A framework for integrating science, management and community in Lowveld catchments

Outcomes of the Kruger Rivers Post-Flood Research Program Workshop

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Centre for Water in the Environment, University of the Witwatersrand

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1 INTRODUCTION

Ecologists are becoming increasingly aware of the role of large-scale, infrequent disturbances (LIDs) in defining the structure and functioning of natural ecosystems. Studying the impact of these events and their influence on system behaviour is difficult because understanding of pre-event characteristics is seldom scaled in a way that provides context for the event, or an appropriate baseline for follow-up research. Consequently, ecologists have limited ability to effectively advise on the implications of such events for setting management goals. However, the Kruger National Park Rivers Research Program (KNPRRP) of the 1990s generated a hierarchically scaled understanding of river form and function. This knowledge now provides a unique background upon which to study the effects of the large infrequent flood disturbance that occurred in February 2000 in the Sabie River.

The aim of this workshop was to formulate a statement that would identify priority areas to guide the development of proposals for research into the 2000 flood as a large infrequent disturbance. The workshop was attended by a mix of ecologists, geomorphologists, hydrologists, managers, Kruger National Park (KNP) staff, social scientists and funding body representatives (Appendix 1). As the workshop progressed, two issues emerged that expanded the scope to a larger platform:

1. Discussions on the nature and definition of LIDs in river systems suggested that LIDs should not be studied as discrete events, but rather, as a component of longer-term variability. Thus, the focus became the description of variability as a context for LIDs, rather than the scientific view, stemming from terrestrial systems, that LIDs are extreme but discrete events to be studied independently. However, we lack the means to measure and evaluate river system variability in this long-term context and there is a need to direct research along these lines.

The concept of long-term variability is an important aspect to scientific understanding of flow variability and environmental heterogeneity in semi-arid systems such as the Sabie River. The maximum discharge of a river varies markedly over time, and includes both extreme flood events and extreme drought events (Figure 1). At any point in time, the river is responding to a unique historical set of events of different magnitudes. Each event, or set of events, may influence different components of the river ecosystem in different ways and the response of each component may vary spatially and temporally. Thus, river ecosystem state at any point in time is a composite of the imprint of events that have occurred across a range of spatial and temporal scales. Our understanding of Kruger river systems is based on a state that had developed over some 70 years since the previous very large flood in 1925 (Figure 1). However, the 2000 flood reset the ecosystem to another state. As such, the post-flood program needs to provide information about:

- how the system is different in the post-flood era than it was in the pre-flood era;
- how the response of the system to new events such as post-flood droughts and floods is different from the responses to similar events pre-flood; and,
- an understanding of the implications of the 2000 floods for river management.

Consideration of the river system within a context of long-term variability facilitates a broader understanding of the drivers and cycles that influence the Sabie River ecosystem.

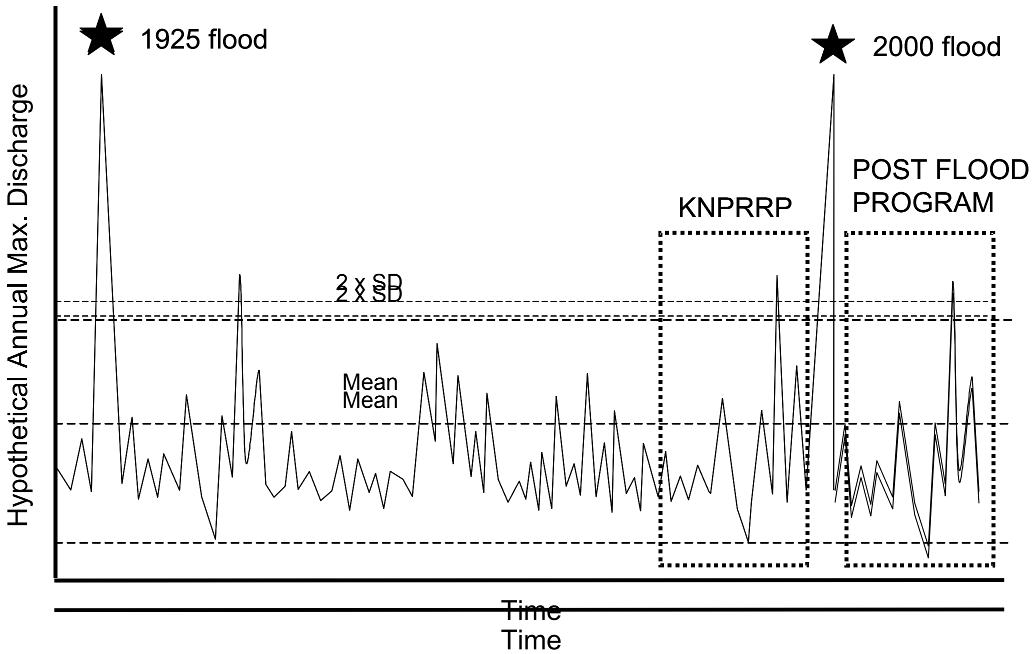

Figure 1. Long-term variability in river systems. The long-term discharge regime includes extreme flood and drought events. At any point in time, the river system is responding to historical events of different magnitudes. The KNPRRP was conducted during the 70 years after the last flood of a similar magnitude. The 2000 flood has reset the system to a new state, in which the behaviour of the river system may differ from a pre-flood state. The post-flood program will operate in this new state.

2. The workshop identified a strong need for a broad program that integrates the biophysical, management and social dimensions of a catchment in the context of long-term variability. This integrated program will facilitate the management of water resources in an empowered and sustainable manner.

This report outlines the initial vision for the broad program, developed during the workshop. This vision recognizes that variability in the biophysical, social and management dimensions occur simultaneously, and that integration of these components within a catchment context requires the promotion of joint learning and doing. As a continuation of research conducted within the KNPRRP, studies of post-flood biophysical responses of the Sabie River can be implemented relatively rapidly. The scientific context of these studies is nested within the overall program vision and thus, biophysical research will be detailed in a separate document. This document outlines priority areas for biophysical research, as a companion to the social and management aspects of the broad program.

2 A BROAD PROGRAM FOR INTEGRATING SCIENCE, MANAGEMENT AND COMMUNITY WITHIN A CATCHMENT CONTEXT

2.1 Philosophy of the program

In South Africa today there are several driving imperatives. Among these are the needs for rural development and local government empowerment in a context of environmental sustainability. We have a unique opportunity to develop a catchment-based working model that brings together land, water and people. This opportunity arises out of three factors:

1. A new water policy, law and management strategy;
2. A strong scientific understanding of the variable nature of natural water resources; and,
3. An awareness of the interdependence of human and environmental health.

A major shortfall of the KNPRRP of the 1990s was that it did not consider the portions of the catchment falling outside the park. Implementation of the National Water Act, and imminent management of instream flow requirements in the Sabie River, creates an opportunity to test the social and environmental implications of the new Water Act. The initiation of a program that brings science, water resource management and governance together will therefore provide a model for people in a catchment to manage their water resource sustainably.

It is proposed that such a program will have three pillars of action and focus (Figure 2). These pillars sit within a broader context of long term variability but interact via a process of joint learning and doing (Figure 2). The biophysical pillar is the science of biological and physical aspects of the river ecosystem, and the synthesis of this knowledge into an understanding of spatial and temporal variability at multiple scales. The management pillar is concerned with processes of environmental decision-making, policy setting and the actions required to implement these decisions and policies at various levels of governance. The social pillar is essentially the people dimension and encompasses the role of humans in a socio-ecological system. Presently, these three pillars generally operate independently. However, the 2000 flood in the Sabie River has scientific, management and social implications and so provides the impetus to generate a model that integrates these pillars in a catchment context, and is cognizant of long-term variability.

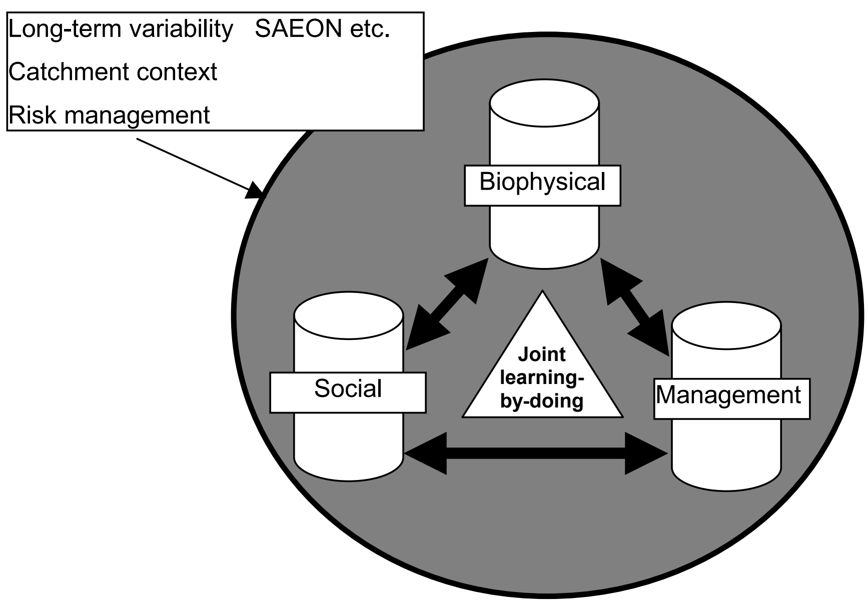

Figure 2. Three pillars for integrating science, management and community within a broader catchment context. The three pillars are cognizant of long-term variability, and are linked by a joint learning-by-doing approach that incorporates adaptive management.

2.2 The biophysical pillar

The 2000 flood elicited a necessary re-evaluation of environmental variability because it is considered that the river system template is 'reset' by a flood of this magnitude. Previously, environmental variability in the Sabie River was only considered as a sub-decadal or multi-decadal influence. However, the approximately 1 in 100 year flood has caused us to re-think how the temporal dimension influences river system processes and the delivery of ecosystem services, and forces the focus into a longer-term context that may encompass centuries. This longer-term context represents a scientific opportunity unique to this generation of scientists. We have a wealth of existing information and understanding generated from the KNPRRP and from the present workshop, we have generated a broad interactive model within which biophysical science can be integrated with the social and management pillars. We have also identified some key scientific priorities that should be considered initially (see Section 3). Thus, we could expect a good return on investment on biophysical science conducted within the context of environmental variability.

2.3 The social pillar

The sustainable future of ecosystems as providers of goods and services in the Lowveld is critically dependent on harmony between the social and ecological systems. The Lowveld, with its multiple juxtaposed land uses and a fragmented social and political legacy arising from historical and current factors, presents a challenging opportunity to implement processes that integrate social and ecological realms. The future of the Kruger National Park as an element of the Lowveld landscape hinges on successful embedment of social processes into its strong ecological focus, and on consideration of the park beyond its borders in a catchment context. Several new developments in the theory and practice of complex socio-ecological systems can aid in constructing a way forward for the social pillar. The theory of change and transformation in social and ecological systems is based around the realization that we need to understand change cycles, build resilience to cope with change and to recognize the role of the relationships between people and their environment in change cycles. Decentralized natural resource management centers on the premise that devolved management of common property can respond more rapidly and effectively to changes that affect the flow of resource-based goods and services within society, than centralised management structures. The concept of ecosystem management acknowledges that resource management should shift focus away from the management of ecosystem outputs and the control of resources, towards understanding of the way in which ecosystem structure and functioning support the delivery of a range of goods and services. These developments enhance the chance of developing a successful model to integrate the social and biophysical pillars within the Lowveld region.

2.4 The management pillar

Socio-ecological initiatives need to find effect in local government empowerment (including CMAs) and resource management actions. The National Water Act provides a policy framework for water resource management and within this, there is an urgent need to develop working models that demonstrate effective implementation. However, effective implementation of policy depends on keeping pace with scientific knowledge (the biophysical pillar) and the functioning of the socio-ecological system (the social pillar) within a dynamic and variable environment. This type of integration is demonstrated by the well-developed and successful adaptive and strategic science-management interface currently operating in the Kruger National Park. The same adaptive management model can be extended into the Lowveld in a joint learning-by-doing manner. Implementation will result in the unprecedented ability to consider policy as evolving and changeable, because policies will be supported by incremental understanding in a long-term context of social and ecological change.

While each pillar has unique properties, the joint learning-by-doing process that binds and facilitates the pillars across stakeholder groups within the water management arena requires specific attention. Some experience of the learning-by-doing process has already been gained in the Kruger National Park. On the basis of the Kruger experience, active implementation requires ongoing cycles of learning, action and reflection by active, participatory individuals and organizations. These cycles can present challenges at various stages and thus, the learning-by-doing process needs to be supported by innovative communication, funding, leadership and education initiatives. However, commitment to the process can bring about effective and timely solutions that are relevant within current global awareness of risk management, long-term variability, socio-ecological coupling and biodiversity conservation.

3 PRIORITY AREAS FOR INITIAL CONSIDERATION IN THE BROAD PROGRAM

The previous section outlined the underlying philosophies of the social-biophysical-management trinity. These social, biophysical and management pillars are linked by a joint learning-by-doing approach. The following section identifies some initial activities that can be examined within the learning-by-doing approach. These activities provide starting points that integrate within the broader program. The biological and physical components of the biophysical pillar are considered separately because the science that can be conducted in each of these is quite detailed. However, biological and the physical activities should also be considered in relationship to each other, because there is a strong link between the physical environmental template and biological pattern and process.

3.1 Social

Through the provision of goods and services, ecosystems form a template that influences societal structure and behaviour. In turn, society's use of ecosystem goods and services translates to impacts on ecosystems. The extent and patterns of ecosystem use are shaped by decisions that are based on societal trade-offs. However, the intimate relationship between society and ecosystems begs a fresh viewpoint, because systems operate within an increasingly vulnerable landscape. This viewpoint requires improved understanding of socio-ecological systems in a manner that regards trade-off decisions as nodes of influence that can form points of management intervention and research effort.

The need for a fresh viewpoint on the relationship between society and ecosystems is supported by our current inability to ensure sustainable flows of ecosystem goods and services because of the manner in which we decouple ecosystem management from social functioning. For example, there is a growing sense that conservation areas such as KNP cannot be managed sustainably in isolation from ecosystems and institutions outside the park. Hence, the 2000 flood has provided the impetus to advance our understanding of socio-ecological systems and processes at various scales and across various boundaries. In this way, we can discover avenues to promote appropriate human behaviour in water resource decision-making that, in turn, influence and promote sustainability and support the effective implementation of the National Water Act.

Implementation of an integrated viewpoint on the socio-ecological system, which integrates natural capital and social capital will require consideration of the following factors:

- A **recognition** that KNP is embedded within a social context, and management of the park must consider interdependencies with stakeholders, resource users, surrounding communities and the ecosystem itself.

- The **process** of implementing the viewpoint will require:
    - supportive policy and institutional frameworks;
    - mechanisms to bring people together in a constructive environment;
    - building of trust and relationships;
    - co-evolution of perceptions and preferences;
    - development of a vision for equitable distribution of the costs and benefits associated with using ecosystem goods and services;
    - allocation of resources to implement the vision; and,
    - establishment of an ongoing process to build social capital and a resilient society
- **Principles** that build on existing and realistic power relationships, work through existing authority structures, support DWAF and CMA objectives, serve society and reflect societal values.

3.2 Physical

The Sabie River within KNP is the best-studied river in South Africa, and much of our knowledge and understanding of the geomorphology of southern African rivers is derived from here. However, this understanding was developed during a relatively stable period of river state and process. The understanding and predictions derived during this time may not be useful under the present post-flood dynamic state. Thus, the change from a stable to a dynamic river state may affect how we determine Ecological Reserves, monitor desired states and understand river ecosystem functioning.

To improve our geomorphological understanding of the river system within the context of long-term variability of river state, we need a description of the structure, function and dynamics of the underlying physical template. The physical template is determined by the quality and quantity of water and sediment delivered from the catchment, and by channel characteristics such as underlying geology and vegetation. We identified a number of key baseline studies that will provide a good starting point for a long-term study of the physical template of the Sabie River, both within KNP and within the larger Sabie River catchment. The recommended required baseline information on the physical template is:

- Spatially explicit examination of the post-flood physical template in comparison to pre-flood historical records of the physical template;
- Characterisation of the geomorphic river template outside of KNP;
- Evaluation of the present and historical condition of the catchment, including factors such as sediment yield, runoff, land use and the link between land use and society;
- Multiscaled study of geomorphic change that expands our understanding of the geomorphic template from a structural basis to one that is centred around geomorphic dynamism; and,
- Examination of the role of groundwater in the Sabie River system.

3.3 Biological

The KNPRRP generated a detailed understanding of the relationships between riparian vegetation and the physical river template. The 2000 flood has essentially reset the riparian vegetation community back to an earlier successional stage and thus, the biological core focuses on riparian vegetation, in terms of long-term patterns of vegetation succession and the way in which succession occurs on the physical river template (Figure 3). Other biological elements such as nutrient cycling and the role of animals within the riparian zone are related to this underlying theme of vegetative succession (Figure 3). Aquatic organisms such as fish and macroinvertebrates sit outside of this succession core theme, although are related to the physical template and vegetative response (Figure 3). There is also an important interaction between the biological and the physical. The 2000 flood has left a heterogeneous legacy, with an interactive biological and physical mosaic. However, this mosaic will change over short and long time scales, and at small and large spatial scales, in response to ecosystem drivers. There have been significant shifts in the main drivers since the last major flood in 1925. These will markedly affect both residuals and subsequent events, providing opportunity to test many hypotheses of succession and vegetation recovery:

- Fire regimes, flow regimes and sediment transport dynamics have all been altered as landuse and management practices have changed;
- Large infestations of exotic weeds will markedly change the competitive environment of early colonizers;
- Animal densities, especially of large herbivores, have increased many fold in response to sustained conservation management; and,
- The future ecosystem will be faced with the many implications of population growth and development, which did not exist post 1925.

The character of these multiscaled changes can be measured using numerous instream and riparian physical and biological components. The KNPRRP provided a sound knowledge of the structure, function and distribution of components such as geomorphology and riparian vegetation. However, there is a need to examine the extent to which the flood has changed the structure, function and distribution of these components, and the interactions between the physical and the biological. There is also a need to understand the process side of these components, such as nutrient cycling, population dynamics, trophic dynamics, sediment transport and disturbance.

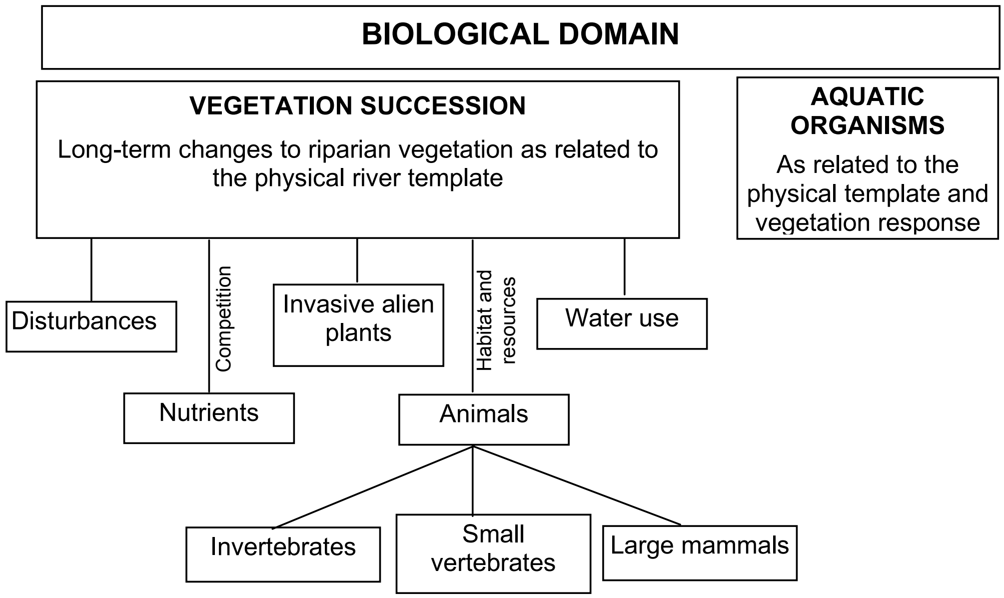

Figure 3. Components of the biological domain.

3.4 Management

The success of strategic adaptive management in KNP suggests that it is a useful tool for integrating science and management, and should be continued as a long-term management strategy for the park. However, there is growing recognition that KNP needs to extend some of its management focus beyond its boundaries. This moves strategic adaptive management into the realm of integrated catchment management, and into the realm of social science. Successful merging of strategic adaptive management with integrated catchment management in a socio-ecological system will require consideration of how the fundamental components and processes of the KNP management strategy can be applied outside the park, and how the character of these units may differ inside and outside of the park in response to the different activities that occur in these areas. Strategic adaptive management, as practiced in Kruger, is essentially a co-operative management process and should be easily expanded to deal with multi-dimensional, collective decision-making in complex socio-ecological systems.

4 WHERE TO FROM HERE?

The workshop clearly identified the need for an ambitious program of interdisciplinary research that could advance our understanding and ability to manage rivers both nationally and internationally. This document presents a vision for such a program and not a definitive list of research projects. Much work lies ahead if we are to realize this vision. Three sets of initial activities are:

- Focused workshops to define research directions and needs in the Biophysical, Social and Management "pillars" and to link this initiative to the array of current individual projects in these arenas. A workshop has already been held to refine biophysical research needs with emphasis on vegetation and physical systems;
- Initiation of research projects that explore the early response of river, social and management systems to the 2000 floods. We envisage that this document and those that arise from the focused workshops will provide guidance to scientists and their funding agencies in planning research proposals. A number of projects are already underway and it is important that interested parties liaise with Kruger scientists to ensure effective and original participation; and,
- Engage agencies such as WRC, SAEON (NRF), DWAF and SANParks in developing a long-term research program that effectively integrates biophysical, social and management research initiatives to meet common goals. Responsibility for this could rest initially with the steering committee of the post-flood program funded by the Andrew Mellon Foundation, but it would need to rapidly broaden its base and constituency.

Appendix 1. List of workshop participants

Abri de Buys	SANParks, Shingwedzi
Andrew Deacon	SANParks, Scientific Services, Skukuza
Angela Gaylard	SANParks, Shingwedzi
Bernie Moon	University of the Witwatersrand
Bill Robertson	Andrew W. Mellon Foundation, New York
Chris James	Centre for Water in the Environment, University of the Witwatersrand
Craig McLoughlin	Centre for Water in the Environment, University of the Witwatersrand
Dirk Roux	CSIR
Ernita van Wyk	CSIR
Freek Venter	SANParks, Scientific Services, Skukuza
Glynn Alard	SANParks, Skukuza
Harry Biggs	SANParks, Scientific Services, Skukuza
Hendrik Sithole	SANParks, Scientific Services, Skukuza
Holger Eckhardt	SANParks, Scientific Services, Skukuza
Johan Pauw	South African Environmental Observatory Network, National Research Foundation
Kevin Rogers	Centre for Water in the Environment, University of the Witwatersrand, Johannesburg
Llewellyn Foxcroft	SANParks, Scientific Services ,Skukuza
Mark Rountree	Centre for Water in the Environment, University of the Witwatersrand
Melissa Parsons	Centre for Water in the Environment, University of the Witwatersrand
Karen King	School of Bioresources Engineering and Environmental Hydrology, University of Natal
Mick Angliss	Northern Province Department of Agriculture, Land and Environment
Neil Pettit	University of Washington
Nick Rivers-Moore	School of Bioresources Engineering and Environmental Hydrology, University of Natal
Rina Grant	SANParks, Skukuza
Shayne Jacobs	University of Washington
Sharon Pollard	AWARD
Shaun Levick	Centre for Water in the Environment, University of the Witwatersrand
Steve Mitchell	Water Research Commission
Stepfanie Frietagh	SANParks, Scientific Services, Skukuza
Tally (Carolyn) Palmer	Rhodes University
Tamsyn Sherwill	Centre for Water in the Environment, University of the Witwatersrand