KSA 2: WATER-LINKED ECOSYSTEMS

SCOPE

Water-linked ecosystems are defined as instream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river), groundwater and water table-dependent (dependent on a water table, but not on surface water). This KSA focuses on the protection and sustainable utilisation and management of the aquatic environment and biota (instream, riparian and ground¬water). Stakeholders and communities require an environment that is safe to live in and water resources that are safe for consumption. Therefore, the WRC, through this KSA, will continue to generate knowledge and develop tools or technologies that assist society and managers to sustainably use water and associated resources while at the same time advancing the protection of these critical resources. The products of this research portfolio are used to ensure that everybody in South Africa can experience a safe environment to live in and safe food and drinking water. This KSA has been at the forefront of funding fundamental research that has established the causal effect of human activities on water quality and aquatic ecosystem health, and has worked with different stakeholders to disseminate and transfer research outputs to policy makers and water resource managers.

The portfolio addresses five key issues that are important in managing and utilising water resources and ecosystems: our environment that constantly changes (ecosystems and global change), the process, function and structure driving ecological systems (ecosystem processes), management tools and frameworks that we can use to benefit from aquatic ecosystems (ecosystem management), the sustainable utilisation of our natural infrastructure (ecosystem utilisation), and the means to correct degraded water resources or the whole environment so that they can provide ecosystem services needed by the society (rehabilitation and remediation).

The KSA programmes and initiatives support sustainable development principles as stated in the National Strategy for Sustainable Development (NSSD1). The sustainable development principles are enshrined in the South African Constitution and advocate a whole-system approach. According to those principles, natural resources must be used sustainably, socio-economic systems should be included since they are dependent on ecosystems, and basic human needs must be met to ensure that resources necessary for long-term survival are not destroyed for short-term gain.

OBJECTIVES

The strategic objectives of KSA 2 are as follows:

- To enhance knowledge on healthy ecosystems and preserve biodiversity
- To generate knowledge that informs ecosystem management and the implementation of policy and legislation
- To support the social and economic requirements of society from ecosystems
- To generate innovative approaches that can be used in rehabilitation and restoration of ecosystems
- To develop innovations and knowledge that demonstrate the actual value of ecosystems and support to people's livelihoods
- To improve understanding of the connectivity between land, water, atmosphere and people

THRUST 1: ECOSYSTEM PROCESSES

Scope: This thrust includes research addressing the biophysical processes, form and function of ecosystems. This understanding will assist those managing the resource (water services, crop and aquaculture, biodiversity, etc.) to maximise socio-economic benefits in a sustainable manner. The aim is to generate knowledge that informs policy and management.

Programme 1: River, wetland, groundwater and dam processes	**Scope:** Programmes to investigate the ecosystem functioning, structure and processes of riparian zones, rivers and impoundments will be developed. This is an area in which South Africa needs improved capability to manage and, in the case of riparian zones, is a topic attracting international interest.
Programme 2: Estuarine, coastal and marine processes	**Scope:** Estuarine, coastal and marine systems are fragile, while they are highly productive ecosystems and are highly sought after as places to live and establish various enterprises. Catchment activities and land uses affect terrestrial water resources and ultimately the estuarine environment, while marine water conditions also have an impact on the estuarine environment and ecosystems. Projects in this programme will generate knowledge about the ecological processes, structure, and functions of ecosystems of these systems. The programme will also address the impact of land uses and marine conditions on ecological processes in the estuarine and coastal environment.
Programme 3: Aquatic, riparian and land connectivity	**Scope:** Research will be conducted to develop understanding of the interconnections among various ecosystems and ecological processes and functions of water resources, terrestrial systems (soil, air and vegetation) and to assess their value to both the catchment and people.
Programme 4: Surface and groundwater interactions	**Scope:** Within this programme, the dynamics of groundwater-dependent ecosystems will be investigated in relation to the aquifers on which they depend. This will be related to exploitation of the groundwater. Special attention will be given to the vulnerability of these systems.

THRUST 2:
ECOSYSTEM MANAGEMENT

Scope: This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation and provision of the ecosystem benefits that people depend on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Support will be provided in building the capacity to implement the research findings.

Programme 1: Ecological Reserve	**Scope:** Research in this programme will be conducted to develop and refine methods for determining and operationalizing the ecological Reserve as required by the NWA. The programme will address the more strategic issues, such as the development of new and improved methods, as well as the shorter-term issues, such as implementation of the Reserve. This programme is managed in close association with DWA.
Programme 2: Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems	**Scope:** Within this programme research will be conducted to develop an understanding of the effect of anthropogenic disturbance on aquatic ecosystems in various water resources. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage water resources sustainably.
Programme 3: Land-use and aquatic ecosystem management	**Scope:** This programme focuses on enhancing understanding of the effect of human interventions (land uses and decision making) on the environmental health of various water resources and/or ecosystems. As such the programme covers all water resource types, hence the inclusive name of National Aquatic Ecosystem Health Monitoring Programme is used, whereas the name River Health Programme focuses only on rivers.
Programme 4: Integrated environmental and drinking water quality	**Scope:** Within this programme research will be conducted to develop integrated methods and procedures which will be employed to protect people and the environment from the effects of poor water quality. The programme will develop methods and competence to support policies for the issuing of water or ecosystem use authorisations. This will promote the use of research knowledge in managing environmental water quality as required in the ecological Reserve, and thus reduce drinking water treatment costs.

Programme 5: Ecosystem risks and disaster management	**Scope:** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation. Existing tools and procedures will be assessed with the intention of refining/developing them. The success of the programme will be achieved by working closely with water resource managers and relevant government departments.
Programme 6: Biodiversity and conservation	**Scope:** The overall objective of this programme is to develop and integrate knowledge needed by the country in efforts aimed at protecting and preserving our unique biodiversity and natural landscapes. The projects will look at drivers (sociological, political and economic) that are critical in developing the understanding and competence necessary to sustainably manage the aquatic environment and its biodiversity. Collaboration and partnership with other institutions will be considered for this programme to achieve its aim.
Programme 7: Ecosystem governance, legal framework and ethics	**Scope:** Implementation of research outputs and regulations require appropriate governance systems and structures. The overall objective of this programme is to develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this. The research under this programme should develop knowledge needed for good governance of water resources. The research will develop knowledge needed to support policy, planning and development that promote protection of ecosystems and water resources.
Programme 8: Transboundary ecosystem management	**Scope:** This programme will support projects that enhance ecosystem processes and functions, conservation and planning across regional and national borders. Transboundary research has gained some interest in recent years, and neighbouring countries or catchments will have to manage shared natural capital in an integrated manner. Collaborations with neighbouring countries and international funding agencies will be considered for research under this programme.

THRUST 3:
ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Scope: This thrust addresses the rehabilitation, restoration and remediation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities, with the view to restoring, as far as possible, process, form and function in order to provide the stream of services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. Support will be provided in building the capacity to implement the research findings. Remediation is the only addition to this portfolio. This is proposed to encourage innovative approaches that can be used in rehabilitation and restoration of water resources and their ecosystems. Research in this thrust will be carried out in collaboration with key stakeholders.

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)	**Scope:** The research conducted within this programme aims to provide protocols for the rehabilitation of rivers wetlands, estuaries and dams/impoundments, with the emphasis on the impacts of mining and forestry through testing and refinement of buffer zones, taking particular care of the role of underground/surface water interactions, soil types and flow dynamics. This is critical in authorising mining around these systems, especially pans (wetlands). This programme also enables a strong focus on green innovations and the role of ecological infrastructure role in securing water and ecosystem services to the benefit of society and the green economy.
Programme 2: Socio-economic dynamics	**Scope:** The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment. The role of society in prioritizing the importance of natural capital, as well as the role of business in interacting responsibly with nature, is emphasized.
Programme 3: Environmental risk management	**Scope:** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation.

THRUST 4:
SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Scope: This research portfolio investigates issues relating to ecosystem services. The research addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend on. Central to this is the need to ensure that individuals and communities derive benefits (social, economic, and environmental) from ecosystems. Support will be provided in building the capacity to implement and apply the research findings. The projects in this thrust will develop innovations and knowledge that demonstrate the actual value of ecosystems to people's livelihoods, well-being, and business sustainability.

Programme 1: Environmental economics (goods & services) and accounting	**Scope:** The overall objective of this programme is to investigate ways to evaluate economic benefits of ecosystem products (goods and services). Appropriate methods and their implementation to local conditions will be promoted by research in this programme. The economic opportunities that are presented by ecosystems will be evaluated so that they can be appropriately developed. Different evaluation and accounting methods and tools will be developed and adapted to local conditions.
Programme 2: Ecosystem value-chain and markets	**Scope:** Research in this programme will develop knowledge about developing and strengthening markets for ecosystem services. The research will cover the whole value chain of the ecosystem services' market. There is a growing interest in developing markets for ecosystem services to support local economies in rural and peri-urban areas. The development of tools or procedures to promote payment for ecosystem services needs to be further developed and implemented appropriately. Product development for various markets will also be the focus of this programme. For instance, environment-based business opportunities should be explored and developed since different ecosystems have different products and services that they offer.
Programme 3: Gender, culture and heritage for ecosystems	**Scope:** In their design or implementation, natural resource management (NRM) initiatives overlook critical socio-cultural dimensions of the challenge to advance sustainability. This programme will investigate relationships and associations of gender, culture, heritage and aquatic ecosystems. The relationships and tensions related to gender, ethnicity, population, age and socio-economic status are among the threads in the larger tapestry that comprises the socio-cultural dimension in natural resource management and access to ecosystem services. The programme will also investigate ideas and innovations from indigenous/local knowledge systems that relate to natural resource management.
Programme 4: EGreen economy and sustainable (green) innovations	**Scope:** People in rural and peri-urban areas rely on ecosystems for their livelihoods. The research in this programme will support economic development that does not violate the sustainability of socio-ecological processes. Projects in this programme will encourage the production of green technologies (biotechnology) and innovations supporting service- and commercial-based sectors. Outputs from research should contribute to improving the lives of people while also contributing to improving the conditions of water resources and the environment at large. The involvement of the business sector and other individual companies will be sought to fast-track implementation of the research output. The projects will contribute to the Water–Energy–Food Nexus Lighthouse of the WRC.

THRUST 5:
ECOSYSTEMS AND GLOBAL CHANGE

Scope: This thrust will address research to improve our understanding of the connectivity between land, water, atmosphere and people. Any change in the environment may have an impact on every other environmental factor and this impact should be assessed to be able to quantify the risks and to implement IWRM. This thrust will also focus on the movement of people (migration) and the response of aquatic ecosystems to these population dynamics.

Programme 1: Ecosystems and population dynamics	**Scope:** The impact of social dynamics on ecosystems and the environment will be addressed in this programme. As human population increases, moves and changes in different areas, sociological studies in relation to ecosystems (environment) are needed to support planning and development of rural and urban areas. In most cases, informal settlements are established in the riparian zones of water resources, which exerts pressure on those resources as people demand more services from those resources. In most cases, water resources such as wetlands and rivers become the only available service infrastructure for the homeless and for poor immigrants in urban and peri-urban areas. Research in this programme will support the Water Sensitive Design Lighthouse and greening of cities.
Programme 2: Ecosystems and climate change	**Scope:** This programme will deal with all aspects of climate change in relation to ecosystems. The research will develop knowledge about mitigation of and adaptation to climate change by aquatic biodiversity. The impact of climate change on ecosystem processes, functions, and structure will be given attention in this programme. The knowledge generated will be used to inform policy makers, businesses, and water managers. Aspects such as readiness, or lack thereof, by rural and urban communities to adapt to climate change, as well as ecosystem resilience, will be the subject of this programme.
Programme 3: Ecological thresholds	**Scope:** Research aimed at determining ecological thresholds will be supported in this programme. These studies will assist in developing understanding about how much degradation the environment or ecosystems can tolerate before collapsing or losing resilience. The research will also analyse the costs of restoring ecosystems and their functionality after total collapse, as well as the costs of not restoring or delayed restoration versus proactive prevention of degradation.

RESEARCH PORTFOLIO FOR 2016/17

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2:
Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems

Investigation of peatland characteristics and processes as well as understanding of their contribution to the South African wetland ecological infrastructure

WetResT (Centre for Wetland Research and Training); ARC Institute for Soil, Climate and Water; International Mire Conservation Group; Eon Consulting; Imperata Consulting; Wet-Earth Ecospecs; University of Groningen; Nancy Job; Sustento Development Services cc; Prime Africa Consultants cc

2346

Worldwide, peatlands cover approximately 3% of the earth's surface. The global carbon stored in peat is estimated to be in the order of 500 billion tons, approximately 30% of the world's soil carbon; as well as storing 10% of the world's freshwater. Although peatlands are not common in South Africa (less than 10% of SA wetlands are peatlands), some are unique. The Mfabeni Mire, for example, is 45 000 years old and is one of the oldest active peat-accumulating wetlands in the world. In South Africa, less is known about peatlands than other ecosystems such as forests, and so policy formulation and management decisions are not always grounded on a scientific knowledge base and may inadvertently lead to further destruction of these important ecosystems. Therefore, the first step in effective peatland conservation is to have accurate scientific baseline information in order to draft effective management guidelines and to define the socio-economic value of these ecosystems to society. Through this research project, 8 case-study peatlands in the different peat eco-regions have been characterized, classified and mapped to compile an inventory and to determine their conservation status. Based on these scientific baseline values the socio-economic value of peatlands in South Africa was established. The project not only supports the current wetland inventory of SANBI, DEA's obligations towards the Ramsar Convention and wetland rehabilitation initiatives, but also provides information on the credibility of conservation protocols in a regulatory environment where the value of ecosystems are forever competing in a losing battle with infrastructure

and social development initiatives. Therefore, the aim of this study was to evaluate the characteristics of peatlands and related processes; as well as their contribution to South African wetland ecosystem services.

Cost: R1 000 000
Term: 2014 – 2017

Programme 3:
Land-use and aquatic ecosystem management

Testing the preliminary guidelines for the determination of buffer zones for rivers, wetlands and estuaries

Institute of Natural Resources NPC; Nelson Mandela Metropolitan University; Diatom and Environmental Management; Eco-Pulse; University of KwaZulu-Natal (Pietermaritzburg)

2463

This report is a refinement of the 'Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries' (Macfarlane et al., 2014). An opportunity was provided to test the preliminary guideline at a series of national training and development workshops. A key recommendation that came out of the workshops was the compilation of a technical manual and a separate practical guide. The technical manual highlights the complete process that was followed in the development of a guideline for the determination of buffer zones for rivers, wetlands and estuaries. It provides the concepts, background and technical aspects of the approach required for determining appropriate buffer zones. The separate practical guide provides users with the relevant information required to consistently determine aquatic impact buffer zones. In addition, the buffer zone tools were developed for determining desktop buffer zones. The technical manual therefore needs to be used in conjunction with the practical guide and the tools developed, namely: 'Practical guide for determining aquatic impact buffer zones for rivers, wetlands and estuaries', 'Desktop buffer zone tool'. It is hoped that this practical guide for the determination of aquatic impact buffers for rivers, wetlands and estuaries, along with the technical manual and the buffer zone tools, provide the tools required to meet the demand for a scientifically defensible approach to determining buffer zones.

Cost: R398 600
Term: 2015 – 2017

Programme 4:
Integrated environmental and drinking water quality

The development and application of periphyton as indicators of flow and nutrient alterations for the management of water resources in South Africa

Freshwater Research Centre; GroundTruth; University of KwaZulu-Natal (Pietermaritzburg); SANBI

2351

This study (conducted in KwaZulu-Natal and the Western Cape) has provided clear evidence to suggest that specific algal indicators defined by growth form and

division are sensitive and robust over a broad range of conditions. Not only do these indicators respond to flow and nutrient alteration, but seem to respond rapidly to change and thus are ideally suited as an early detection of ecological change in rivers. Therefore, these indicators are ideally suited to predicting the effects of flow alteration under different levels of enrichment as part of the ecological Reserve determination process. Furthermore, these indicators would provide a sound basis for establishing 'ecospecs' as part of the setting of Resource Quality Objectives for rivers affected by both quality and quantity changes. The greatest contribution to biomonitoring from this study was the testing of the rapid chl-*a* (algae) tool, called Bentho-Torch.

Cost: R1 223 574
Term: 2014 – 2017

THRUST 4:
SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 2:
Ecosystem value-chain and markets

Investigation of aquatic ecosystem services, their value chain, and markets in South Africa

CSIR; Rhodes University
2341

The understanding of the value chains, markets and actual economic value of ecosystem services from aquatic ecosystems is still limited. Different studies have developed various approaches for determining the economic value of these benefits, as well as the associated natural capital. Most confirm that the value of aquatic ecosystems lies in the sustained net benefits derived from the many ecosystem services they supply; including various ecological functions, products for direct and indirect human consumption, energy, aesthetic and recreational benefits, and assimilative capacity of the residues of human activities. However, the geographic, cultural, and economic differences between countries or nations have resulted in different views which affect the market potential of ecosystem services from aquatic ecosystems. This study focused on identifying key ecosystem services, their forward linkages, understanding how to improve market access for such services, and to create or improve the value chains in the South African context. The research is intended to help identify more broadly the opportunities for improvements that benefit society. It is anticipated that the study will be useful to land use planners, the designers of infrastructure, and town planners. The study explored aquatic ecosystem services in South Africa within the context of a value chain assessment, with special focus on identify challenges and opportunities in the value chains of markets. A causal loop diagram (CLD) formed the basis for presenting and analysing the value chains of aquatic ecosystem services (AES). This model was the main product of this study;

however, it is still at an early stage and not yet ready for incorporation into policy and licensing. Further vigorous testing under different catchment scenarios (pollution pressure drivers) is required beyond the Baviaanskloof pilot study area. Tradable pollution permits (also called

cap-and-trade) – a market-based approach incentive to reduce pollution – was trialled in the Dwars River catchment, Western Cape, due to data demand for illustrations not available from Baviaanskloof. Tradable permits are based on the polluter-pays principle and aim to impose a cost on pollution, or generate a reward for pollution abatement. Filamentous algae treatment costs farmers more than R1.2 m/yr. Much verification and willingness of regulators will be required before this theory can be operationalized in South Africa, as it is administratively onerous.

Cost: R1 000 000
Term: 2014 – 2016

THRUST 1: ECOSYSTEM PROCESSES

Programme 3:
Aquatic, riparian and land connectivity

Linkages between the hydrodynamic and biological drivers of the Mgobezeleni Catchment

Nelson Mandela Metropolitan University
2259

The understanding gained from an integrated system will develop the tools and understanding to be able to predict the impacts of changes on the hydrology and ecology, and hence on the local communities in the area, in the Zululand Coastal Plain. The project brings together lead scientists with over 150 years of collective research experience, knowledge and management application in the different disciplines of hydrology, ecology, water quality and estuarine system dynamics. The knowledge generated is expected to be applicable to other communities, in particular, in Mozambique and Madagascar. The interaction between surface and subsurface water resources is dependent on many factors that influence the hydrodynamic processes and flow paths in various ways. The plethora of pathways that water can travel from its source to the various points of departure within a catchment are too numerous to mention and impossible to measure. Consequently, the most pragmatic approach to understanding and describing these pathways is through the development and application of three-dimensional numerical models. However, these models are very simplistic representations of the natural system. In the Zululand Coastal Plain, groundwater is an important component of the aquatic system and consequently the numerical model must provide a suitable representation of the groundwater hydrodynamics that include direct linkages to the surface water resources and the ecological system. The overriding aim of the project is to determine/understand the goods and services rendered to the ecological system by the hydrological system in a developing environment on a coastal aquifer with various surface water resources that are dominated by the groundwater. The specific aims are:

- Create conceptual and numerical models of the surface and groundwater components involving the interactions of the hydrological systems to support the investigation of biotic and abiotic linkages in a coastal system incorporating the groundwater, lakes, rivers, wetlands, estuary and marine environments
- Create conceptual models of the interactions of the biotic and abiotic components of the hydrodynamic system based on field studies of the groundwater, lakes, rivers and wetlands; these will include a classification of the wetlands based on their drivers,

and identification of their sensitivities to change – a special focus will be on peat and how it could be affected by a reduction in water availability
- Create conceptual models of the interaction of the biotic and abiotic components of the hydrodynamic system based on field studies of the hydrology of the estuary and the export of water and nutrients to the marine environment
- Identify and quantify actual and predictable anthropogenic impacts on the natural environmental components of the Mgobezeleni catchments on the hydro-biological components of the coastal environments
- Create platforms for the capturing, storage and dissemination of spatial and other forms of the biotic and abiotic data collected from the field studies at Mgobezeleni and utilised in the creation of the conceptual models

Cost: R2 700 000
Term: 2013–2015

Tools for monitoring and quantifying instream restoration success following removal of alien invasive plants

Stellenbosch University (Conservation Ecology & Entomology); Freshwater Research Centre

2460

A major objective of this project is to develop a composite index or tool to measure stream restoration success following removal of alien and invasive plants.

Specific objectives are:
- Determine the effects of riparian restoration on stream species functional diversity and abundance of stream species and compare this to natural and invaded conditions
- Determine the effect that riparian zone restoration has on nutrient cycling (nitrogen) in streams and compare this to natural and invaded conditions
- Quantify the nature and significance of the relationship between functional diversity and abundance of stream organisms and nutrient cycling
- Develop and transfer skills in the assessment of stream surface flow dynamics, nutrient dynamics, aquatic biodiversity, and riparian restoration

Cost: R1 000 000
Term: 2015–2018

Developing wetland distribution and transfer functions from Land Type data as a basis for the critical evaluation of wetland delineation guidelines by inclusion of soil water flow dynamics in urban catchment areas

ARC (Institute for Soil, Climate and Water); Terra Soil Science CC; University of the Free State; University of Pretoria; University of Fort Hare

2461

This project aims to provide knowledge to inform policy development and subsequent decision making actions in land use planning involving wetlands. Specific aims are:
- Develop a computer programme to collectively

sum and categorize the soils of SA Land Types with redoximorphic through to free drainage soil properties
- Map and quantify the occurrence and regional distribution of soils with redoximorphic features in South Africa based of Land Type Broad Soil Patterns
- Describe and analyse crest to footslope transects reporting on the morphological, physical and chemical soil properties in selected geographic study areas of intensive development in urban Gauteng
- Develop Hillslope (HiTF) and Land Type Transfer (LTTF) Functions by evaluating conceptual hydrological response models for selected developed (urban) Land Types of Gauteng
- Extrapolate and test these conceptual hydrological response models against similar Land Types
- Formulate a statement based on soil, hillslope and Land Type properties towards the regional assessment of wetland guidelines for South Africa
- Populate the Land Type database with pedological data supporting eco-, urban-, mining-, agricultural- and hydrology information and hydrology in general

Cost: R1 000 000
Term: 2015 – 2018

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1:
Ecological Reserve

Integrating a daily disaggregation modelling tool into a water resources simulation model

IWR Water Resources (Pty) Ltd
2263

One of the key principles of integrated water resource management (IWRM) is sustainable management of rivers to preserve ecosystems. To address this need, ecosystem scientists are working to establish (or have established) environmental flows within rivers. To determine the future reliability (ability to consistently meet environmental flows in future) of environmental flows, there is need to integrate environmental flows into catchment-wide water resource management models. However, technical issues arise during integration which need to be resolved. Increasingly ecologists are demanding daily hydrological models to improve their understanding of the link between river flow and ecological response. This issue was addressed in WRC Project K5/1979 and tools were developed to generate daily flow time-series which are consistent with monthly hydrological time-series currently used in water resource planning models. The next step is to integrate this daily aggregation tool into existing water resource models. The water resources planning models currently in use in South Africa all operate at a monthly time step. This is a major

stumbling block in assessing the increasingly complex scenarios that ecologists require water resources modellers to evaluate. As an example, the recently published guidelines for the evaluation of estuarine flow requirements require estimates of flood frequencies and how these flood frequencies change under changing development scenarios. This is not possible with the existing monthly models. Within the context of river ecology, the frequency and flood magnitude of spills from dams is becoming increasingly important as catchments become increasing impounded. Again, these crucial parameters cannot be assessed with the current monthly models. A secondary consideration within the framework of daily versus monthly modelling is that of sediment transport modelling. Geomorphologists have for many years only been able to provide broad guidelines to ecologists based on monthly hydrology. A recent positive development within the geomorphological realm of determining ecological flow requirements is WRC Project K5/1797 'Implementation of Strategic Adaptive Management for freshwater protection under the South African National Water Policy', commonly referred to as the Breonadia Model. The Breonadia Model is essentially a rule-based matrix population model coded in Visual Basic. It requires daily hydrological and rainfall data and starting proportions of different substrate types (which are defined by the site being modelled and which change with time depending on flows) as input data. Hence the provision of daily water resources modelling capabilities will be of huge benefit to the Breonadia Model. A logical extension of the Breonadia Model would be to incorporate sediment transport procedures into the proposed daily water resources model. This will then replace the rule-based substrate model with a more scientific approach with the added ability of scenario modelling. A specific request has been made by the Breonadia development team to carry out this development. Project aims are:

- Integrate the daily disaggregation model into a water resources model in order to provide ecologists with daily water resources modelling capabilities
- Incorporate flow and sediment routing algorithms into this daily model

Cost: R300 000
Term: 2013 – 2014

The use of long-term, large-scale data combined with historic ecological data to support Reserve implementation

Southern Waters Ecological Research & Consulting
2345

Project aims:

- To use a variety of sources of data to establish a timeline of temporal change in river and wetland ecosystem nature and/or condition at a basin scale
- To identify the main drivers of historical change and, if possible, isolate flow-driven changes
- To augment the basin-level data with site-specific information on riverine community composition, set in the context of the basin-level drivers of historical change
- To provide a template of long-term changes in aquatic ecosystems against which future monitoring of potential impacts associated with abstraction can be evaluated

- To assess key assumptions used in the determination of the ecological Reserve and suggest changes, if necessary and/or appropriate
- To investigate the occurrence and nature of ecological thresholds

Cost: R1 700 000
Term: 2014 – 2018

Quantification of transmission losses along the Letaba River for improved delivery of environmental water requirements (ecological Reserve)

SAEON Ndlovu Node

2338

Project aims:

- Determine environmental water requirement real-time implementation model uncertainties due to transmission loss parameterisation
- Select river reaches under various geological/hydrogeological settings where transmission losses need to be determined
- Select river reaches under various land management types where transmission losses need to be determined
- Quantify abiotic mechanisms for transmission losses in these reaches through groundwater–surface water interaction determination
- Quantify biotic mechanisms for transmission losses in these reaches through determination of actual evapotranspiration losses in the riparian zone
- Upscale the quantified processes through extrapolation with remote sensing, geophysical, hydrochemical and modelling techniques
- Develop accurate transmission loss parameters and incorporate in real-time Reserve implementation models
- Provide added-value by transcribing the findings to other rivers in the Lowveld

Cost: R882 000
Term: 2014 – 2017

Environmental water temperature guidelines: bridging the gap between research and implementation

Freshwater Research Centre; University of Venda; University of Cape Town

2537

Project aims:

- To identify requirements of river managers and practitioners for incorporating water temperature into the ecological Reserve
- To develop a protocol for collection and/or derivation of water temperature time-series data
- To develop tools for setting water temperature targets for the ecological Reserve
- To produce a manual for setting water temperature targets for the ecological Reserve
- To disseminate knowledge on the protocol, tools and guidelines through workshops and discussions

Cost: R1 500 000
Term: 2016 – 2019

Programme 2:
Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems

Developing a refined suite of tools for assessing the Present Ecological State of wetland ecosystems

Freshwater Research Centre; Eco-Pulse Environmental Consulting Services; University of KwaZulu-Natal (Pietermaritzburg)

2549

Project aims:

- To engage with key stakeholders to clarify user requirements for a wetland PES assessment tool, and to agree on an assessment framework for different types of wetlands and levels of PES assessment
- To integrate the existing wetland PES assessment tools into a single suite of user-friendly tools, in line with user requirements, and to address the shortcomings of the existing methods
- To undertake iterative testing of draft versions of the PES assessment tool so as to improve the tools that are developed

Cost: R1 500 000
Term: 2016–2019

Programme 3:
Land-use and aquatic ecosystem management

Geospatial analysis of microbial community structure and antimicrobial resistance analysis in the management of natural streams and selected wetlands

North-West University (Environmental Sciences & Management)

2347

Project aims:

- To determine and establish water quality of selected surface water sites and classify these based on physico-chemical and microbiological conditions
- To optimize microbial DNA extraction and next generation sequencing methods for establishing microbial biodiversity indices
- To determine the accumulation and attenuation of antibiotic resistant bacteria (ARBs) and genes (ARGs) in water environment at the various sample sites using culture-dependent and culture-independent methods
- To track the origin and movement of ARBs and ARGs from the terrestrial watershed to water environment using comparative and statistical analysis
- To map the landscape to link anthropogenic activities (animal and agriculture operations) with the concentration of ARB and ARGs in the watershed

Cost: R990 000
Term: 2014 – 2017

The investigation of selected Ramsar wetlands biodiversity status and tourism value in support of the Ramsar convention information requirements

North-West University (Biological Sciences)

2352

Project aims:

- Review of available aquatic information for South Africa's Ramsar sites
- Compilation of available aquatic information of Ramsar sites into a database
- Management of land use surrounding selected South African Ramsar sites

Cost: R1 774 700
Term: 2014 – 2017

Aligning and integrating biodiversity and environmental water quality into the mining development life-cycle

AWARD

2355

Project aims:

- To conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management
- To investigate and evaluate the decision-making processes followed in issuing mining authorizations
- To determine the relationship between licensing processes and ecological infrastructure from a landscape and connectivity perspective
- Propose an integrative decision-making process and institutional arrangement

Cost: R2 000 000
Term: 2014 – 2017

Programme 4:
Integrated environmental and drinking water quality

Development of an immobilized receptor-based EDC detection kit

Stellenbosch University (Zoology)

2271

The first reports of synthetic compounds that could interfere with the normal physiological functioning of the endocrine system in mammals, amphibians and reptiles emerged several years ago. The physiological effects of these compounds, later collectively named endocrine-disrupting compounds (EDCs), were observed in lakes, rivers and surface waters in North America and subsequently Europe. A hallmark of EDC contamination is the low concentrations (lower than mg/L levels) at which these substances can occur in various water sources. Despite the rapid development of detection and screening techniques for specific EDCs, the chemical diversity of EDCs that have the same biological effect is severely hampering the indication of these compounds. It is therefore important to continue the search for sensitive and reproducible assays based on the biological effects of compounds rather than their specific chemical structures. Current consensus is that EDCs pose a significant, long-term environmental risk to

the wellbeing of both humans and wildlife. At present, there are no rapid on-site detection systems available for the detection of EDCs with potential estrogenic or androgenic activity. The construction of a rapid, on-site monitoring system could give an initial indication whether particular bodies of water, including wastewater effluent and municipal water supplies, contain EDCs and are, thus, in the long term, fit for use. This kit is not to be used in isolation but rather to serve as the first step in identifying water sources that may be contaminated with EDCs. The key objectives of the project are:

- Synthesis and modification of a PVP spacer arm
- Synthesis of a membrane surface chelating agent, PGEAH
- Assembly of SMA-PVP co-polymer affinity membrane
- Immobilization of ligand binding domains of the androgen and oestrogen receptors on SMA-PVP co-polymer affinity membrane
- Testing EDC binding by immobilized ligand binding domains of the androgen and oestrogen receptors
- Developing a colorimetric visualization method for detection of EDCs
- Validation of membrane based detection method against an ELISA-based method

Cost: R1 070 000
Term: 2013 – 2015

The application of ecotoxicity and an activity analysis of salt management to water resource protection and use (domestic, agriculture, mining and industry)
Rhodes University
2462

The project intends to find the best way to manage salinization of freshwater in South Africa. This will be done by testing the toxicity levels of wastewater from different industries or sectors using aquatic biota. A salinization management framework will be developed. Specific aims are:

- To conduct short-term chronic (10–14 days, i.e. 240–336 h) ecotoxicological tests using Caridina nilotica as test organism and toxicologically important major salts (TIMS) specific to municipal wastewater, agriculture, mining and industry
- To use the results from the ecotoxicity tests to develop a set of salinity ranges that correspond to the levels of protection within the resource classification system specific to municipal wastewater, agriculture, mining and industry
- To use the resultant risk-based salinity guideline as the basis for setting resource objectives to contribute to the management of streams potentially impacted by the respective saline effluents from municipal wastewater, agriculture, mining and industry
- To analyse salt management activities in selected agricultural, industrial, mining and domestic (mainly wastewater treatment) facilities and propose a new management practice using Cultural Historical Activity Theory (CHAT)
- To develop a salinization management framework based on the developed SSD salinity risk-based guidelines and CHAT-based management practices

Cost: R2 000 000
Term: 2015 – 2018

A new approach to strategic resource planning for South Africa's estuaries – shifting from an activity-based to a multi-sector paradigm

CSIR (NRE: Marine & Coastal); Nelson Mandela Metropolitan University; Department of Agriculture, Forestry & Fisheries

2464

Project aims:

- The sector-based (or activity-based) approach to estuarine resource planning in South Africa is not sustainable. This research aims to explore an alternative multi-sector approach (tool) using available data and information (already residing within various sectors and the scientific literature) and standardizing formats and outputs suitable for strategic planning processes (e.g. using geo-referenced spatial formats).
- Develop a tool (using spatially-explicit software and/or spreadsheets) to enable intuitive (visual) analysis and interpretation of data and information to inform strategic spatial planning (e.g. through application of spatial analysis technologies).
- Demonstrate to key lead agencies (e.g. DWS, DAFF and DEA) how this tool can be applied to easily identify potential conflicts among sector resource use plans and to explore multi-sector resource use scenarios in order to sensitize managing authorities to the value of joint, multi-sector estuary resource planning.

Cost: R1 796 800
Term: 2015 – 2017

Programme 5:
Ecosystem risks and disaster management

Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment

Stellenbosch University

1712

Scientific research has shown that all major aquatic wildlife groups are experiencing endocrine disruption (ED). ED, at many sites, is caused by a complex mixture of substances, very often in low concentrations but acting in synergy with other compounds in the mixture. Imperfect knowledge about the effects of endocrine disrupting compounds (EDCs) on ecosystem structure has implications for environmental risk assessment for EDCs. An important emerging approach is to develop models for ED exposure in food chains, including pathways for human exposure. This study will research and design a conceptual risk assessment model related to the unique features of EDC dynamics in the aquatic environment in South Africa. This project aims to assess the advances made in the development of ecological-based risk assessment models and the use of the precautionary principle (vs. weight of evidence) in ecological risk assessments, as well as associated data requirements, with particular reference to EDCs. An appropriate ecological risk assessment model or framework for application in South Africa will then be recommended. The results will add value to the

existing EDC programme and will provide guidance regarding future research.

Cost: R370 000
Term: 2007 – 2013

Programme 8:
Transboundary ecosystem management

Development and innovative use of community-based water resource monitoring tools to research and mainstream citizen science and improve transboundary catchment management

Groundtruth cc

2350

Project aims:

- In collaboration with partners in South Africa and each of the six neighbouring transboundary countries, identify and develop existing and new rapid tools for citizen and school learner monitoring of river and catchment health indicators
- Package the tools into an integrated river and catchment monitoring toolkit for roll-out within South Africa and neighbouring countries
- Dissemination of the developed toolkit to promote citizen and school-level education and awareness of catchment and river health
- Through application of the toolkit and geo-database, initiate the growth of a transboundary citizen science dataset of river and catchment health covering South Africa, neighbouring countries and beyond
- Through collaboration with specialists in each neighbouring country, foster research around transboundary water resource management at citizen level
- Assess the successes and barriers to the application of the citizen science tools in effecting meaningful change in the challenges of transboundary water resource management

Cost: R1 432 180
Term: 2014 – 2017

THRUST 3:
ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1:
Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

Evaluating fish and macroinvertebrate recovery rates in the Rondegat River, Western Cape, after river rehabilitation by alien fish removal using rotenone

SA Institute for Aquatic Biodiversity

2261

One of the greatest threats to South Africa's native freshwater fishes is the negative impact of invasive alien fishes. These impacts include predation, arguably the most serious threat, competition and hybridization. Native fishes in the Cape Floristic Region are characterised by high diversity, endemism and geographic isolation. This makes them vulnerable to the impacts of alien fishes which have extirpated many native fishes from lower reaches of rivers resulting in decreased distributional range and genetic isolation. Many native freshwater fish in the Cape Floristic Region are now red-listed as critically endangered, endangered or vulnerable. In addition, there are strong indications that the loss of native fishes has profound impacts on the aquatic food web. What is significant from a river rehabilitation perspective is that in many river areas the only impact is the presence of invasive alien fish. By eradicating the alien fish, it is often possible to rehabilitate several kilometres of a river, with very significant benefits for the endangered fish species present and for the associated aquatic biota. To fully evaluate the use of rotenone as an alien fish removal and river rehabilitation tool it is important that both the immediate and long-term impact of rotenone on community composition and recovery is evaluated. Such research is critical as it will determine whether native fish and invertebrate communities recover after the removal of alien fishes or if the system moves towards an alternative state. To fully assess the consequences of alien fish eradication on the faunal communities in the Rondegat River will require recovery monitoring for a period of at least three years; hence this study. The project will be achieved through the following objectives:

- Determine how the Rondegat River ecosystem responds to the removal of alien fishes over a three-year period
- Assess rates of recovery of invertebrate and fish communities after rotenone treatment over a three-year period
- Test the hypothesis that native invertebrate and fish communities rebuild to approximate those in the non-invaded zone of the river
- Develop post-fish eradication monitoring guidelines for fish and invertebrates
- Provide recommendations for future river rehabilitation projects where alien fish are to be eradicated using rotenone

Cost: R445 320
Term: 2013–2016

Assessing the impact of selected methods of removal of alien invasive trees and biomass on fynbos riparian ecosystem functioning

Stellenbosch University

2343

Project aims:

- Evaluate the impact of recommended levels of herbicides used to control alien invasive growth and regeneration on soil microbial diversity and on selected beneficial groups of microbes in situ and ex situ and in riparian soils from two different longitudinal zones
- Determine the impact of slash-and-burn of *Eucalyptus* and *Acacia mearnsii* biomass on soil microbial diversity and on selected beneficial groups of microbes in situ, and measure regeneration of various native plant species grown in soil from slash-and-burn scars ex situ
- Determine the impact of slash-and-burn of *Eucalyptus* and *Acacia mearnsii* biomass on soil physical and chemical properties in situ
- Determine the biomass and nutrient content of E*ucalyptus* and *Acacia* mearnsii trees of different sizes growing at different stem densities in riparian sites from two different longitudinal zones

Cost: R1 500 000
Term: 2014–2017

Evaluation of the socio-ecological outcomes of wetland rehabilitation in South Africa

GroundTruth cc

2344

Project aims:

- Develop (through iterative application and testing) a monitoring and evaluation framework for the socio-ecological outcomes of wetland rehabilitation in South Africa
- Provide a formative and outcomes-based evaluation of wetland rehabilitation within South Africa, with a focus on the Working for Wetlands operations
- Skills development within the Working for Wetlands programme to allow an internal evaluation of a sub-set of rehabilitated wetlands
- Deepening our understanding of wetland socio-ecology in terms of rehabilitative management
- Specific evaluation of rehabilitation methods employed with the objective of identifying those methods most suitable for labour-based approaches and inform further research
- Contextualize the value of the wetland rehabilitation when viewed as an investment in ecological infrastructure

Cost: R2 500 000
Term: 2014–2019

Rotenone policy support and capacity development through integrating aquatic-ecosystem monitoring in postgraduate research projects with particular emphasis on HBUs

South African Institute for Aquatic Biodiversity; Rhodes University (Albany Museum); University of Fort Hare; University of Venda; Stellenbosch University; Cape Nature; University of the Western Cape

2538

Project aims:

- Provide data on ecosystem responses of two rivers and two dams following rotenone treatment to guide national policy on the use of rotenone for alien fish removals
- Test the hypothesis that ecosystem recovery rates in Krom River (invertebrates and fish) will approximate those in the Rondegat River for two years following treatment with rotenone
- Monitor rates of recovery of fish communities in the Rondegat River continuously to determine when complete recovery has occurred by testing the hypothesis that native fish communities rebuild to approximate those in the non-invaded zone of the river within 5 years after treatment
- Assess the recruitment and recovery rates of invertebrate communities to the removal of alien fishes using rotenone in two off-channel dams
- Develop a concept for integrating postgraduate (BSc Honours) projects into a long-term monitoring framework
- Develop human capacity in fish and invertebrate monitoring at Historically Black Universities (HBUs) by integrating postgraduate students and supervisors from HBUs in monitoring projects to develop interest for students to pursue careers in aquatic ecology
- Using lessons learnt from this project in the Western Cape, provide recommendations for the implementation of long-term monitoring projects in river ecosystems in the Eastern Cape and Limpopo Provinces
- Develop a Policy Brief to justify rotenone as the chemical of choice for alien fish eradication; this Policy Brief will facilitate national policy support and buy-in

Cost: R1 443 200
Term: 2016 – 2019

Determining the hydrological functioning of the Palmiet wetlands in the Eastern and Western Cape of South Africa

Institute for Water Research; Parsons & Associates

2548

Project aims:

- Determine the surface and groundwater dynamics of the Kromme River upper catchment (K90A)
- Identify the relationship between wetlands and hydrological functioning of the catchment
- Determine whether wetland degradation is impacting the hydrological integrity of the river, thereby compromising water security and human wellbeing

Cost: R500 000
Term: 2016–2018

Programme 2:
Socio-economic dynamics

Green village catchment management: guidelines and training

Aurecon; Phuhlisani Solutions cc; University of the Western Cape; AWARD

2508

Project aims:

- To improve water-energy-food security as well as environmental health in rural catchments
- To empower and upskill rural communities to support their own green villages (incl. service delivery)
- To identify stumbling blocks to guideline implementation and catchment management interventions sustainability in rural areas
- To improve the state of rural catchments from the individual–household–village outwards
- To develop an education and skills development programme to support rural job creation to support green villages

Cost: R1 500 000
Term: 2015 – 2019

THRUST 4:
SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 1:
Environmental economics (goods & services) and accounting

Upscaling understanding of water movement, land degradation and carbon cycle in support of effective payment for ecosystem services

University of KwaZulu-Natal (Agriculture, Earth & Environmental Sciences)

2266

Natural ecosystems provide key functions essential to the sustainable economic development of societies. Concerns about long-term sustainability and high environmental costs support the need for an increased understanding of the processes and consequences of land degradation. Land degradation is not limited to an impact on water resources and agricultural production (crop and animal); the living system of the soil also provides a range of ecosystem services that are essential to the wellbeing of farmers and society as a whole. Initially focused on the water resource, Payment for Ecosystem Services (PES) systems now focus on land-water interactions and highlight that catchment condition and, where necessary, rehabilitation, are key to sustained water supply and water quality. However, we still lack an understanding of carbon (C) and nutrient cycles and their role in land rehabilitation techniques. Additionally, there still remain a myriad of unresolved questions and problems related to scale, water quantity and quality, and C and soil nutrient cycles. Addressing

these issues remains one of the outstanding challenges in the field of hydrology and environmental sciences and is fundamental in order to foster sustainable economic development in rural areas of South Africa. Moreover, because both the expected results and scale issues are not unique to hydrology there is a range of disciplines, such as meteorology and climatology, geomorphology, soil science/biology and social sciences, which will also benefit from this field of research. As a consequence, we seek through this interdisciplinary project to understand organic C and nutrient cycles from hillslope to basin level, to promote optimal functioning of natural ecosystems.

The aims of the project are:

- Upscaling understanding of carbon and nutrient cycles, from the small agricultural catchment to the basin level, through: (i) out-scaling (lateral extension across similar landscapes), and (ii) up-scaling to assess how processes change as the catchment size increases
- Select and evaluate best management practices (BMP) for improved ecosystem functioning and link understanding of carbon and nutrient cycles to remediation activities and Payment for Ecosystem Services (PES)
- Apply BMP at large scale (both spatial and temporal) by running scenarios through improved modelling

Cost: R2 907 000
Term: 2013 – 2018

Evidence-based analysis of environmental degradation: Impact of ecological degradation on water resources, ecosystems and socio-economic development

Prime Africa cc
2272

Degradation of aquatic ecosystems has negative impacts on the economy, and on the health of people and water resources through losses in ecosystems goods and services (EGS). In some cases, the use of the precautionary principle can prevent damage, but this can also prevent economic development. It is thus poor communities who are most often affected by changes in EGS. Rivers, the arteries of a catchment, reflect the health of the environment and the social-ecological system (SES). Any problems in a river basin are reflected in the health of the rivers. The DPSIR model (Driving forces, Pressures, State, Impacts and Responses) provides a framework which enables the drivers exerting the pressure causing the change in the state of the environment to be identified. This directs the response of management to address the drivers, so providing a long-term solution to degradation. There is a lot of research (research outputs include databases and scientific findings) on the degradation of inland waters, but this has not been drawn together into a cohesive whole. The rigorous evidence-based methodology employed by E-BASES (WRC Project K5/1978) will provide a thorough review of the existing knowledge. This, combined with the ecosystem service valuation methods developed by WRC Project K5/1644, will indicate what the cost of environmental degradation has been to the SES. An

important part of this work will be to develop a legal view on the standards and level of evidence that would be sufficient to prove liability for ecological degradation. By example, a recent EU directive (EU 2004) has developed a framework of environmental liability based on the polluter-pays principle to prevent and remedy environmental damage, which may provide a way forward in implementing this principle. Specific objectives are:

- To develop appropriate approaches for assessing the causal effect of degraded water resources resulting from catchment land uses on socio-economic development
- To review the subject in the context of water resource and thus aquatic ecosystem goods and services
- To develop or refine approaches and tools needed to analyse the socio-economic impact of environmental destruction or degradation, with special focus on the health and integrity of water resources
- To investigate possible effects of degraded water resources on users and associated food chains and the effect on the benefits derived from the ecosystem goods and services used in both rural and peri-urban/urban catchments
- Apply and provide a critical analysis of the results, including policy implications, opportunities, and threats to local communities and to the country

Cost: R2 000 000
Term: 2013–2017

Demonstration of how healthy ecological infrastructure can be utilized to secure water for the benefit of society and the green economy through a programmatic research approach

University of KwaZulu-Natal (Centre for Water Resources)
2354

Project aims:

- To investigate and report on the status of catchment land-use and water resource quality in the selected catchment(s)
- Cost the impacts of the degradation of ecosystem infrastructure on water users from different stakeholder experiences using an evidence-based approach
- Investigate how an intact ecological infrastructure could secure and enhance the benefits provided to society and economy in the catchment
- Investigate how investment in the protection and enhancement of the environmental asset base (or ecological infrastructure) of the uMngeni catchment could contribute to resilient economic growth, greater social equity and justice and the reduction of environmental risks, thereby addressing the goals of the green economy
- With the aid of the stakeholder water resource management framework produced in Phase 1, develop a cost-effective conservation management strategy based on the principles of the green economy
- Develop and train actors in the catchment in an appropriate governance model/approach, which includes social learning, knowledge production

(including spatial knowledge), participatory engagement and technical methods (models, guidelines, indicators, procedures) necessary to achieve a paradigm shift to transform society and the economy towards a healthy relationship with the ecological infrastructure within the catchment, i.e., to change the socio-ecological relations in the catchment to ensure greater resilience through the development of a transformative governance approach
- Describe the catchment connectivity in terms of both bio-physical and social aspects that are core in understanding drivers of the catchment processes and characteristics
- Recommend further research on the social and ecological interface critical to improve natural resources governance at the catchment scale

Cost: R5 000 000
Term: 2014 – 2020

Development of a methodology and decision support system to determine appropriate protection levels of water resources using ecosystem services and socio-economic tools

Prime Africa Consultants cc; Institute of Natural Resources; Golder Associates Africa

2465

There is a need for credible implementation of the Water Resource Classification System. Implementation has been weakened by the existing inconsistencies in the use of the current 7-step guideline. Therefore, this project intends to close this gap. This will support the work of DWS and CMAs. The specific aims are:

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

Cost: R2 000 000
Term: 2015 – 2018

The utilization of water hyacinth (*Eichornia crassipes*) from Hartbeespoort Dam in biogas and bio-fertilizer production, as a solution to water weed challenges

ARC (Institute for Soil, Climate & Water); The Moss Group; University of Pretoria

2543

Project aims:

- To characterise the substrate (water hyacinth and algal soup) and to determine the optimum solid retention time (SRT), hydraulic retention time (HRT)

and biogas yield at lab-scale; this information will be used to optimise the design of the digester for the anaerobic digestion of water hyacinth and algal soup obtained from Hartbeespoort Dam
- To co-digest water hyacinth, algal soup and various other substrates in an attempt to maximize bio-methane yield
- To test the effect of catalysts on the digestion process (e.g. certain bacterial species) in an attempt to augment biogas yield
- To determine the microbial composition (using next generation sequencing and DGGE) at various stages of digestion which will aid in selecting the species that may be used in bio-augmentation experiments and to determine the feasibility of the effluent to be used as a bio-fertilizer (chemical composition and absence of pathogens)
- To conduct a cost–benefit analysis of the system that incorporates anaerobic digestion, in comparison to the current method of dam remediation (i.e. harvesting and composting)
- To determine the social-economic impact of removing water hyacinth and algal soup from Hartbeespoort dam on members of the surrounding communities

Cost: R500 000
Term: 2016 – 2018

Programme 3:
Gender, culture and heritage for ecosystems

Explore and incorporate indigenous knowledge systems into natural resource planning policies and government strategies in order to create space for rural community engagement and empowerment aimed at improving their livelihood while sustaining infrastructure

University of the Western Cape (PLAAS)
2353

Project aims:
- To conduct an extensive review on the current uptake of the diversity of indigenous knowledge systems in water resource management policies and strategies
- To establish the implications of the extent to which cultural or indigenous knowledge is considered in the development of strategies meant for decentralization of water resource management, such as catchment management strategies, national biodiversity framework, etc.
- To understand the socio-economic and political perspectives of the value of aquatic ecosystems by rural communities
- Understand how the current distribution of power and gender dynamics impacts decision making in water resource planning strategies and policies
- Develop and test an approach for the inclusion of all knowledge systems (indigenous, scientific and governmental) in policies and strategies for more holistic water management
- Identify future research pathways for the integration

of indigenous knowledge systems in policies and strategies

Cost: R1 000 000
Term: 2014 – 2017

Programme 4:
Green economy and sustainable (green) innovations

Green water innovations for sustainable aquatic ecosystems and socio-economic development

African Centre for a Green Economy (Africege)
2349

Project aims:

- To evaluate the impact of green innovations on water resources and aquatic ecosystems
- To evaluate the effects of green innovations on corporate performance and society; special focus on South African companies will be prioritised
- To investigate the usefulness and appropriateness of the metrics or indicators that are used to determine the efficiency of green innovations on water resources; recommend a set of indicators that are most appropriate for South Africa
- To recommend specific green innovations that companies should consider to improve the triple bottom-line in South Africa

Cost: R1 333 000
Term: 2014–2016

Investigation and demonstration of how integrated green innovations and technologies can be utilized to create entrepreneurship/jobs that improve the economic conditions of communities in the upper Umzimvubu River (Ntabelanga) and Okhombe, within Jo Gqabi and Thukela District Municipalities, respectively

Department of Environmental Affairs; Umhlaba Consulting Group (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); University of Fort Hare (Agronomy); Aquamet; Renen Energy Solutions (Pty) Ltd
2423

Project aims:

- Identify drivers of poverty, opportunities offered by natural ecosystem, and develop community-based vision of a Green Village using a bottom-up approach
- Through integration of indigenous knowledge, green innovations, research, and technology, develop a toolbox of green solutions that can address the impact of climate change and help communities or sectors to adapt to climate change
- Identify and develop a business (economic) framework that poor and local communities can use to improve their livelihoods without furthering land-use degradation
- Develop and test practical and appropriate mechanisms, manuals and guidelines for landscape development and management that will protect the infrastructure and improve ecosystem services
- Train communities (mainly the youth) on appropriate skills/capacity necessary to sustain the businesses and ecosystem services that transform the poor community to be more self-sufficient

- Integrate the green solutions toolbox and business framework with core line-functions of government departments in order to ensure sustainability of the intervention and to forge partnerships with all key stakeholders
- Develop models on how to expand the green toolbox of solutions and business framework utility, from household/village to the national or country-wide scale

Cost: R2 000 000
Term: 2015 – 2018

Landscape green innovations to improve aquatic ecosystem services for the benefit of urban and peri-urban communities

African Centre for a Green Economy (Africege); Environmental Monitoring Group; University of Cape Town; NM Envirotech Solutions

2507

Project aims:

- Investigate the nature of landscape innovations suitable for protecting urban and peri-urban aquatic ecosystem services, using Khayelitsha Wetlands Park as a case study
- Investigate the nature of ecosystem services that the wetland provides to local community members
- Identify enterprise development opportunities that can be used to boost community involvement in the protection of the wetland
- Develop a business case for a bankable project locally owned and managed by local community members that addresses issues related to water, food and/or energy security

Cost: R600 000
Term: 2015 – 2017

Pharmaceuticals from South African aquatic plants

University of Pretoria; Mothong Heritage; Walter Sisulu University

2540

Project aims:

- Investigate propagation possibility
- Investigate biological and chemical action of *Mentha longifolia* against melasma
- Investigation of 20 other aquatic plants for treatment of melasma, TB and cancer and for peridontal care

Cost: R2 358 960
Term: 2016 – 2020

THRUST 5:
ECOSYSTEMS AND GLOBAL CHANGE

Programme 1:
Ecosystems and population dynamics

Response of urban and peri-urban aquatic ecosystems to riparian zone land uses and human settlements

Nxt2u (Pty) Ltd

2339

Project aims:

- To complete a literature study on work previously done on challenges regarding informal settlements and consequential degradation of natural resources
- To investigate the regulatory framework that governs human settlements, including processes associated with spatial planning as well as effectiveness of the implementation thereof
- To investigate issues arising from the influx of people into areas that are characterised by sensitive ecosystem and infrastructural resources, including water provision, access and use
- To undertake a pilot study of human-induced impacts on sensitive aquatic ecosystems and changes in ecological dynamics, particularly due to informal settlements
- To investigate the impacts of riparian land-use activities on aquatic ecosystem goods and services
- To develop a framework to propose how ecological resilience can be attained, or how a balance can be struck between human settlements and good ecosystem functioning

Cost: R1 500 000
Term: 2014 – 2017

Programme 2:
Ecosystems and climate change

A climate change risk assessment of water hyacinth biological control

University of the Witwatersrand (Animal, Plant & Environmental Sciences)

2265

Alien weed control costs South Africa approximately R6.5 billion per annum, and climate change will impact the effectiveness of those efforts. This project seeks to develop a tool to help manage the outcome of future climate scenarios on alien weed control. Water hyacinth is one of the world's most invasive aquatic plants, originating from South America and invading many ecosystems; its control is crucial. Multiple methods such as mechanical, herbicidal, and biological control have been used against it. However, biological control is considered to be the best long-term, sustainable approach, and is potentially many times more cost effective than other methods, when successful. With such an economic benefit, understanding and improving the success of biological control of water hyacinth is essential. This study proposes to incorporate the effects of biological control by *Neochetina* weevils,

with temperature and nutrients, into a model of water hyacinth growth which will give site-specific predictions of population growth of both weevils and water hyacinth, and have applications in climate change risk assessment and management, e.g., by Working for Water. The key project objectives are:

- Model the relationship between environmental temperature and water hyacinth weevil population density and growth
- Model the relationship between water nutrients and water hyacinth population density and growth
- Model the relationship between nutrients and weevil population density and growth
- Combine the above elements to determine how effective biological control of water hyacinth by *Neochetina* weevils will be under different climate scenarios

Cost: R500 000
Term: 2013 – 2016

A multi-proxy investigation into past and present environmental change at Lake St Lucia

University of the Witwatersrand (Chemistry)
2336

Project aims:

- To investigate both the long-term and short-term geomorphic and sedimentological evolution of Lake St Lucia through a combination of geophysical, geochemical, and palaeo-environmental techniques
- To relate these changes to long-term change in climate, lake water chemistry, and shorter-term anthropogenic influences on the system
- To provide an analysis of climatic controls on the geomorphic and sedimentological evolution of the lake system
- To inform system management practices using insights gained from a longer-term evolutionary perspective

Cost: R849 500
Term: 2014 – 2017

Assessing the effect of global climate change on indigenous and alien fish in the Cape Floristic Region

Freshwater Research Centre
2337

The overall aim of the project is to determine the vulnerability of indigenous fishes to a changing environment:

- To map the current distribution of indigenous and alien fish species in the CFR based on existing and new data
- To evaluate the vulnerability of indigenous fish species and the threat of invasive alien fish species in the CFR under projected climate change
- To characterise flow, habitat and thermal requirements of target fish species
- To determine the thermal ranges and/or thermal preferences of target fish species using field data,

niche models, in situ and ex-situ experiments
- To evaluate the likely consequences of climate change on fish species through scenario analysis
- To provide recommendations for the conservation of indigenous fishes in the CFR with a criterion-based evaluation of extinction risk

Cost: R1 860 100
Term: 2014 – 2017

Ecosystem process and function of temporary wetlands: baseline data for climate change predictions

Nelson Mandela Metropolitan University

2348

Project aims:
- Determine the level of biogeochemical cycling generated by primary producers (e.g. micro- and macro-algae) in temporary wetlands during different levels of inundation in order to refine understanding of this process for use in global climate change models
- To examine trophic relationships in temporary wetlands under different levels of inundation and link these to different climate change models
- To experimentally determine different temperature, water level and nutrient regimes that affect the growth and production of various algal taxa, for use and refinement in climate change and eutrophication models
- To determine loss of ecosystem services from temporary wetlands associated with changes in global climate

Cost: R1 500 000
Term: 2014 – 2017

Long term WRFChem modelling and verification of wet and dry acid deposition over South Africa and investigation of impact of power generation stack emission limits on acid deposition

eScience Associates (Pty) Ltd; University of the Witwatersrand; University of Cape Town; North-West University (Potchefstroom)

2466

The project intends to develop a time-dependent emission inventory using 15 years of climate and deposition data. The project will consider using the WRFchem model to predict dry and wet acid deposition in South Africa. This will be done by modelling future power (stations) emissions with or without SO2. Results from the model will be verified with actual data (dry and wet acid deposition) from other sources (e.g., Eskom and Josipovic data).

Cost: R700 000
Term: 2015 – 2016

Development of a predictive management tool for Orange River blackfly outbreaks

Groundtruth cc; Red Meat Research & Development SA; Nepid Consultants; Department of Agriculture, Forestry & Fisheries; Philagro SA (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg)

2459

The study will use an integrated approach that includes water variables and farming practices to model and predict blackfly outbreaks. The modelling results will also be used to put together preventative measures, taking into consideration climate change. Specific aims are:

- Test and refine the current probabilistic blackfly outbreak model by inclusion of temperature and turbidity data, and using previous flows and monitoring data
- Undertake climate change scenario analyses to assist future management planning
- Provide an evaluation framework for monitoring data of blackfly larval densities, based on the outbreak model
- Provide a Blackfly Control Programme auditing system using a mobile phone application whereby the general public can report on nuisance levels of adult blackfly
- Capacity building for Blackfly Control Programme (Northern Cape Agriculture) staff

Cost: R1 200 000
Term: 2015 – 2017

THRUST 1: ECOSYSTEM PROCESSES

Programme 1:
River, wetland, groundwater and dam processes

Assessment of carbon storage in wetlands

Eon Consulting; WetResT (Centre for Wetland Research and Training); University of Pretoria

2542

Project aims:

- Assess, through a review of international and national literature, the effectiveness of wetlands to store carbon
- Assess, through field studies, the amounts of carbon stored in the various hydrogeomorphic wetland types
- Assess the flux of carbon in the wetlands
- Assess the value of using carbon storage as an indicator of wetland functionality and health
- Assess the value of carbon stored by wetlands and neighbouring ecosystems in terms of the UN-REDD+ programme

Cost: R880 000
Term: 2016 – 2018

Programme 2:
Estuarine, coastal and marine processes

The development of a Bayesian model of the ecosystem and mouth dynamics for temporary open/closed estuaries (TOCEs)

University of Zululand; Hydrological Research & Training Specialists

2541

Project aims:

- To understand and model the evolving relationship between fluvial and marine conditions/states (based on surrogate variables) that control the estuarine vegetation and mouth dynamics using a Bayesian statistical approach based on derived data and information from the Mlalazi catchment and estuary
- To model the hydrology and hydrodynamics of the Mlalazi catchment and estuary to provide the daily/sub-daily flows and depths at the mouth to provide the variables for the development of the Bayesian models of the vegetation and mouth dynamics
- To describe the present and historical vegetation patterns within the Mlalazi functional estuarine zone (including that in the beach region of the mouth) and describe the drivers that have caused these patterns

to provide the variables for the development of the Bayesian models of the vegetation
- To assist with the resurrection of the HRU as a sustainable Research Unit at the University of Zululand to promote advanced multidisciplinary research in aquatic coastal systems; this will be done by using the Mlalazi catchment, estuary and estuary mouth studies as a catchment-to-coast systems approach to support academic studies at postgraduate level

Cost: R1 000 000
Term: 2016 – 2019

Programme 4:
Surface and groundwater interactions

Development and application of passive samplers for determining the fate of toxic metals in wetlands polluted by mining activities

University of the Witwatersrand; Masaryk University
2551

Project aims:
- To develop a modified DGT derivative passive sampler for the evaluation of the fate of toxic heavy metals in wetlands
- To develop a modified DGT derivative passive sampler based on a polymer inclusion membrane for the evaluation of the fate of toxic heavy metals in wetlands
- To optimize a modified DGT derivative passive sampler for the evaluation of the fate of toxic heavy metals in wetlands
- To optimize a modified DGT derivative passive sampler based on a polymer inclusion membrane for the evaluation of the fate of toxic heavy metals in wetlands
- To apply the developed passive samplers for the evaluation of the fate of toxic heavy metals in wetlands
- To compare the performance of the developed passive samplers with commercial DGT

Cost: R760 000
Term: 2016 – 2019

THRUST 2:
ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1:
Ecological Reserve

Refinement of the Revised Desktop Reserve Model

Rivers for Africa; eFlows Consulting (Pty) Ltd; Rhodes University; Clean Stream Biological Services cc; Streamflow Solutions cc; MacKenzie Ecological and Development Services

2539

Overall aim: To provide an updated version of the RDRM model that can estimate EWRs at a desktop level, as well as be used to facilitate the links between hydrology, hydraulics and ecology within more detailed EWR assessments:

- To use select riparian vegetation information generated during the PES and EI-ES study (DWS/WRC), as well as SANBI spatial data, to compile a list of obligate species/guilds and their flooding requirements for direct use in the desktop model
- To develop the flood component sub-model based on generic rules linked to river type and hydraulics; this component must cater first and foremost for desktop use and must also include the opportunity to include specific determined floods identified during more detailed EWR assessments
- To use the fish and possibly invertebrate information generated during the PES and EI-ES study (DWS/WRC) to compile a list of species and taxa with sensitivities and weights attached to this for direct and automated use in the desktop model
- To revise the ecological sub-model and undertake the required testing which could not be done during the design of the model; the aim is to result in a more user-friendly subcomponent which is explicit in terms of the ecological link
- To ensure that all relevant stakeholders are aware of the revised model and the changes that have been made

Cost: R1 578 947
Term: 2016 – 2018

Programme 2:
Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems

The development of a refined procedure for determining wetland RQOs, and the development of a wetland RQO implementation manual

Institute of Natural Resources NPC; University of KwaZulu-Natal (Pietermaritzburg); Wetland Consulting Services (Pty) Ltd

2547

Project aims:

- Develop a refined procedure for determining wetland RQOs
- Develop a wetland RQO implementation manual that provides a step-by-step approach to implementing wetland RQOs

Cost: R1 000 000
Term: 2016 – 2019

Atmospheric deposition impact assessment
EScience Associates (Pty) Ltd; North-West University (Potchefstroom); University of the Witwatersrand
2550

Project aims:

- Prepare the necessary historical and projected deposition scenarios
- Evaluate the adequacy of existing hydro-salinity models and make necessary improvements
- Set up the hydro-salinity model for the Vaal Dam catchment
- Calibrate the model for the main sub-catchments upstream of Vaal Dam
- Simulate historical and projected catchment runoff salinity and the status of Vaal Dam
- Estimate the economic impact

Cost: R900 000
Term: 2016–2018

Programme 4:
Integrated environmental and drinking water quality

Investigation of large-scale drivers of seasonal fluctuation on water chemistry and toxicant levels in the Flag Boshielo System
University of Limpopo
2544

Project aims:

- Explore seasonal fluctuations in selected water quality parameters at Flag Boshielo Dam during drought and flood cycles (if possible within the duration of the project)
- Evaluate seasonal fluctuation in the metal concentration in fish muscle at Flag Boshielo Dam
- Investigate the factors influencing the concentration of metals in fish muscle tissue at Flag Boshielo Dam by distance-based linear modelling of the environmental data
- Investigate whether crocodile deaths in the Kruger National Park can be linked to the quality of the water entering the park
- Propose management actions to improve the ecosystem health of Flag Boshielo Dam

Cost: R1 000 000
Term: 2016–2019

Programme 5:
Ecosystem risks and disaster management

Enabling more responsive policy and decision-making in relation to wetlands through improving the quality of spatial wetland data in South Africa

SANBI; Department of Environmental Affairs; University of KwaZulu-Natal (Pietermaritzburg); Nick Rivers-Moore; CSIR; Department of Water and Sanitation

2546

Project aims:

- Assess the accuracy of the current National Wetland Map and improve the quality of spatial data on wetland extent across the country
- Investigate the impacts of scale and regional environmental patterns on predictor variables informing probabilistic models of wetland occurrence, type and condition

Cost: R1 500 000
Term: 2016–2019

THRUST 4:
SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 4:
Green economy and sustainable (green) innovations

Insurance value of ecosystems: streamlining nature-based mitigation solutions to drought/floods in business

Institute of Natural Resources NPC; EconoLogic; Urban Earth (Pty) Ltd

2611

Project aims:

- To assess evidence of nature-based solutions in drought and flood mitigation
- To make evidence more intelligible to, and coherent for, business to incorporate into decision-making
- Recommend further research required to promote business's role in embracing nature
- To secure the insurance industry as a key research partner going forward

Cost: R200 000
Term: 2016 – 2017

Inland water related tourism in South Africa by 2030 in the light of global change

Institute of Natural Resources NPC; University of Limpopo; University of Venda

2620

Project aims:

- Undertake a baseline assessment that provides a sound understanding of the links between tourism and natural capital with a focus on inland water

resources

- Develop and apply models to understand and quantify global change risks, with a focus on water pollution, and mitigation measures to sustain inland water ecosystems and tourism
- Demonstrate how eco-tourism can benefit SMMEs in marginalised communities and generate a flow of economic and job creation benefits, using two pilot sites as examples
- Empower the pilot-site community to understand the sustainable development opportunities associated with healthy ecological infrastructure that supports inland water resource tourism
- Identify policy gaps and mitigation measures necessary to support sustainable tourism
- Generate recommendations for additional research required to promote environmental conservation through eco-tourism within the green economy context

Cost: R2 000 000
Term: 2016–2020

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 3: Ecological thresholds

Establishing remote-sensing toolkits for monitoring freshwater ecosystems under global change

CSIR; University of Fort Hare; University of KwaZulu-Natal (Pietermaritzburg); University of the Free State; Freshwater Research Centre; Nancy Job; Wet-Earth Ecospecs

2545

Project aims:

- Determine the capability of the new space-borne sensors to separate wetland vegetation (communities or species) from upland vegetation (structural assessment)
- Assess the capability of SAR technology to detect the temporal dynamics of vegetation structure and wetland inundation
- Investigate whether EO tools can detect the seasonal or annual variation of freshwater ecosystems (reporting variation in structure, function and condition indices)
- Evaluate the capability of earth observation tools for the inventory and monitoring of freshwater ecosystems under global change as part of the national programmes such as the National Wetland Monitoring Programme

Cost: R2 620 000
Term: 2016 – 2020

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