicket ecos	2008		Ecological
28	PDF	Jansen, K.	The relevance of socio-cultural values of ecosystem services to re	2008		Ecological
29	PDF	Van der Burg, L.	Valuing the benefits of restoring the water regulation services in th	2008		Ecological
30	PDF	Powell, M.	Restoration of degraded subtropical thickets in the Baviaasnkloof	2009		Ecological
31	PDF	Jansen, H. C.	Water for food and ecosystems in the Baviaanskloof Mega Reser	2009		Ecological
32	PDF	De Palio, G.	River system restoration for a sustainable land & water managem	2008		Ecological
33	PDF	Ali Javed, H.	Investigating the Intitutional Arrangements required to implement	2009		Ecological
34				0		Ecological
(AutoNumber)				0		

Figure 11: Microsoft Access data access page illustrating the document list

9.2.5 Organization Type List

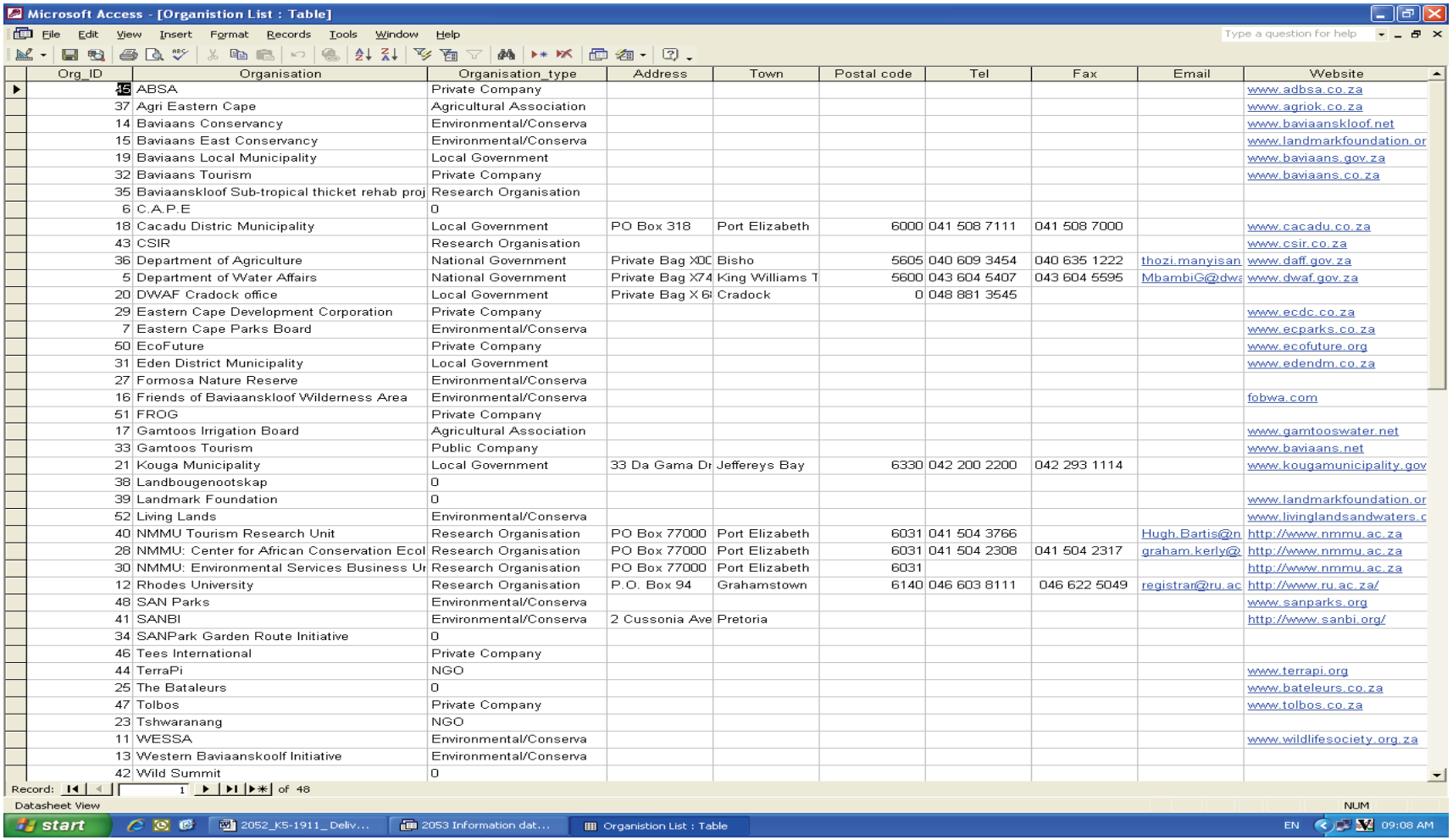
This table lists the types of organizations that have been identified during the stakeholder engagement process (Table 7). These range from the government department, agricultural organizations, community organization, research organizations to conservation organizations, just to mention a few.

Table 7: Organization types used in the Information Database

OrgTyp_ID	Organisation type
1	Agricultural Association
2	Catchment Management Agency
3	Catchment Management Forum
4	Community Organisation
5	Environmental/Conservation Organisation
6	Industrial Association
7	Irrigation Board
8	Local Government
9	National Government
10	NGO
11	Private Company
12	Provincial (Regional) Government
13	Public Company
14	Research Organisation
15	Water Board
16	Water Service Provider
17	Water User Association

9.2.6 Organization List

The organisation list provides an indication of the various organizations that were identified and contacted during the stakeholder consultation process, as well as their contact details for easier reference (Annexure 6). Figure 12 provides an example of the organisation list table in the Microsoft Access database,



Org_ID	Organisation	Organisation_type	Address	Town	Postal code	Tel	Fax	Email	Website
45	ABSA	Private Company							www.adbsa.co.za
37	Agri Eastern Cape	Agricultural Association							www.agriok.co.za
14	Baviaans Conservancy	Environmental/Conserva							www.baviaanskloof.net
15	Baviaans East Conservancy	Environmental/Conserva							www.landmarkfoundation.or
19	Baviaans Local Municipality	Local Government							www.baviaans.gov.za
32	Baviaans Tourism	Private Company							www.baviaans.co.za
35	Baviaanskloof Sub-tropical thicket rehab proj	Research Organisation							
6	C.A.P.E	0							
18	Cacadu Distric Municipality	Local Government	PO Box 318	Port Elizabeth	6000	041 508 7111	041 508 7000		www.cacadu.co.za
43	CSIR	Research Organisation							www.csir.co.za
36	Department of Agriculture	National Government	Private Bag X0(	Bisho	5605	040 609 3454	040 635 1222	thozi.manyisan	www.daff.gov.za
5	Department of Water Affairs	National Government	Private Bag X74	King Williams T	5600	043 604 5407	043 604 5595	MbambiG@dws	www.dwaf.gov.za
20	DWAF Cradock office	Local Government	Private Bag X 6i	Cradock	0	048 881 3545			
29	Eastern Cape Development Corporation	Private Company							www.ecdc.co.za
7	Eastern Cape Parks Board	Environmental/Conserva							www.ecparks.co.za
50	EcoFuture	Private Company							www.ecofuture.org
31	Eden District Municipality	Local Government							www.edendm.co.za
27	Formosa Nature Reserve	Environmental/Conserva							
16	Friends of Baviaanskloof Wilderness Area	Environmental/Conserva							fobwa.com
51	FROG	Private Company							
17	Gamtoos Irrigation Board	Agricultural Association							www.gamtooswater.net
33	Gamtoos Tourism	Public Company							www.baviaans.net
21	Kouga Municipality	Local Government	33 Da Gama Dr	Jeffereys Bay	6330	042 200 2200	042 293 1114		www.kougamunicipality.gov
38	Landbougenootskap	0							
39	Landmark Foundation	0							www.landmarkfoundation.or
52	Living Lands	Environmental/Conserva							www.livinglandsandwaters.c
40	NMMU Tourism Research Unit	Research Organisation	PO Box 77000	Port Elizabeth	6031	041 504 3766		Hugh.Bartis@n	http://www.nmmu.ac.za
28	NMMU: Center for African Conservation Ecol	Research Organisation	PO Box 77000	Port Elizabeth	6031	041 504 2308	041 504 2317	graham.kerly@	http://www.nmmu.ac.za
30	NMMU: Environmental Services Business Ur	Research Organisation	PO Box 77000	Port Elizabeth	6031				http://www.nmmu.ac.za
12	Rhodes University	Research Organisation	P.O. Box 94	Grahamstown	6140	046 603 8111	046 622 5049	registrar@ru.ac	http://www.ru.ac.za/
48	SAN Parks	Environmental/Conserva							www.sanparks.org
41	SANBI	Environmental/Conserva	2 Cussonia Ave	Pretoria					http://www.sanbi.org/
34	SANPark Garden Route Initiative	0							
46	Tees International	Private Company							
44	TerraPi	NGO							www.terrapi.org
25	The Bataleurs	0							www.bateleurs.co.za
47	Tolbos	Private Company							www.tolbos.co.za
23	Tshwaranang	NGO							
11	WESSA	Environmental/Conserva							www.wildlifesociety.org.za
13	Western Baviaanskoolf Initiative	Environmental/Conserva							
42	Wild Summit	0							

Figure 12: Microsoft Access data access page illustrating the organization list

9.3 PERFORMANCE MANAGEMENT SYSTEM

The outcomes from the identification of the preliminary set of performance management indicators are provided in Figure 13 to Figure 20. These indicators are a preliminary set, which will be refined and validated by the implementation of the model in Phase II. The results are provided in a hierarchy with the following tiers:

- Tier 1: Human activity systems, colour-coded to represent the relevant STEEP category
- Tier 2: Sub-systems within each human activity system
- Tier 3: Objectives for each sub-system
- Tier 4: Measurable indicators to ensure that each objective is reached.

Note that indicators which are highlighted **bold** are repeated in other human activity systems and represent potential loci of management control due to this identified overlap.

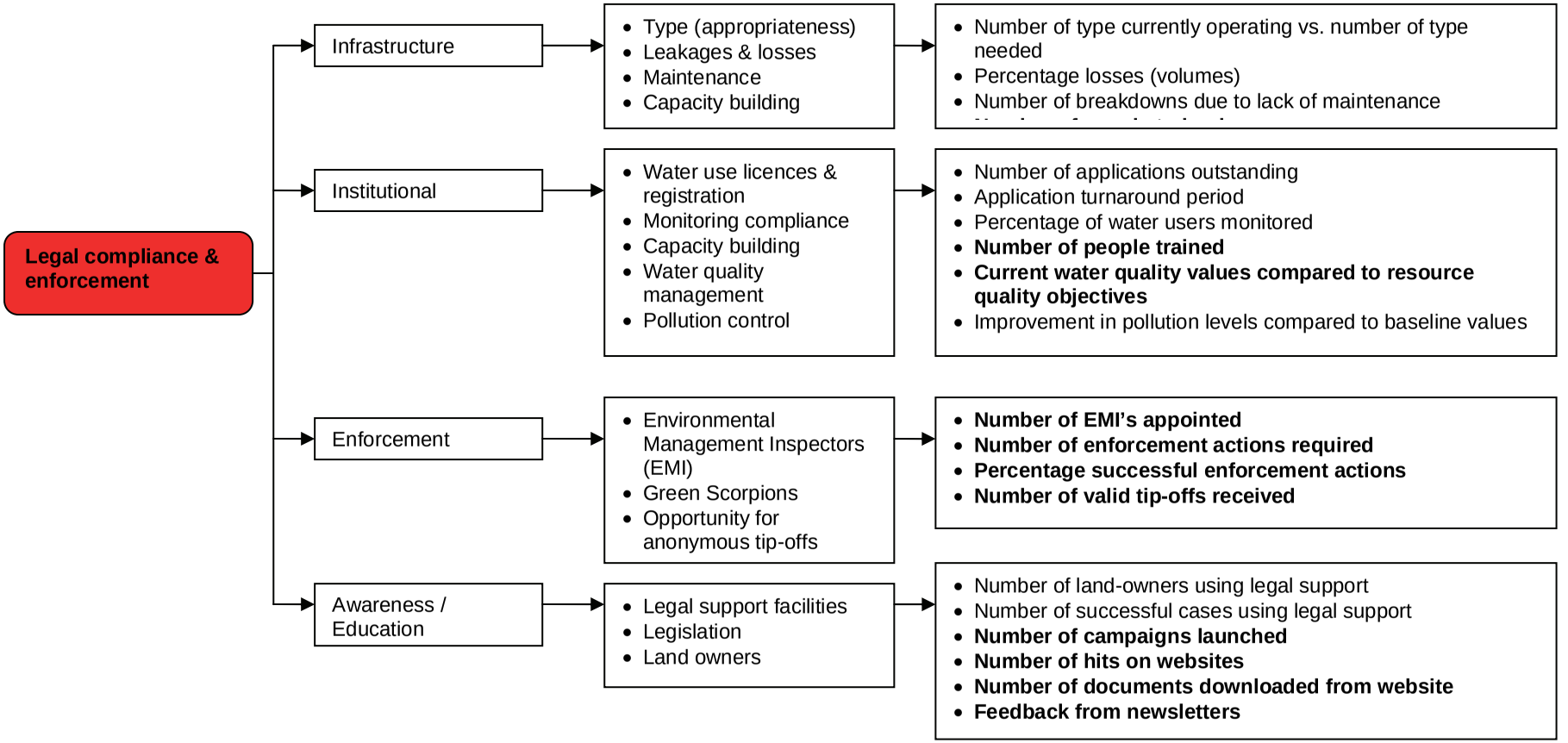


Figure 13: Hierarchy for the legal compliance and enforcement human activity system

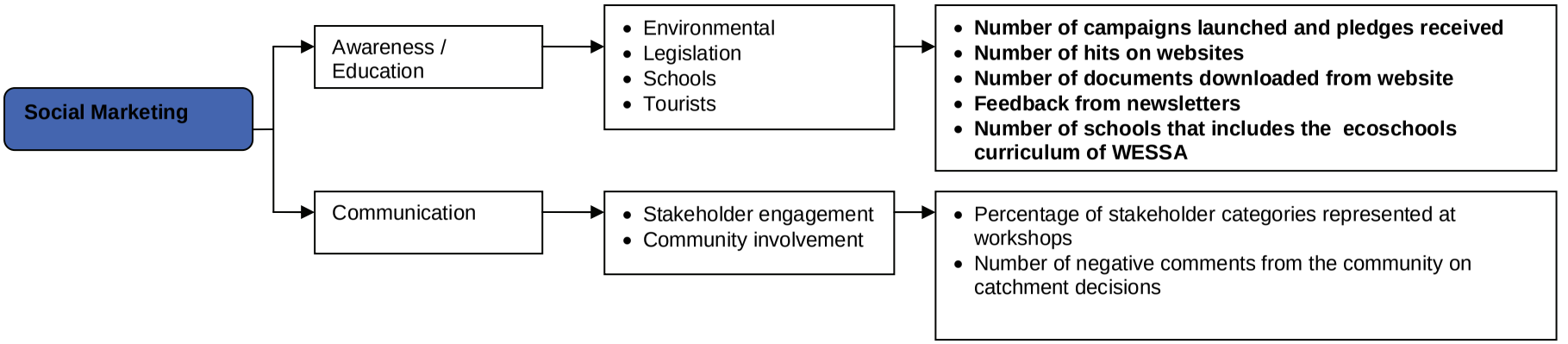


Figure 14: Hierarchy for social marketing human activity system

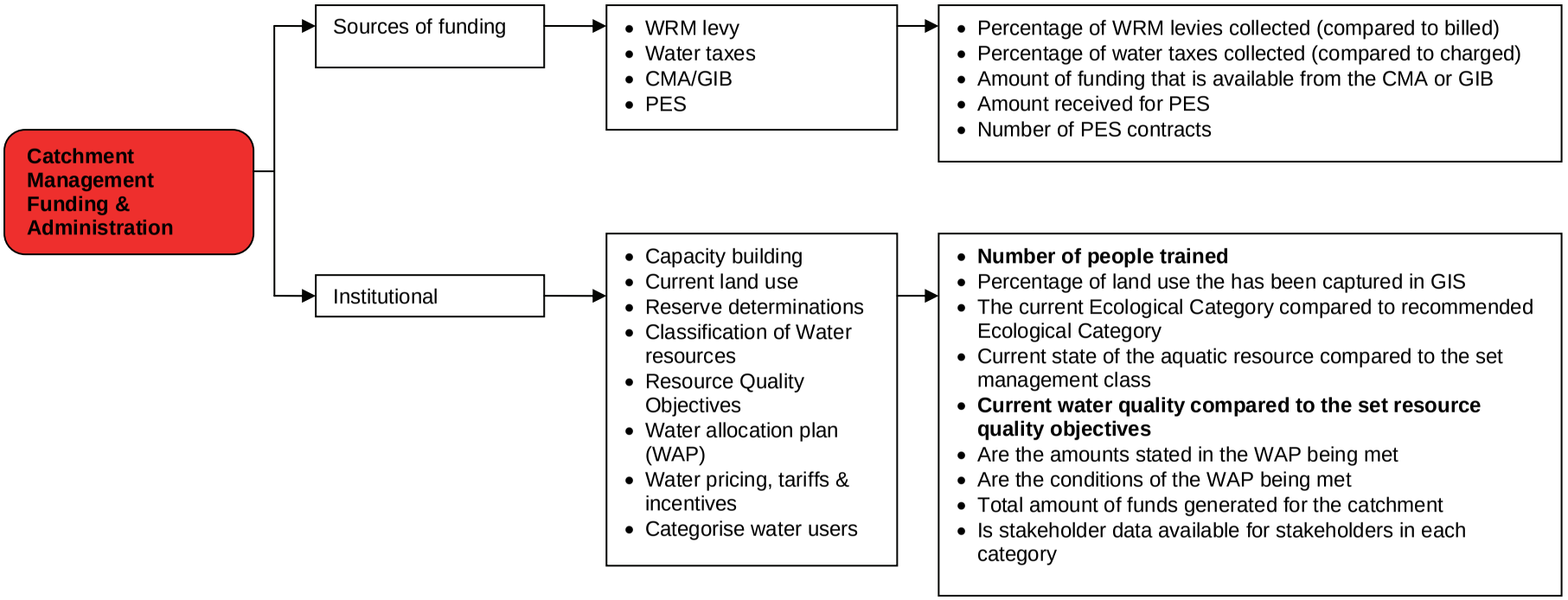


Figure 15: Hierarchy for the catchment management funding and administration human activity system

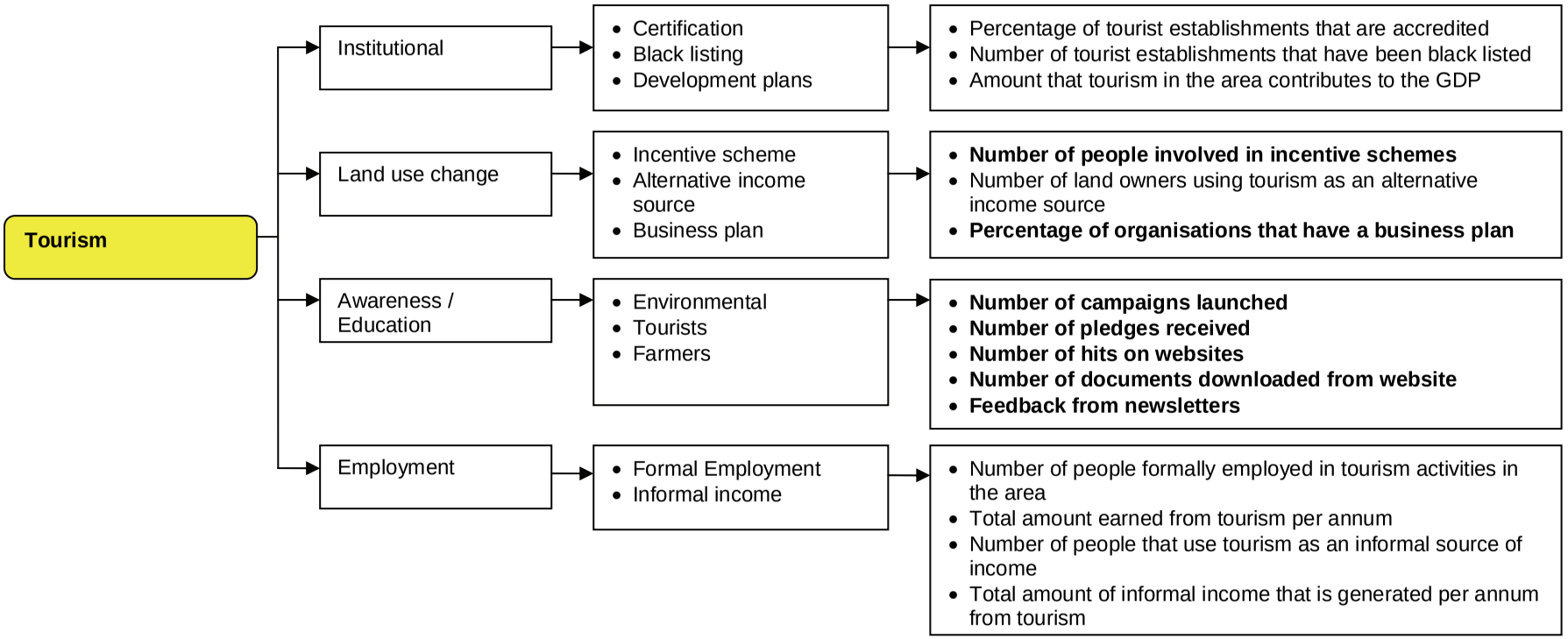


Figure 16: Hierarchy for the tourism human activity system

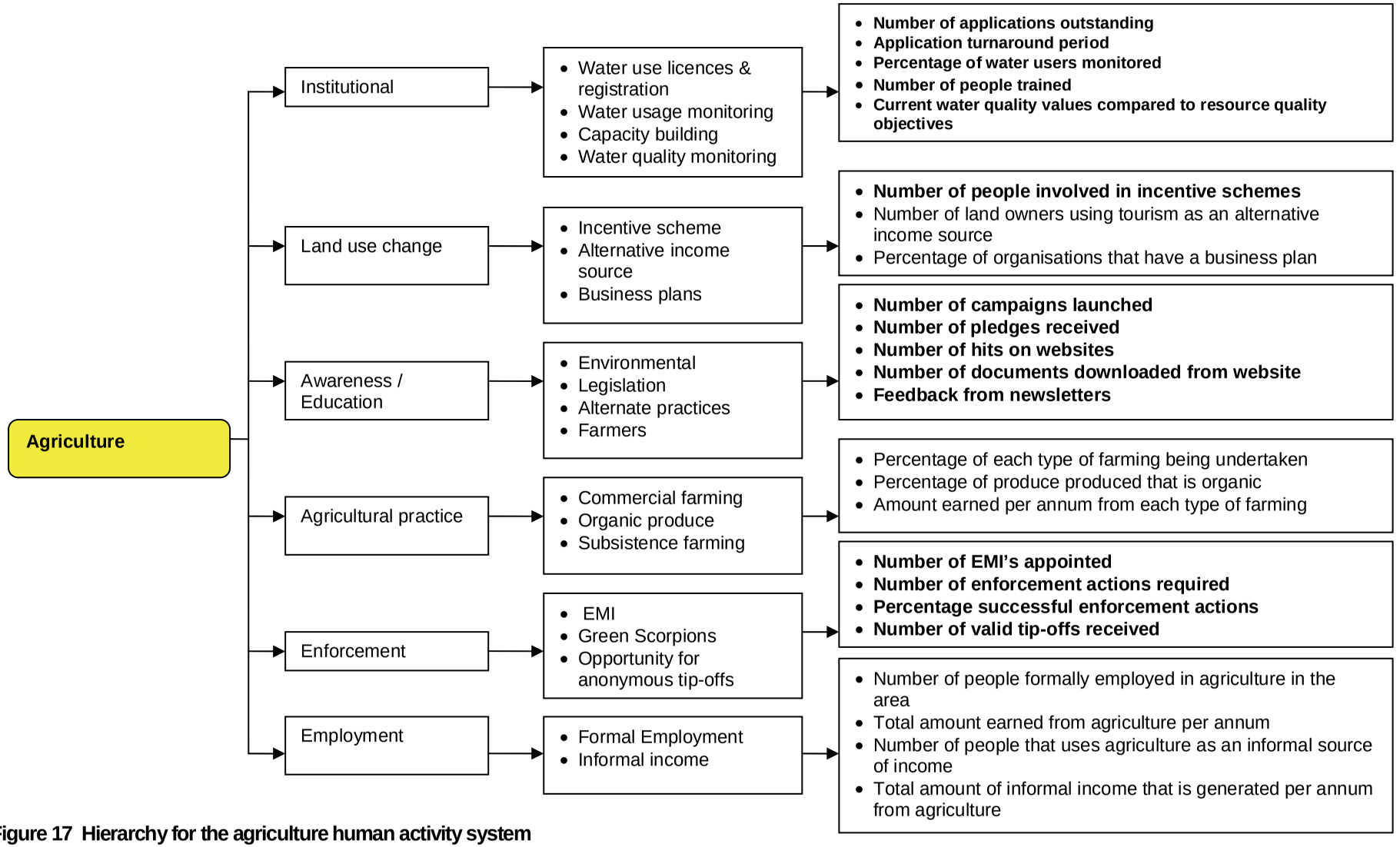


Figure 17 Hierarchy for the agriculture human activity system

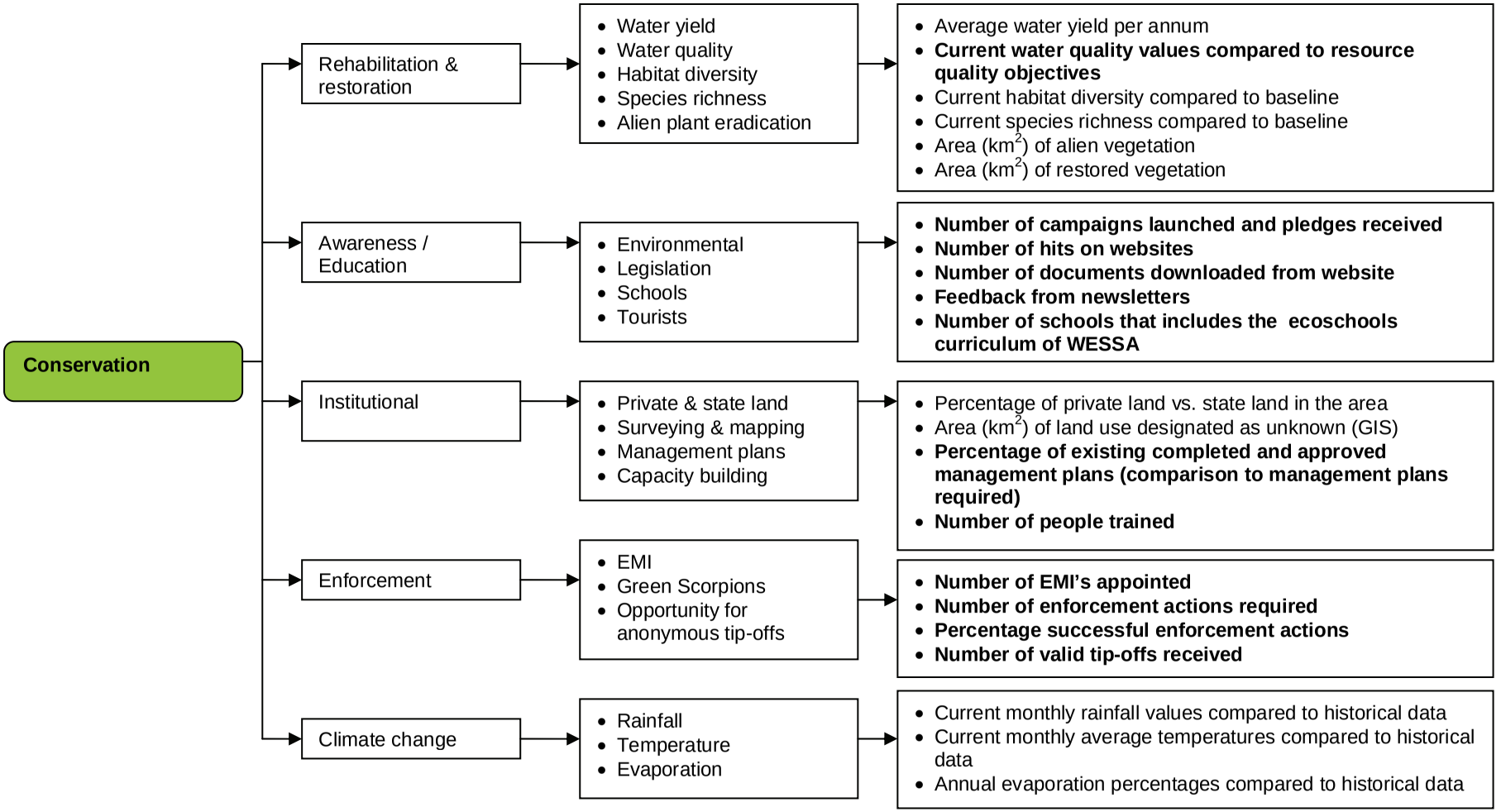


Figure 18: Hierarchy for the conservation human activity system

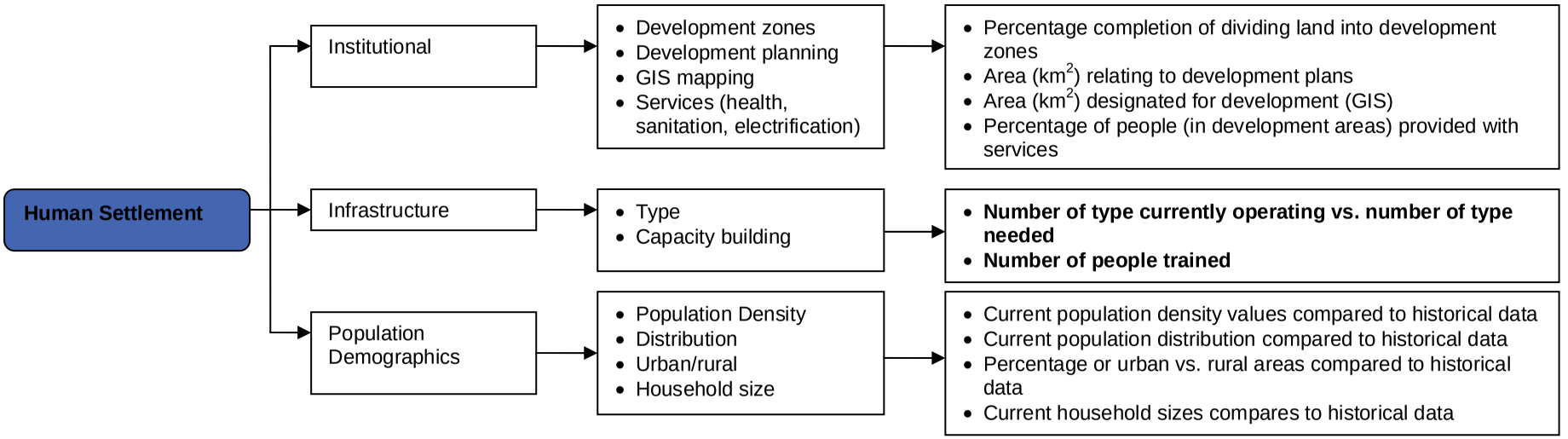


Figure 19: Hierarchy for the human settlement human activity system

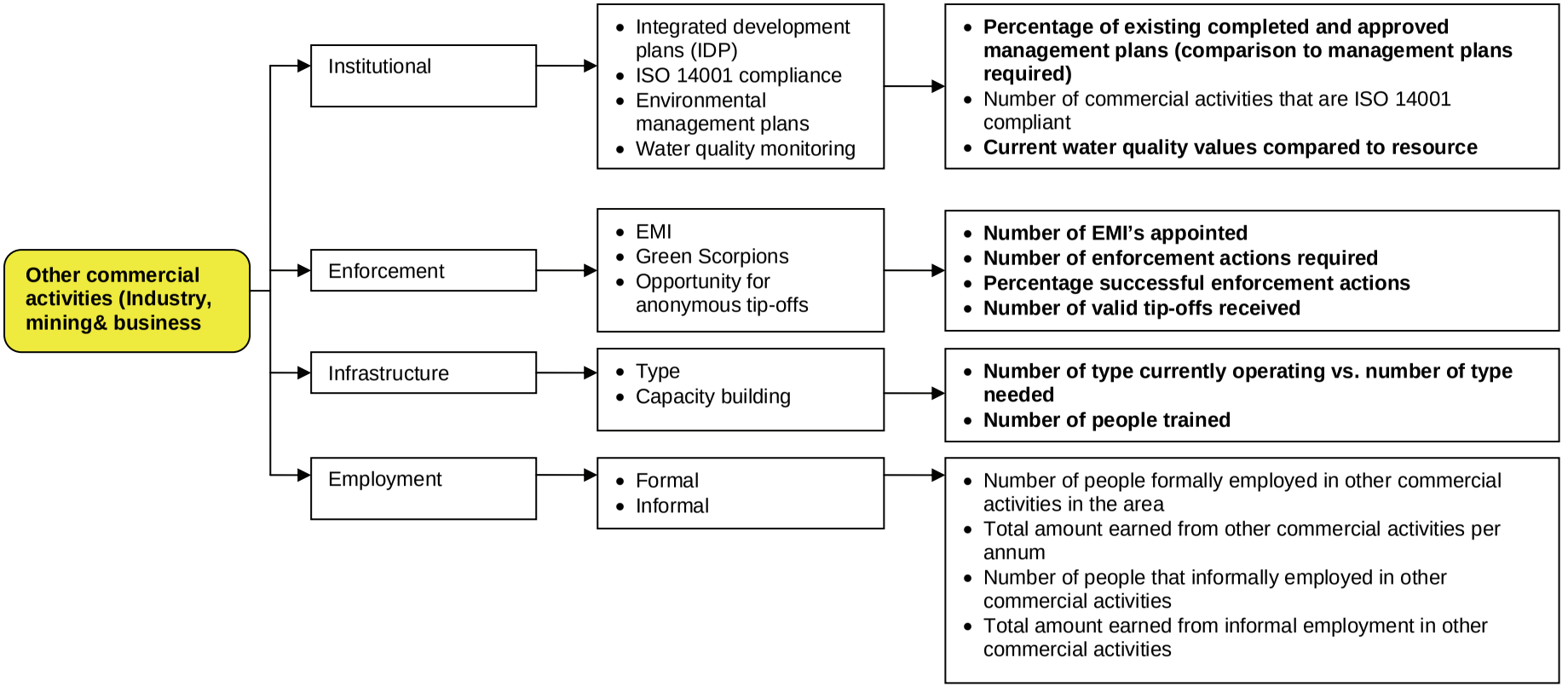


Figure 20: Hierarchy for the other commercial activities human activity system

9.4 CONCEPTUAL MODEL

The various components of the conceptual catchment management model as well as their interactions are represented in Figure 21. Each system of human activity that was identified during the 2nd workshop was divided into various subsystems of which there were 12 common subsystems. Each system of human activity was allocated owners who would be responsible for that system of human activity and each subsystem was allocated actors who could take action to implement the transformation processes. In total 8 common owners were identified and 13 common actors. The linkages between the owners, systems of human activity, subsystems and the actors are illustrated in Figure 22.

The transformation process were grouped together to form 11 common transformation processes. The linkages between the systems of human activity and the transformation processes as well as the linkages between the transformation processes themselves are illustrated in Figure 23. Figure 24 describes 12 broad management objectives which have been derived from the transformation processes. Because the total number of performance indicators is higher than 50, the relationships between the management objectives and the indicators have been shown as links between the management objectives and the systems which comprise the performance indicators. An integrated list (matrix) of indicators for each of the systems of human activity, is given in Annexure 7. Therefore Figure 24 describes how the transformational processes gave rise to objectives which relate to the systems of purposeful activity. The performance indicators are designed to measure whether all the management objectives are being achieved.

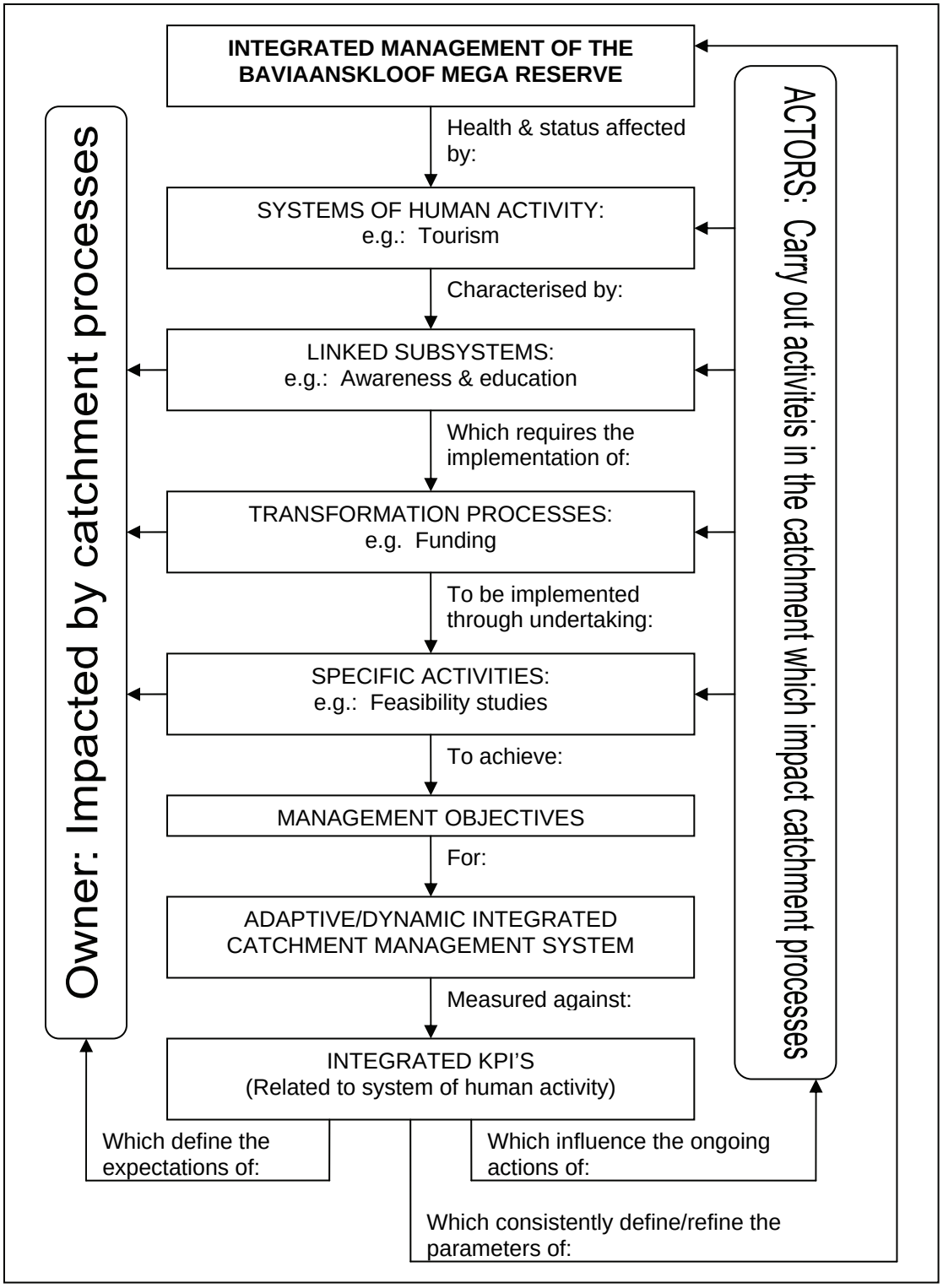


Figure 21: The components of the conceptual catchment management model

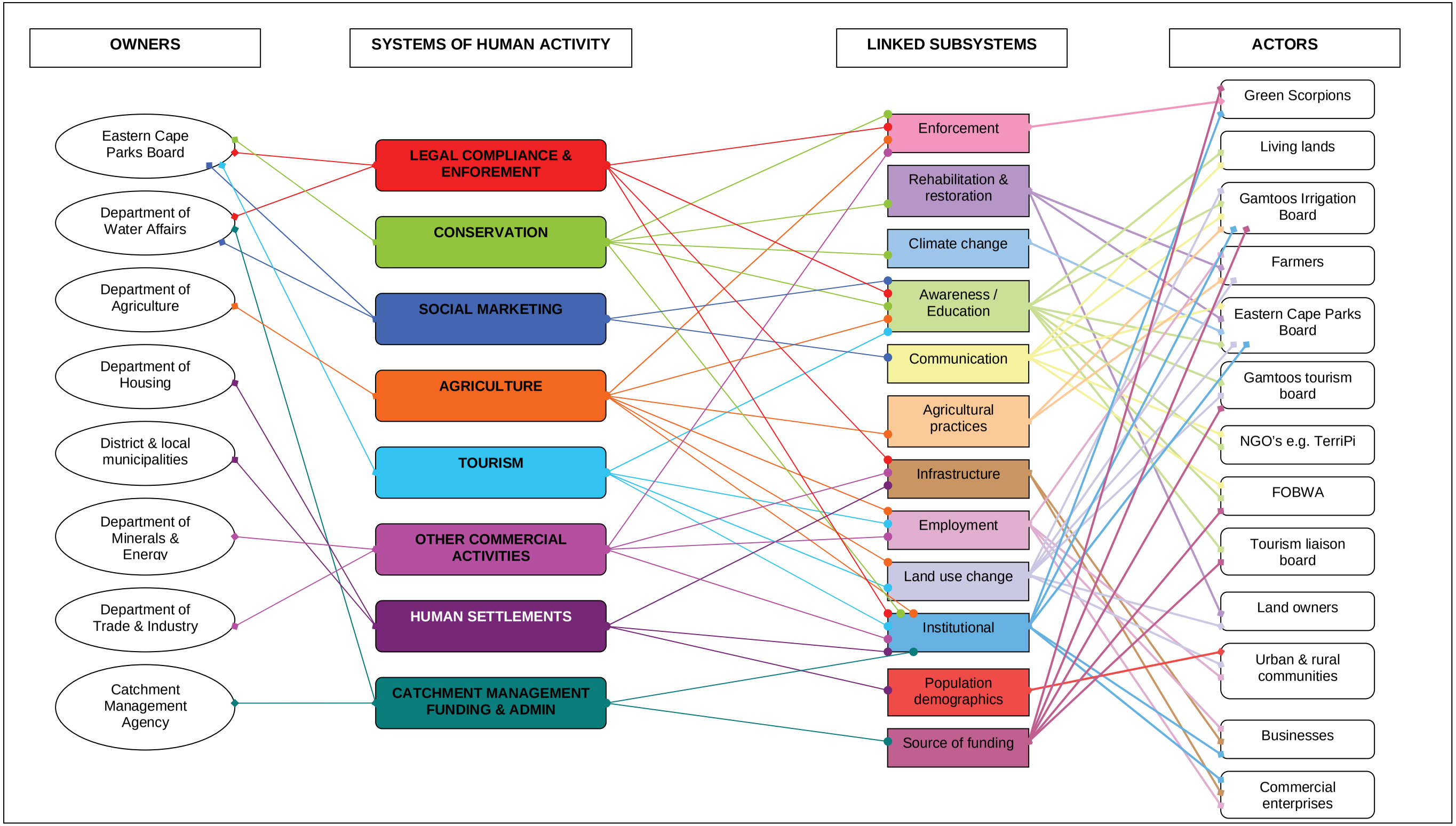


Figure 22: Linkages between owners, systems of human activity, subsystems and actors

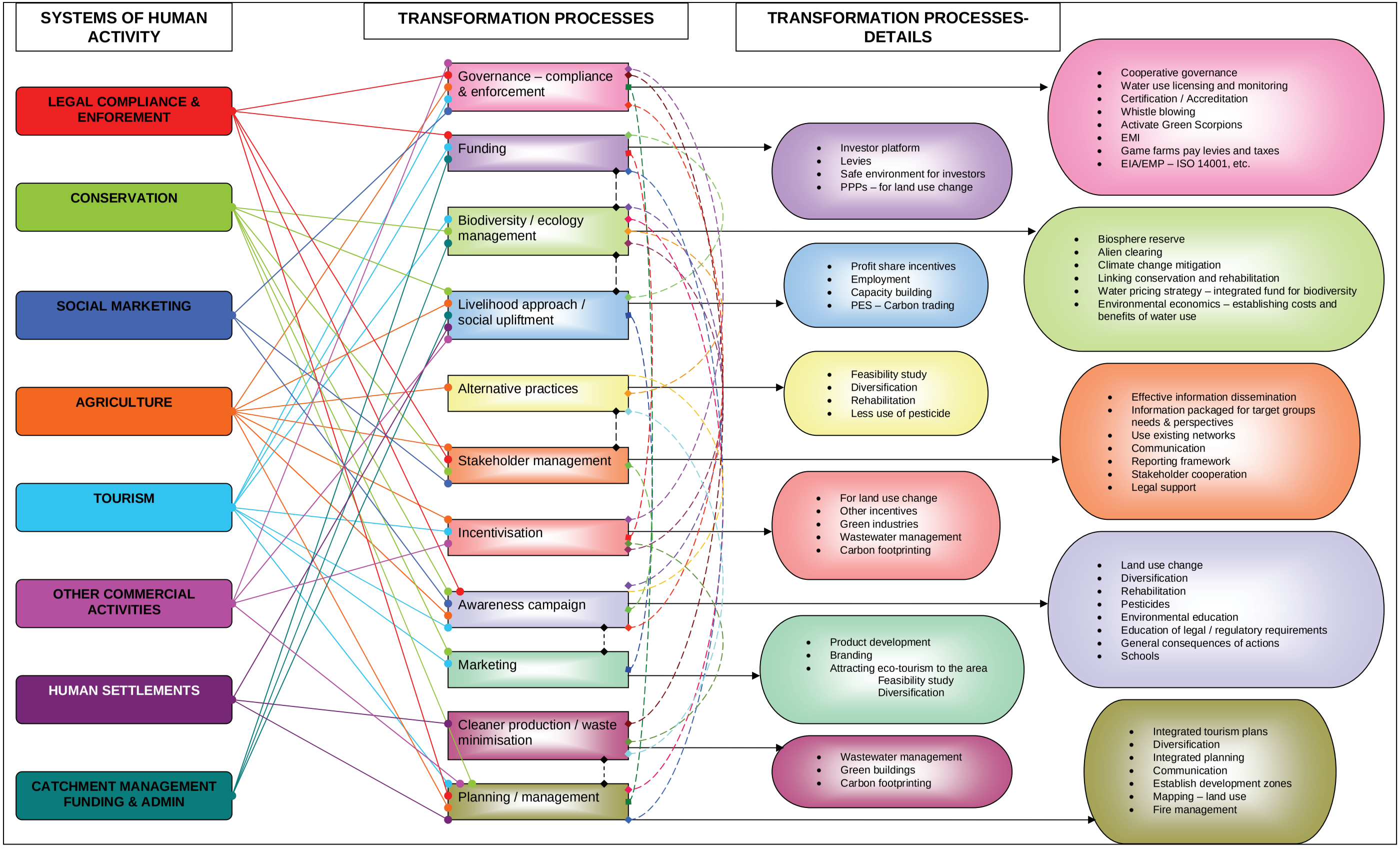


Figure 23: Linkages between the systems of human activity and the transformation processes

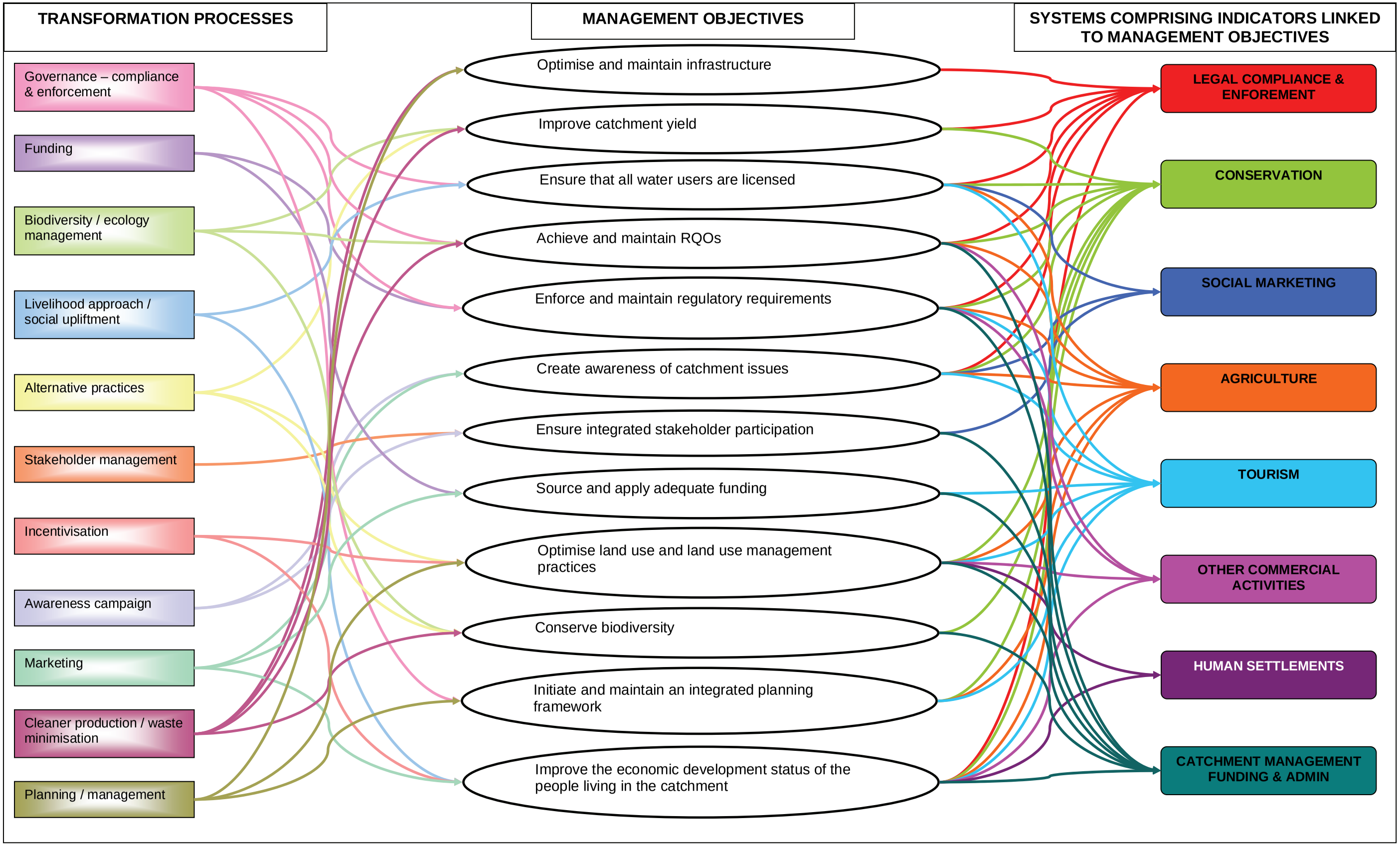


Figure 24: Management objectives derived from transformation processes and relating to the performance indicators of the various systems

9.5 SYSTEMS DYNAMIC MODEL

The various components of the System Dynamics Model for the Baviaanskloof Mega Reserve system as well as their interactions are represented in Figure 25. The linkages illustrated in Figure 25 provide an indication of how certain activities (converters) within the system could either increase or decrease a stock through flows. This in turn translates to how the water resource in the system could be negatively affected or positively enhanced.

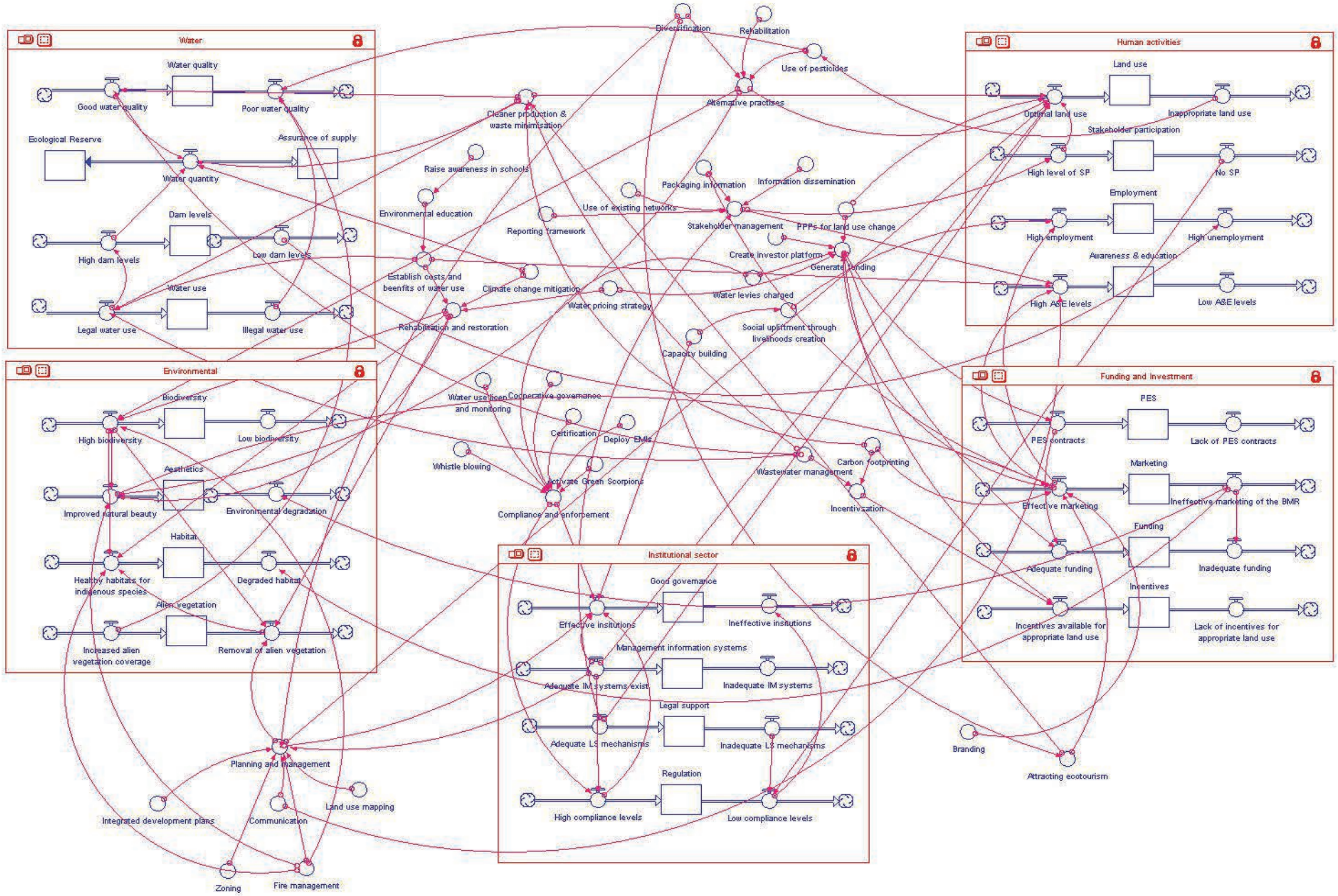


Figure 25: Systems Dynamics Model for Baviaanskloof Mega Reserve

10 WAY FORWARD

The development of the System Dynamic model has marked the completion of Phase 1 of the project. However the project progresses into Phase 2 whereby the model will be populated by the creation of scenarios as a way of assessing how the objectives of IWRM within the Baviaanskloof Mega Reserve can be achieved. There will be a further creation of scenarios that correspond to different values on axes of input parameters, with intangibles being ranked. This would be a way of providing measurable components to the system and the factors affecting it. The preliminary set of performance indicators developed under Deliverable 8 of this project, will now be applied to the populated model to refine them and possibly reduce the number of indicators through an improved understanding of the system linkages. For the purpose of management of the catchment, impacts on the system may be quantified by running a simulation of different scenarios and observing the behaviour of key variables in the model that correspond to performance indicators, which could be either health indicators of sustainability indicators. The model will then be applied to the catchment in order to calibrate assumptions, refine variables and determine baseline values during Phase 2 of this project.

11 REFERENCES

Anonymous. 2004. Baviaanskllooof Mega-reserve, Eastern Cape: Conservation Strategy 2004-2007. Third draft. Wilderness Foundation, Port Elizabeth. (see www.baviaanskloofmegareserve.co.za)

Boshoff, A. 2005. The Baviaanskloof Mega-Reserve: An environmentally, socially and economically sustainable conservation and development initiative. Terrestrial Ecology Research Unit. TERU Report No 52.

Bossel, H. 2001. Assessing viability and sustainability: a systems-based approach for deriving comprehensive indicator sets. Conservation Ecology 5(2):12. [online] URL: http://www.consecol.org/vol5/iss2/art12

Campbell, P.B., Sayer, J.A., Frost, P., Vermeulen, S., Ruiz Pérez, M., Cunningham, A. and Prabhu, R. 2001. Assessing the performance of natural resource systems. Conservation Ecology 5(2): 22. [online] URL: http://www.consecol.org/vol5/iss2/art22/

Checkland, P.B. 1981. Systems Thinking, Systems Practice. Wiley: Chichester. (Republished 1999 with 30-year retrospective.)

Checkland, P.B. and Scholes, J. 1990. Soft Systems Methodology in Action. Wiley: Chichester. (Republished 1999 with 30-year retrospective.)

Checkland, P. and Tsouvalis, C. 1996. Reflecting on SSM: the link between root definitions and conceptual models. Systems Research and Behavioural Science 14(3): 153-168.

Checkland, P.B. and Wilson, B. 1980. `Primary task' and `issue based' root definitions in systems studies. Journal of Applied Systems Analysis 7: 51-54.

Department of Water Affairs and Forestry. 2002. Fish to Tsitsikamma Water Management Area. Water Resources Situation Assessment. Main Report: Volume 2: Appendices. Compiled by Ninham Shand Consulting Engineers.

Department of Water Affairs and Forestry, South Africa. 2004a. National Water Resources Strategy: Directorate National Water Resources Planning.

Department of Water Affairs and Forestry, South Africa. 2004b. Fish to Tsitsikamma Water Management Area: Tsitsikamma to Coega Internal Strategic Perspective. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resources Planning. DWAF Report no. P WMA 15/000/00/0304.

Department of Water Affairs and Forestry. 2007. Guidelines for the Development of Catchment Management Strategies: Towards equity, efficiency and sustainability in water resources management. By R.S. Polland, D. du Toit , Y. Reddy and T Tlou. Department of Water Affairs and Forestry, Pretoria, South Africa.

Eastern Cape Parks Board. 2007. Integrated Reserve Management Plan. Strategic Management Plan: Baviaanskloof Cluster. Version: Draft 1.

National Water Act. (Act 36 of 1998)

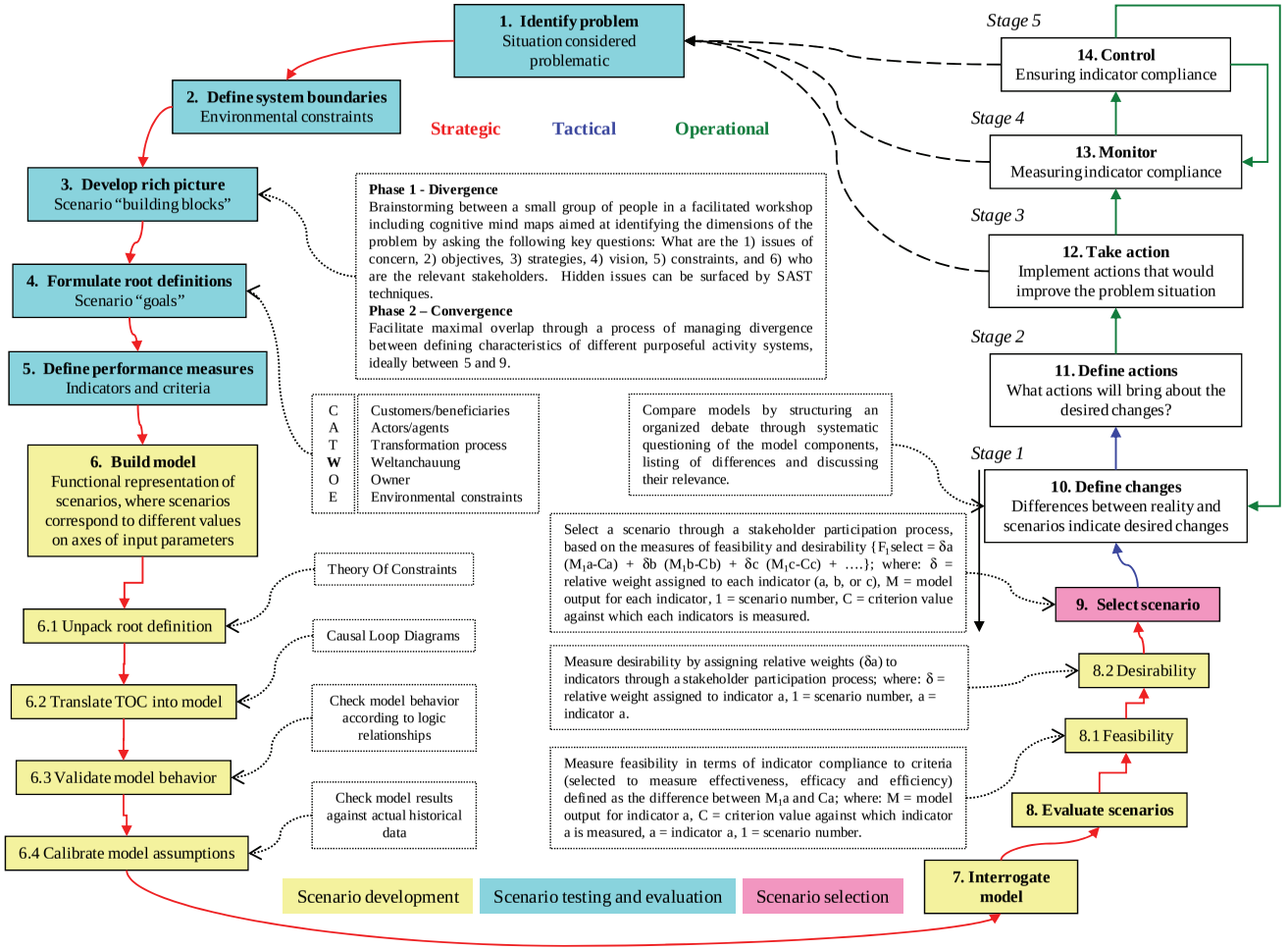
iThink™ – HP: http://www.iseesystems.com/

Sterman, J. D. 1991. A Skeptic's Guide to Computer Models. In Barney, G. O. et al. (eds.), Managing a Nation: The Microcomputer Software Catalog. Boulder, CO: Westview Press, 209-229.

Wikipedia: http://en.wikipedia.org/wiki/Peter_Checkland#cite_note-LUMS_News- 0#cite_note-LUMS_News-0

12 ANNEXURES

ANNEXURE 1


1. Identify problem
Situation considered problematic
2. Define system boundaries
Environmental constraints
Strategic
Tactical
Operational
3. Develop rich picture
Scenario "building blocks"
4. Formulate root definitions
Scenario "goals"
5. Define performance measures
Indicators and criteria
6. Build model
Functional representation of scenarios, where scenarios correspond to different values on axes of input parameters
6.1 Unpack root definition
6.2 Translate TOC into model
6.3 Validate model behavior
6.4 Calibrate model assumptions
Phase 1 - Divergence
Brainstorming between a small group of people in a facilitated workshop including cognitive mind maps aimed at identifying the dimensions of the problem by asking the following key questions: What are the 1) issues of concern, 2) objectives, 3) strategies, 4) vision, 5) constraints, and 6) who are the relevant stakeholders. Hidden issues can be surfaced by SAST techniques.
Phase 2 – Convergence
Facilitate maximal overlap through a process of managing divergence between defining characteristics of different purposeful activity systems, ideally between 5 and 9.
C
A
T
W
O
E
Customers/beneficiaries
Actors/agents
Transformation process
Weltanchauung
Owner
Environmental constraints
Theory Of Constraints
Causal Loop Diagrams
Check model behavior according to logic relationships
Check model results against actual historical data
Compare models by structuring an organized debate through systematic questioning of the model components, listing of differences and discussing their relevance.
Select a scenario through a stakeholder participation process, based on the measures of feasibility and desirability {Fi select = δa (Mia-Ca) + δb (Mib-Cb) + δc (Mic-Cc) + ….}; where: δ = relative weight assigned to each indicator (a, b, or c), M = model output for each indicator, 1 = scenario number, C = criterion value against which each indicators is measured.
Measure desirability by assigning relative weights (δa) to indicators through a stakeholder participation process; where: δ = relative weight assigned to indicator a, 1 = scenario number, a = indicator a.
Measure feasibility in terms of indicator compliance to criteria (selected to measure effectiveness, efficacy and efficiency) defined as the difference between Mia and Ca; where: M = model output for indicator a, C = criterion value against which indicator a is measured, a = indicator a, 1 = scenario number.
Stage 5
14. Control
Ensuring indicator compliance
Stage 4
13. Monitor
Measuring indicator compliance
Stage 3
12. Take action
Implement actions that would improve the problem situation
Stage 2
11. Define actions
What actions will bring about the desired changes?
Stage 1
10. Define changes
Differences between reality and scenarios indicate desired changes
9. Select scenario
8.2 Desirability
8.1 Feasibility
8. Evaluate scenarios
7. Interrogate model
Scenario development
Scenario testing and evaluation
Scenario selection

ANNEXURE 2

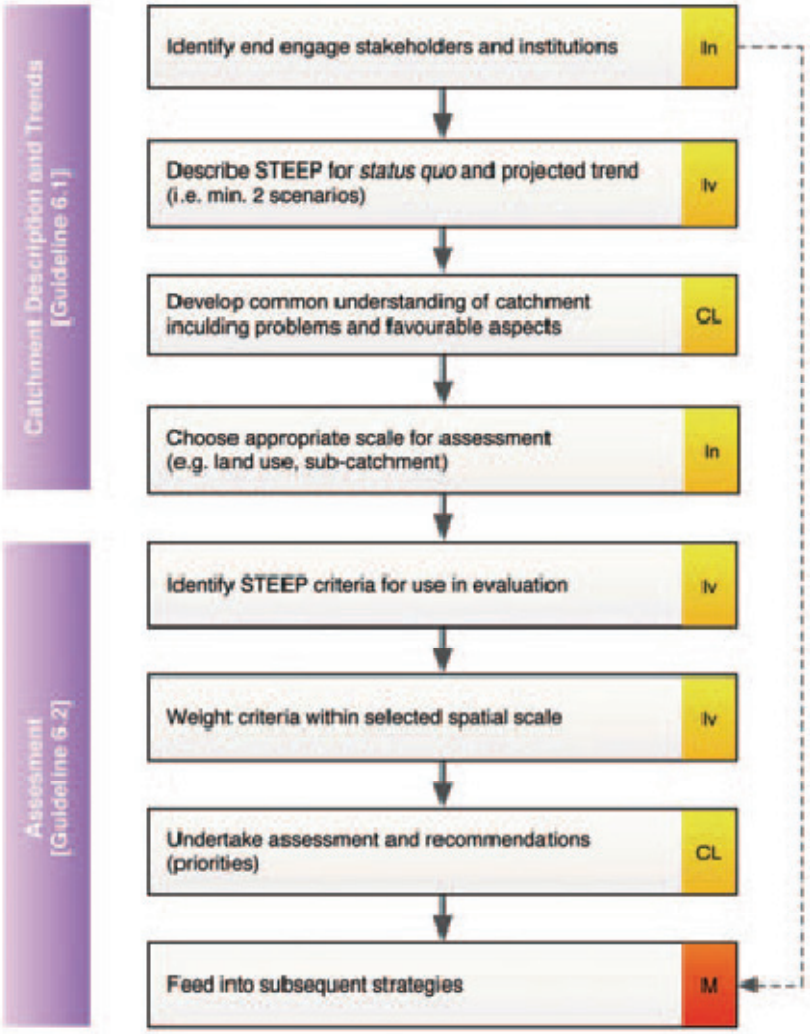


Figure 26: Schematic representation of steps for the catchment description and assessment (extract from DWAF, 2007)

ANNEXURE 3

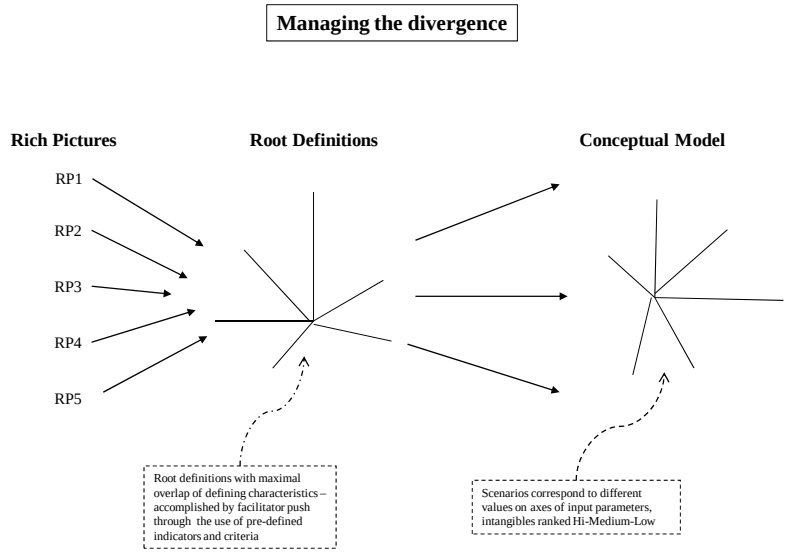


Figure 27: Diagrammatic representation of the sub-model for managing divergence

ANNEXURE 4

Table 8: Contacts details that was inputted into the Information database

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
1	A Boonzaaier			042 280 0251		**Error! Hyperlink reference not valid.**	
2	A Kelly	Friends of Baviaanskloof Wilderness Area			082 555 8283	marcuskelly@vodamail.co.za	Ecological
3	A Knight	Friends of Baviaanskloof Wilderness Area			083 304 9340	knighta@mweb.co.za	Ecological
4	A Knipe	Gamtoos Irrigation Board				**Error! Hyperlink reference not valid.**	Ecological
5	A Muir	Wilderness Foundation SA		041 373 0293	083 441 0532	andrew@sa.wild.org	Ecological
6	AG Draaijer					**Error! Hyperlink reference not valid.**	
7	Andrew Brown	SANPark Garden Route Initiative				**Error! Hyperlink reference not valid.**	Ecological
8	B Dell				084 462 8642	strider@icon.co.za	
9	B Meyer	Friends of Baviaanskloof Wilderness Area			072 456 3702	ankerdata@george.com	Ecological
10	B Reyers	CSIR				**Error! Hyperlink reference not valid.**	Ecological
11	B Smuts	Landmark Foundation			083 324 3344	**Error! Hyperlink reference not valid.**	Political
12	B Arends	Baviaans Local Municipality	WSDP Contact	044 923 1004		b.arends@ymail.com	Political
13	Bolweka Kama	Department of Water Affairs	Catchment Manager	043 701 0221		kamab@dwaf.gov.za	Political

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
14	C Costanza				076 828 6100	christianconstanza@hotmail.com	
15	C Jeffrey	WESSA			083 553 1036	chrisj@pemail.co.za	Ecological
16	C Lamprecht					**Error! Hyperlink reference not valid.**	
17	C Marias	Working for Water				**Error! Hyperlink reference not valid.**	Ecological
18	C Strydom	Kouga Municipality		042 293 1111	082 227 4630	**Error! Hyperlink reference not valid.**	Political
19	C Wild	Friends of Baviaanskloof Wilderness Area		041 504 2137		cathy.wiid@nmmu.ac.za	Ecological
20	Christo Marais (Dr)	Working for Woodlands				**Error! Hyperlink reference not valid.**	Ecological
21	CJ Pietersen	Agri Eastern Cape		041 363 1890		**Error! Hyperlink reference not valid.**	Ecological
22	D Balfour	Eastern Cape Parks Board				**Error! Hyperlink reference not valid.**	Ecological
23	D Brauer	ABSA			079 894 2548	dalenebr@absa.co.za	Economic
24	D Grobler	C.A.P.E		021 887 7161		dana@bluescience.co.za	Ecological
25	D Stigant	Friends of Baviaanskloof Wilderness Area			084 838 0369	stigs@absamail.co.za	Ecological
26	D Van der Broeck	Living Lands				broeck@earthcollective.net	Ecological
27	E Lock	Baviaans Local Municipality		044 923 1004		jama@baviaans.gov.za	Political
28	E Marias	Working for Water				**Error! Hyperlink reference not valid.**	Ecological
29	E Sunde	Friends of Baviaanskloof Wilderness Area		041 581 4539		sunde@intekom.co.za	Ecological

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
30	E Van Huyssteen	CSIR				**Error! Hyperlink reference not valid.**	Ecological
31	F Ellery	Rhodes University				**Error! Hyperlink reference not valid.**	Ecological
32	F Weitz	Department of Agriculture		042 291 0596		**Error! Hyperlink reference not valid.**	Political
33	G Daniel				073 938 3501	gary.daniel@goodyear.co.za	
34	G Mans	CSIR				**Error! Hyperlink reference not valid.**	Ecological
35	G Shaw	Eastern Cape Parks Board			079 496 7893	gavshaw@iafrica.com	Ecological
36	G Tainton	Department of Agriculture			072 823 5588	**Error! Hyperlink reference not valid.**	Political
37	Gerhard Eloff	Eastern Cape Parks Board	ECPB Baviaanskloof	044 923 1061	079 496 7818	**Error! Hyperlink reference not valid.**	Ecological
38	Graham Kerley	NMMU: Environmental Services Business Unit	Director: Centre for African Conservation Ecology	041 504 2308	083 633 3040	Graham.Kerley@nmmu.ac.za	Ecological
39	H Bateman	TerraPi				**Error! Hyperlink reference not valid.**	Ecological
40	H Hill	Eden District Municipality		082 906 7331		**Error! Hyperlink reference not valid.**	Political
41	H Van der Zande	Living Lands				**Error! Hyperlink reference not valid.**	Ecological
42	I Van de Hoek	Friends of Baviaanskloof Wilderness Area			083 294 9555	ivdhoek@yahoo.co.uk	Ecological
43	J Blignaut					**Error! Hyperlink reference not valid.**	
44	J De Baal					**Error! Hyperlink reference not valid.**	

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
45	J Hurter	Wild Summit			082 487 0348	summit@vodamail.co.za	Ecological
46	J Merron	Rhodes University				**Error! Hyperlink reference not valid.**	Ecological
47	J Steyn	Eastern Cape Parks Board				-	Ecological
48	J Zaayman	Baviaans Tourism			082 906 7331	**Error! Hyperlink reference not valid.**	Economic
49	Jimmy Thanyani	Formosa Nature Reserve			079 496 7883	**Error! Hyperlink reference not valid.**	Ecological
50	K Petrus	Friends of Baviaanskloof Wilderness Area			083 490 7722	-	Ecological
51	K Rowntree	Rhodes University				**Error! Hyperlink reference not valid.**	Ecological
52	Karen and John Kirkman	Baviaans Conservancy		049 835 0572		gecko@net4all.co.za	Ecological
53	L Matyana	Working for Water			072 747 6299	**Error! Hyperlink reference not valid.**	Ecological
54	LA Meyer	SAN Parks			083 258 3545	lesleym@sanparks.org	Ecological
55	Linden Booth	Western Baviaanskoolf Initiative		044 923 1751	082 878 3688	linden@baviaan.co.za	Ecological
56	Lorraine Egan	Kouga Municipality		043 293 1111		**Error! Hyperlink reference not valid.**	Political
57	M Audouin	CSIR				**Error! Hyperlink reference not valid.**	Ecological
58	M Brouard	Friends of Baviaanskloof Wilderness Area			082 875 4210	mpb@telkomsa.net	Ecological
59	M Du Preez	Gamtoos Irrigation Board				**Error! Hyperlink reference not valid.**	Ecological

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
60	M Kawa	Department of Water Affairs				**Error! Hyperlink reference not valid.**	Political
61	M Kelly	Friends of Baviaanskloof Wilderness Area				**Error! Hyperlink reference not valid.**	Ecological
62	M Le Roux	Friends of Baviaanskloof Wilderness Area		041 502 5700	084 703 9364	mlleroux@npa.gov.za	Ecological
63	M Mander	EcoFuture				**Error! Hyperlink reference not valid.**	Ecological
64	M McConnachie	Rhodes University				**Error! Hyperlink reference not valid.**	Ecological
65	M Sitole	Department of Water Affairs			082 655 9998	SitoleM@dwa.gov.za	Political
66	M Streso	Baviaans East Conservancy		042 283 7401		**Error! Hyperlink reference not valid.**	Ecological
67	M Thanduxolo	Department of Water Affairs				**Error! Hyperlink reference not valid.**	Political
68	M Wood	Friends of Baviaanskloof Wilderness Area			082 361 2718	mkwood@mweb.co.za	Ecological
69	M Zwinkels	Living Lands				**Error! Hyperlink reference not valid.**	Ecological
70	M Zylstra	Living Lands				**Error! Hyperlink reference not valid.**	Ecological
71	M. Norval	Wilderness Foundation SA	BMR Project Manager	041 373 0293	082 806 0805	matthew@sa.wild.org	Ecological
72	Martheanne Finnemore (Prof)	WESSA	Regional Manager: Eastern Province	041 585 9606/585 1157		martheanne@wessaep.co.za	Ecological

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
73	Mike Powell	Baviaanskloof Sub-tropical thicket rehab project				**Error! Hyperlink reference not valid.**	Ecological
74	Morgan Griffiths	WESSA	Conservation Officer	041 585 9606/585 1157		morgan@wessaep.co.za	Ecological
75	N Ferreira	Landbougenootskap		042 273 2067		**Error! Hyperlink reference not valid.**	Ecological
76	N Johnson	SAN Parks			082 905 4678	norman@sanparks.org	Ecological
77	Norman Robbertse	Baviaans East Conservancy		042 283 7900	071 707 8910	info@baviaanskloof.net	Ecological
78	O Selomane	WUR				**Error! Hyperlink reference not valid.**	Ecological
79	P Joubert	Gamtoos Irrigation Board	CEO Gamtoos Irrigation Board	042 283 0329	082-553 0947	pjoubert@lantic.net	Ecological
80	P Kruger	Zandvlakte		049 839 1002		pieterkruger1@gmail.com	Social
81	P Zake	Eastern Cape Parks Board			079 469 7923	patrick.zake@ecparks.co.za	Ecological
82	PB Myles	NMMU Tourism Research Unit		041 504 4089		**Error! Hyperlink reference not valid.**	Ecological
83	Piet Snyman	Cacadu Distric Municipality	WSDP Contact	041 508 7335		psnyman@cacadu.co.za	Political
84	R Carelse	TerraPi			076 777 0812	rob@terrapi.org	Ecological
85	R Gilbert	Wild Summit			082 404 8182	ryan@boskydell.co.za	Ecological
86	Rodney February	World Wildlife Fund	WWF freshwater programme	021 888 2800		rfebruary@wwf.org.za	Ecological
87	S Ngilana	Department of Water Affairs			082 881 3551	NgilanaS@dwa.gov.za	Political
88	S Rollo	Eastern Cape Parks Board			082 962 4028	srollo@aerosat.co.za	Ecological
89	S vd Merwe	Department of Agriculture		042 273 1342		**Error! Hyperlink reference not valid.**	Political

	Name	Organisation_ID	Position	Tel	Cell	Email	Category_Type_Id
90	Saskia Fourie	Rhodes University	Kouga Riparian Rehabilitation project	046 603 7007	082 474 5593	saskia.fourie@ru.ac.za	Ecological
91	Steel Geldenhuys	DWAF Cradock office		048 881 3005		geldent@dwaf.gov.za	Political
92	T Hartwig	Tees International			084 324 9984	teestrade@telkomsa.net	Ecological
93	T Joubert	Tolbos		042 283 0437		tolbos@baviaans.net	Social
94	T Steyn	Eastern Cape Parks Board			079 496 7931	tracey.stey@ecparks.co.za	Ecological
95	T Zacharie	ABSA			082 370 9233	tazz@absa.co.za	Economic
96	V Wilman	Working for Woodlands			073 740 6278	victoria@connectedcat.com	Ecological
97	VDM du Preez	Gamtoos Irrigation Board		042 283 0704		merwe@igen.co.za	Ecological
98	W De Lange	CSIR				**Error! Hyperlink reference not valid.**	Ecological
99	W Enright				082 807 3535	enright@absamail.co.za	
100	Wayne Erland	Eastern Cape Parks Board	ECPB Baviaanskloof	042 283 0630	072 430 6423	wyane.erlank@ecparks.co.za	Ecological

ANNEXURE 5

Table 9: Document list that was inputted into the Information database

	Document_ Type_Id	Author	Title	Date	Category_ Type
2	PDF	Eastern Cape Park Board	Strategic Management Plan Baviaanskloof Cluster	2007	Ecological
3	PDF	Ninham Shand & Umvoto	Fish / Tsitsikamma Water Management Area. Tsitsikamma to Coega Internal Strategic Perspective. Version 1. PWMA 15/000/00/0304	2004	Ecological
4	PDF	Ninham Shand	Fish / Tsitsikamma Water Management Area. Water Resources Situation Assessment. Main report Vol 2. P15000/00/010	2002	Ecological
5	PDF	Department of Water Affairs	National Water Resource Strategy, 1st Edition	2004	Ecological
6	Hard Copy	Coetzee???	A micro invertebrate biomonitoring investigation using SASS5 index in the Gamtoos River (Eastern Cape), undertaken in the context of the River Health Programme.	2004	Ecological
7		Kirkman, K. E.	Baviaans Conservancy Feasibility Study: Feasibility study to investigate the conversion of land-use from domestic stock farming to sustainable biodiversity-based ventures.	2006	Ecological
8		Joubert, A.; Smith, B. & Neke, K.	Preliminary Assessment of the proposed consolidation and expansion of the western sector of the Baviaanskloof Wilderness Area.		Ecological
9	PDF	Baviaans Municipality	Final Integrated Development Plan 2007-2012	2008	Economic
10		Wilson, L. S. & Smith, N.	Changing land-use trends in the thicket biome: Pastoralism to game farming. Terrestrial Ecology Research Unit. Report No. 38	2002	Ecological
11	PDF	Cumming, T. L.	Conservation initiative for private commercial farmers in the thicket biome, Eastern Cape, South Africa. Masters of Science, Rhodes University.	2007	Ecological
12	PDF	Baviaanskloof MR Project Man Unit	Baviaanskloof Mega Reserve Conservation Strategy 2004-2007		Ecological
13	PDF		Constitution and minutes of Baviaanskloof Steering Committee		Political

	Document_ Type_Id	Author	Title	Date	Category_ Type
14	PDF	Department of Water Affairs	Implementation guidelines for water conservation and water demand management in agriculture. Development of irrigation water management plans.	2000	Ecological
15	PDF	Sue Matthews	Kouga Catchment enters rehabilitation. Water Wheel article.	2008	Ecological
16	PDF	Department of Water Affairs	National water conservation and water demand management strategy.	2004	Ecological
17	PDF	Department of Water Affairs	Water conservation and water demand management strategies for the agricultural sector.	2004	Ecological
18	PDF	Department of Water Affairs	Water conservation and water demand management strategies for the industry, mining and power generation sectors.	2004	Ecological
19	PDF	De la Flor Tejero, I.	Valuation of the Goods and Services provided by the thicket ecosystem in the Western Baviaanskloof, South Africa. M.Sc thesis, Wageningen University, The Netherlands.	2008	Ecological
20	PDF	Department of Water Affairs	Water conservation and water demand management strategies for the water services sector.	2004	Ecological
21	PDF	Water Research Commission	Guidelines for catchment management to achieve integrated water resources management in South Africa. Part I & II		Ecological
22	PDF	Department of Agriculture	National guideline for the integrated management of agricultural water use.	2002	Ecological
23	PDF	Department of Water Affairs	Resource Directed Management of Water Quality: Management Instruments. Edition 2. Water Resources Planning Systems Series.	2006	Ecological
24	PDF		Historical flow and water quality data from the DWA weir on the Groot (L7H006) and Kouga (L8H005) Rivers.		Ecological
25	PDF	EarthCollective	PRESENCE Seed Phase: Workshop outcomes. Patensie, South Africa and Wageningen, The Netherlands	2008	Ecological
26	PDF	Noirtin, E.	Analysis of stakeholder interactions and involvement in thicket restoration, Western Baviaanskloof, South Africa. Who is willing to restore & why. M.Sc thesis. Wageningen University.	2008	Ecological

	Document_ Type_Id	Author	Title	Date	Category_ Type
27	PDF	Lorencova, E.	Exploring the organizational institutional capacity of the carbon sequestration projects in South Africa: A comparison between Clean Development Mechanism (CDM) and voluntary carbon offset schemes.	2008	Ecological
28	PDF	De la Flor Tejero, I.	Valuation of the Goods and Services provided by the thicket ecosystem in the Western Baviaanskloof, South Africa. M.Sc thesis, Wageningen University, The Netherlands.	2008	Ecological
29	PDF	Jansen, K.	The relevance of socio-cultural values of ecosystem services to restoration planning and implementation in the Baviaanskloof. M.Sc thesis, Wageningen University, The Netherlands.	2008	Ecological
30	PDF	Van der Burg, L.	Valuing the benefits of restoring the water regulation services in the subtropical thicket biome: a case study in the Baviaanskloof – Gamtoos watershed, South Africa. M.Sc thesis, Wageningen University	2008	Ecological
31	PDF	Powell, M.	Restoration of degraded subtropical thickets in the Baviaanskloof Mega Reserve, South Africa – the role of carbon stocks & Portulacaria afra survivorship. M.Sc thesis Rhodes University.	2009	Ecological
32	PDF	Jansen, H. C.	Water for food and ecosystems in the Baviaanskloof Mega Reserve. Land and water resource assessment in the Baviaanskloof, Eastern Cape Province, South Africa. Altera Report 1812-ISSN1566-7197	2009	Ecological
33	PDF	De Palio, G.	River system restoration for a sustainable land & water management in the Baviaanskloof Mega Reserve. Preliminary assessment of the opportunities and challenges to the creation of a payment for watershed services scheme.	2008	Ecological
34	PDF	Ali Javed, H.	Investigating the Institutional Arrangements required to implement Payment for Environmental Services: A case study in Baviaanskloof watershed, South Africa. M.sc thesis. Wageningen University, The Netherlands.	2009	Ecological

ANNEXURE 6

Table 10: Organisation details that was inputted into the Information database

Organisation	Organisation _type	Address	Town	Postal code	Tel	Fax	Email	Website
ABSA	Private Company							www.adbsa.co.za
Agri Eastern Cape	Agricultural Association							www.agriok.co.za
Baviaans Conservancy	Environmental/ Conservation Organisation							www.baviaanskloof.net
Baviaans East Conservancy	Environmental/ Conservation Organisation							www.landmarkfoundation.org
Baviaans Local Municipality	Local Government							www.baviaans.gov.za
Baviaans Tourism	Private Company							www.baviaans.co.za
Baviaanskloof Sub-tropical thicket rehab project	Research Organisation							
C.A.P.E	0							
Cacadu Distric Municipality	Local Government	PO Box 318	Port Elizabeth	6000	041 508 7111	041 508 7000		www.cacadu.co.za
CSIR	Research Organisation							www.csir.co.za
Department of Agriculture	National Government	Private Bag X0040	Bisho	5605	040 609 3454	040 635 1222	thozi.manyisana@agr.ecprov.gov.za	www.daff.gov.za
Department of Water Affairs	National Government	Private Bag X7485	King Williams Town	5600	043 604 5407	043 604 5595	MbambiG@dwaf.gov.za	www.dwaf.gov.za
DWAF Cradock office	Local Government	Private Bag X 68	Cradock	0	048 881 3545			
Eastern Cape Development Corporation	Private Company							www.ecdc.co.za

Organisation	Organisation_type	Address	Town	Postal code	Tel	Fax	Email	Website
Eastern Cape Parks Board	Environmental/ Conservation Organisation							www.ecparks.co.za
EcoFuture	Private Company							www.ecofuture.org
Eden District Municipality	Local Government							www.edendm.co.za
Formosa Nature Reserve	Environmental/ Conservation Organisation							
Friends of Baviaanskloof Wilderness Area	Environmental/ Conservation Organisation							fobwa.com
FROG	Private Company							
Gamtoos Irrigation Board	Agricultural Association							www.gamtooswater.net
Gamtoos Tourism	Public Company							www.baviaans.net
Kouga Municipality	Local Government	33 Da Gama Drive	Jeffreys Bay	6330	042 200 2200	042 293 1114		www.kougamunicipality.gov.za
Landbougenootskap	0							
Landmark Foundation	0							www.landmarkfoundation.org.za
Living Lands	Environmental/ Conservation Organisation							www.livinglandsandwaters.org
NMMU Tourism Research Unit	Research Organisation	PO Box 77000	Port Elizabeth	6031	041 504 3766		Hugh.Bartis@nmmu.ac.za	http://www.nmmu.ac.za
NMMU: Center for African Conservation Ecology	Research Organisation	PO Box 77000	Port Elizabeth	6031	041 504 2308	041 504 2317	graham.kerly@nmmu.ac.za	http://www.nmmu.ac.za
NMMU: Environmental Services Business	Research Organisation	PO Box 77000	Port Elizabeth	6031				http://www.nmmu.ac.za

Organisation	Organisation_type	Address	Town	Postal code	Tel	Fax	Email	Website
Unit								
Rhodes University	Research Organisation	P.O. Box 94	Grahamstown	6140	046 603 8111	046 622 5049	registrar@ru.ac.za	http://www.ru.ac.za/
SAN Parks	Environmental/ Conservation Organisation							www.sanparks.org
SANBI	Environmental/ Conservation Organisation	2 Cussonia Ave, Brummeria	Pretoria					http://www.sanbi.org/
SANPark Garden Route Initiative	0							
Tees International	Private Company							
TerraPi	NGO							www.terrapi.org
The Bataleurs	0							www.bateleurs.co.za
Tolbos	Private Company							www.tolbos.co.za
Tshwaranang	NGO							
WESSA	Environmental/ Conservation Organisation							www.wildlifesociety.org.za
Western Baviaanskoolf Initiative	Environmental/ Conservation Organisation							
Wild Summit	0							
Wilderness Foundation SA	Environmental/ Conservation Organisation	PO Box 12509	Port Elizabeth	6006	041 373 0293	041 374 1821	info@sa.wild.org	wildernessfoundation.org.za
Working for Water	Environmental/ Conservation Organisation							www.dwaf.gov.za/wfw

Organisation	Organisation _type	Address	Town	Postal code	Tel	Fax	Email	Website
Working for Wetlands	Environmental/ Conservation Organisation							www.wetalnds.sanbi.org.za
Working for Woodlands	Environmental/ Conservation Organisation							
World Wildlife Fund	Environmental/ Conservation Organisation							www.panda.org.za
WUR	Private Company							
Zandvlakte	Private Company							

ANNEXURE 7

Table 11: Performance management indicators

System	LC&E	Social Marketing	Catchment Management Funding & Admin	Tourism	Agriculture	Conservation	Human Settlement	Other commercial activities	Objectives
PERFORMANCE INDICATORS	**Number of type of infrastructure currently operating vs. required**						**Number of type currently operating vs. required**	**Number of type currently operating vs. required**	1 Optimise and maintain infrastructure
	Percentage water losses (volumes)								2 Improve catchment yield
	Number of breakdowns owing to lack of maintenance								1 Optimise and maintain infrastructure
	Number of WU license applications outstanding				**Number of applications outstanding**				3 Ensure that all water users are licensed
	Application turnaround period				**Application turnaround period**				3 Ensure that all water users are licensed
	Percentage of water users monitored				**Percentage of water users monitored**				3 Ensure that all water users are licensed
	Number of people trained		**Number of people trained**		**Number of people trained**	**Number of people trained**	**Number of people trained**	**Number of people trained**	12 Improve the economic development status of the people living in the catchment
	Current water quality values compared to resource quality objectives		**Current water quality compared to the set resource quality objectives**		**Current water quality values compared to resource quality objectives**	**Current water quality values compared to resource quality objectives**		**Current water quality values compared to resource quality objectives**	4 Achieve and maintain RQOs
	Improvement in pollution levels compared to baseline values								4 Achieve and maintain RQOs
	Number of EMI's appointed				**Number of EMI's appointed**	**Number of EMI's appointed**		**Number of EMI's appointed**	5 Enforce and maintain regulatory requirements
	Number of enforcement actions required				**Number of enforcement actions required**	**Number of enforcement actions required**		**Number of enforcement actions required**	5 Enforce and maintain regulatory requirements
	Percentage successful enforcement actions				**Percentage successful enforcement actions**	**Percentage successful enforcement actions**		**Percentage successful enforcement actions**	5 Enforce and maintain regulatory requirements
	Number of valid tip-offs received				**Number of valid tip-offs received**	**Number of valid tip-offs received**		**Number of valid tip-offs received**	5 Enforce and maintain regulatory requirements
	Number of land-owners using legal support								3 Ensure that all water users are licensed
	Number of successful cases using legal support								3 Ensure that all water users are licensed
	Number of campaigns launched	**Number of campaigns launched**		**Number of campaigns launched**	**Number of campaigns launched**	**Number of campaigns launched**			6 Create awareness of catchment issues
	Number of hits on websites	**Number of hits on websites**		**Number of hits on websites**	**Number of hits on websites**	**Number of hits on websites**			6 Create awareness of catchment issues
	Number of documents downloaded from website	**Number of documents downloaded from website**		**Number of documents downloaded from website**	**Number of documents downloaded from website**	**Number of documents downloaded from website**			6 Create awareness of catchment issues
	Feedback from newsletters	**Feedback from newsletters**		**Feedback from newsletters**	**Feedback from newsletters**	**Feedback from newsletters**			6 Create awareness of catchment issues
		Number of pledges received		**Number of pledges received**	**Number of pledges received**	**Number of pledges received**			6 Create awareness of catchment issues
		Number of schools that includes the ecoschools curriculum of WESSA				**Number of schools that includes the ecoschools curriculum of WESSA**			6 Create awareness of catchment issues
		Percentage of stakeholder categories represented at workshops							7 Ensure integrated stakeholder participation

System	LC&E	Social Marketing	Catchment Management Funding & Admin	Tourism	Agriculture	Conservation	Human Settlement	Other commercial activities	Objectives
		Number of negative comments from the community on catchment decisions							7 Ensure integrated stakeholder participation
			Percentage of WRM levies collected (compared to billed)						8 Source and apply adequate funding
			Percentage of water taxes collected (compared to charged)						8 Source and apply adequate funding
			Amount of funding that is available from the CMA or GIB						8 Source and apply adequate funding
			Amount received for PES						8 Source and apply adequate funding
			Number of PES contracts						8 Source and apply adequate funding
			Percentage of land use the has been captured in GIS						9 Optimise land use and land use management practices and land use management practices
			The current Ecological Category compared to recommended Ecological Category						10 Conserve biodiversity
			Current state of the aquatic resource compared to the set management class						4 Achieve and maintain RQOs
			Are the amounts stated in the WAP being met						5 Enforce and maintain regulatory requirements
			Are the conditions of the WAP being met						5 Enforce and maintain regulatory requirements
			Total amount of funds generated for the catchment						8 Source and apply adequate funding
			Is stakeholder data available for stakeholders in each category						7 Ensure integrated stakeholder participation
				Percentage of tourist establishments that are accredited					5 Enforce and maintain regulatory requirements
				Number of tourist establishments that have been black listed					5 Enforce and maintain regulatory requirements
				Amount that tourism in the area contributes to the GDP					8 Source and apply adequate funding
				Number of people involved in incentive schemes	**Number of people involved in incentive schemes**				9 Optimise land use and land use management practices
				Number of land owners using tourism as an alternative income source					9 Optimise land use and land use management practices
				Percentage of organisations that have a business plan	**Percentage of organisations that have a business plan**				11 Initiate and maintain an integrated planning framework
				Number of people formally employed in tourism activities in the area					12 Improve the economic development status of the people living in the catchment

System	LC&E	Social Marketing	Catchment Management Funding & Admin	Tourism	Agriculture	Conservation	Human Settlement	Other commercial activities	Objectives
				Total amount earned from tourism per annum					12 Improve the economic development status of the people living in the catchment
				Number of people that use tourism as an informal source of income					12 Improve the economic development status of the people living in the catchment
				Total amount of informal income that is generated per annum from tourism					12 Improve the economic development status of the people living in the catchment
					Number of land owners using tourism as an alternative income source				12 Improve the economic development status of the people living in the catchment
					Percentage of each type of farming being undertaken				9 Optimise land use and land use management practices
					Percentage of produce produced that is organic				12 Improve the economic development status of the people living in the catchment
					Amount earned per annum from each type of farming				12 Improve the economic development status of the people living in the catchment
					Number of people formally employed in agriculture in the area				12 Improve the economic development status of the people living in the catchment
					Total amount earned from agriculture per annum				12 Improve the economic development status of the people living in the catchment
					Number of people that use agriculture as an informal source of income				12 Improve the economic development status of the people living in the catchment
					Total amount of informal income that is generated per annum from agriculture				12 Improve the economic development status of the people living in the catchment
						Average water yield per annum			2 Improve catchment yield
						Current habitat diversity compared to baseline			10 Conserve biodiversity
						Current species richness compared to baseline			10 Conserve biodiversity
						Area (km^2) of alien vegetation			2 Improve catchment yield
						Percentage of private land vs. state land in the area			9 Optimise land use and land use management practices
						Area (km^2) of land use designated as unknown (GIS)			9 Optimise land use and land use management practices
						Percentage of existing completed and approved management plans (comparison to management plans required)		**Percentage of existing completed and approved management plans (comparison to management plans required)**	11 Initiate and maintain an integrated planning framework
						Current monthly rainfall values compared to historical data			2 Improve catchment yield
							Percentage completion of dividing land into development zones		9 Optimise land use and land use management practices

System	LC&E	Social Marketing	Catchment Management Funding & Admin	Tourism	Agriculture	Conservation	Human Settlement	Other commercial activities	Objectives
							Area (km^2) relating to development plans		9 Optimise land use and land use management practices
							Area (km^2) designated for development (GIS)		9 Optimise land use and land use management practices
							Percentage of people (in development areas) provided with services		12 Improve the economic development status of the people living in the catchment
							Current population density values compared to historical data		12 Improve the economic development status of the people living in the catchment
							Current population distribution compared to historical data		9 Optimise land use and land use management practices
							Percentage or urban vs. rural areas compared to historical data		9 Optimise land use and land use management practices
							Current household sizes compares to historical data		12 Improve the economic development status of the people living in the catchment
								Number of commercial activities that are ISO 14001 compliant	5 Enforce and maintain regulatory requirements
								Number of people formally employed in other commercial activities in the area	12 Improve the economic development status of the people living in the catchment
								Total amount earned from other commercial activities per annum	12 Improve the economic development status of the people living in the catchment
								Number of people that informally employed in other commercial activities	12 Improve the economic development status of the people living in the catchment
								Total amount earned from informal employment in other commercial activities	12 Improve the economic development status of the people living in the catchment