Complexity, Resilience and Sustainability for Adaptive Ecosystem Management in the Crocodile River Catchment

Nathan Wangusi and Greg Kiker

The Crocodile River System presents an example of a highly complex social-ecological system in which a variety of stakeholders compete for common and shared water resources. As a multifaceted catchment, the Crocodile River is characterized by a diversity of connections between dynamic socio-ecological components. This paper focuses on using a complexity and resilience description of the catchment to provide a useful paradigm for understanding and describing these levels of interaction between the range of actors that exist within the catchment as outlined by Norberg and Cumming (2008).

A variety of scales of interaction need to be accounted for a complete description of the Crocodile River as a complex system. Firstly, environmental asymmetries which describe the natural processes and anthropogenic activities that may cause systematic interruptions in environmental symmetry. These processes may originate from abiotic and biotic drivers (Cummings, 2008). Biodiversity and resilience subsequently come into play when accounting for the ability of an ecosystem to maintain its integrity in ecosystem function and ability to provide ecosystem services. Inherent to complex socio-ecological systems as self-organizing units, is their tendency to shift in ecological states which can be simply defined as regimes and the lateral, tangential or vertical movement between them as regime shifts. In aquatic ecosystems, regimes can be defined according to the flow levels in rivers, characteristics of riparian vegetation, flow regimes and species biodiversity.

In attempting to mitigate against negative shifts within the catchment, environmental managers at the Incomati Catchment Management Agency (ICMA) and the Kruger National Park (KNP) are concerned with defining desired states in the river as ecological endpoints for management. This goes hand-in-hand with implementing the policies of the National Water Act (DWAF, 1998) by establishing an adaptive assessment and management framework that takes into account the needs of various stakeholders within the catchment. Various Thresholds of Probable Concern (TPCs) have been adopted by the KNP and other entities to provide specific criteria for analysis and action (Rogers and Bestbier, 1997). TPCs refer to an assembly of value systems, management endpoints and ecological indicators aimed at facilitating the consultative process of management of the Kruger National Park as a complex adaptive ecological system (KNP, 2006). Operational goals captured in the TPCs provide ecologists, scientists and managers with specific operational targets that represent an undisturbed reference state of ecosystems and serve as environmental monitoring and assessment tools.

The specific focus of this paper is to describe the Crocodile River as a complex socio-ecological system and to identify at various scales of measurement, the interaction between components and the resultant resilience the system attains from its diversity. This will facilitate a process of identifying vulnerabilities enabling a description of more resilient interventions to the management of the catchment. This paper also aims at investigating inter-connections between stakeholders and the associated feedbacks of information/knowledge for an effective adaptive assessment and management framework using the Crocodile River Catchment as a prototype but with wider implementation in water management areas in South Africa (Kiker et al. 2006).