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Strategic Adaptive Management of River Resources in Kruger National Park

ET 455: Adaptive Management and Governance

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Problem

Kruger National Park adopted Strategic Adaptive Management as a river management framework in response to a variety of problems the rivers of Kruger face. The rivers of Kruger National Park suffer from low and unpredictable water flows, high sedimentation, and degradation of riparian vegetation. These problems are the result of increasing human presence upstream of the park, including increased water demand and land use changes.

Of the six major rivers within KNP, five are considered perennial, with one river naturally seasonal, ceasing its flow and drying up during times of low water flows. Reductions in water flow rates were first noticed in the 1960s, when the Letaba River, historically perennial, ceased flowing and transitioned into a seasonal river. The Luvuvhu and Olifants Rivers have also transitioned from perennial to seasonal flows. (Pollard et al. 2011: 4).

Several of KNP's rivers have an unusual combination of both bedrock and sandy sediment substrates. This variable mix of substrate materials creates a variety of habitat types. The rivers that exhibit this combination of substrates, including the Crocodile, Sabie, Olifants, and Letaba, have historically fluctuated between rocky and sandy conditions, but have always exhibited some exposed bedrock substrate. The land use changes upstream of the park have increased sediment inputs to the rivers, thereby decreasing bedrock habitat. (McLoughlin 2011: 9) The Matumi tree is an important indicator species for sedimentation. The Matumi takes root in bare rock along riverbanks; if sedimentation has embedded the bedrock, the tree cannot become established (Skukuza Freshwater Group 2007).

The economic development along the western border of the park since the 1960s has resulted in progressive degradation of the quality and quantity of water in the five perennial rivers that flow through KNP. Furthermore, because the rivers are a shared national resource as well as an important water sources for the mammals in the park, management has become an even more complex issue, thus resulting in the formation of a “wicked problem.” Horst Rittel defines a “wicked problem” as “that class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing.”

The problem is ill-formulated mainly because of where KNP is situated. The fact that all five perennial rivers originate outside the park has created a multifaceted problem that involves the interests of a diverse group of stakeholders including the national park service, park managers, the South African government, tribes, mining companies, farming communities and scientists. The various conflicting values of each stakeholder group created inefficient and ineffective river management approaches that only took certain parts of the system into account, and not the ecosystem as a whole. Furthermore, ecosystem resilience needs to be established before any positive effects can be seen. Due to this fact, the management of rivers often results in long term projects that must account for the variability of the ecosystem. Because river ecosystems are constantly changing to adjust to unforeseen conditions (such as drought or flood), the system must be flexible and not all ramifications can be realized ahead of time.

Adaptive Management: Objectives & Goals

Adaptive management (AM) is defined by Sabine et al. as “an approach that includes scientific methodologies in the design, implementation and evaluation of management strategies.” The authors also state that the two main goals of AM are to “improve environmental management, and to understand the impact of incomplete knowledge” (2004: 177). AM was successfully achieved through the introduction of the Kruger National Park Rivers Research Program (KNPRRP) in 1988. The KNPRRP was initiated through a collaborative process between park managers, resource users, funding agencies and researchers which culminated in a complete reorganization of the way the park was managed. Four core elements were developed as requirements for success of the program and can be seen in **Figure 2**. These core elements were successfully adopted for management of rivers throughout the park, and eventually expanded to include all aspects of the park's management activities.

A key element in the AM approach is the development of Thresholds for Potential Concern (TPCs), which act as indicators for the health of rivers in KNP. While several TPCs were initially identified, our case study will focus on the three TPCs that we think are most important to maintain healthy riverine ecosystems. Therefore, the main objective of the case study is to maintain the overall flow, sediment transport processes and riparian vegetation that are crucial to supporting the overall health and biodiversity of rivers. Due to the fact that rivers present such variability in their natural processes, it is often hard to manage one aspect without negatively affecting other processes. For this reason, it is necessary to adopt a flexible management approach that takes the complexity of a river ecosystem into account. As noted by Rogers, strategic adaptive management (SAM) is "one of the few recognized models for managing uncertainty in interactive social and ecological systems, whilst still aiming purposefully at a carefully articulated desired state" (Pollard et al. 2011: 7).

Adaptive management often follows a seven-step process (Sabine et al. 2004: 179). Kruger National Park's SAM follows the steps of this process, as shown in Figure 3. Within the seven-step process of adaptive management, the first step is to specify objectives. Within the SAM of Kruger National Park, ecological functions at risk are determined; for example, water flow is an important function of Kruger's rivers, and is at risk, as demonstrated by the droughts of the 1960s. The next two steps of the adaptive management process are modeling existing knowledge and identifying the assessment criteria. In Kruger, knowledge is modeled by determining the in-stream flow requirements of the rivers. These in-stream flow requirements were then translated into TPCs. These TPCs represent the acceptable range of water flow in the rivers. Another major facet of the adaptive management structure is monitoring and evaluation; this is conducted in Kruger by monitoring the river flows. Monitoring continues as long as the river flows are within the range deemed acceptable. If river flows fall outside of the acceptable range, exceeding the TPC in place, an investigation of the problem is initiated. The investigation may result in management actions to correct any problems that are identified; monitoring the river flows is continued. Strategic Adaptive Management is Kruger National Park includes "learning as a constructive, progressive activity within its cycles" (Venter et al. 2008: 182). Within the context of the adaptive management cycle, learning is integral; as the stakeholders learn more about the natural variability and river functions, the TPCs are periodically reviewed to determine either their validity or the need "to recalibrate the TPC more appropriately" (Venter et al. 2008: 189).

Roles of Science, Decision Making and Social Learning

Science played an important role in KNP in the 1950's as it was the main approach through which management decisions were made. Initially, SANParks was dependent on scientists to explore applied and descriptive topics, inventory flora and fauna, and to set up long term monitoring programs. The introduction of SANParks peer-reviewed science journal *Koedoe* in 1958 is a prime example of the science promotion that took place throughout the park system in the 50's. Since its induction, *Koedoe* has produced more than 600 articles that cover a wide range of subjects related to national parks (Biggs 2004). However, this approach had its own drawbacks. Park managers and wardens tended to be wary of science, even though they felt morally obligated to allow continued research and monitoring to occur. Harry Biggs noted that these differences in opinions often led to disagreements: "managers have a need for fairly immediate action, and then often go ahead trusting their experience, rather than waiting for an abstract hypothesis to be tested" (2004: 22). Furthermore, the lack of consensus between scientists often resulted in non-application, which was a frustrating reality for many park managers.

Park management continued to tackle problems using scientific management and command and control philosophies well into the 80s. Due to expanding population issues and their socio-economic influences outside the park in the early 90s, it became evident that a combination of constantly shifting strategies would be most effective to tackle the park's biggest concerns. This change in park management has transformed the management strategy from one that was initially guided by many different strategies that constantly changed, to a SAM approach that is guided by the TPCs. Venter el al. note that "[TPCs] contain multi-scale elements but produce a park wide answer as to whether the pattern generated is acceptable" (2008: 178).

The marriage of science and adaptive management is evident in the formation of the KNPRRP, a cooperative mission formed by park managers, resource users, government agencies and researchers. The program was split into three phases that took place over a roughly ten year period. Phase one was generally limited to scientific research including topics like environmental water requirements, potential fragility of the system, pollutant effects on aquatic wildlife and mammals, and vegetation changes. Phase two provided a comprehensive review of phase one, with a special focus on management actions and future decision making. Pollard et al. note that during this phase "collaboration between managers and researchers improved with some co-learning [activities]" (2011: 7). The third and final phase brought scientific data and co-learning together from phases one and two to formulate and promote procedure and technologies that supported SAM of rivers throughout the park, while also promoting community participation throughout the process.

With the introduction of KNPRRP, scientists within the park system became facilitators instead of decision makers. According to Holling, integrative science “has emerged regionally in new forms of resources and environmental management where uncertainty and surprises became an integral part of an anticipated set of adaptive responses” (1998). This is certainly true in the current KNP approach. The emerging theories of Integrated River Basin Management (IRBM) and Integrated Water Resource Management (IWRM) perfectly encapsulate the desire of water professional to move beyond a “one size fits all” management approach. By integrating the scientific data and co-learning of stakeholders throughout the three phases of KNPRRP, a link between science and decision making was formed that acts as the basis of the AM approach in KNP.

The Kruger National Park River Research Program (KNPRRP) was conceptualized as a co-operative undertaking, involving resources managers, resource users, and scientists. While phase one was a largely internal, scientific undertaking, the failure of the recently constructed Zoeknog Dam resulted in a more public voice for the park (Pollard et al. 2011). The lessons learned during phase one led to the second phase of KNPRRP, which better integrated scientists and managers through co-learning. Scientists began having more input on the short-term problems managers experienced, while managers took heed of the longer-term projections of scientists. This increased cooperation represents a distinct change in the decision-making structure of KNP (Pollard et al. 2011). During the second phase, the managers of KNP and KNPRRP had a large collaborative meeting resulting in the integration of TPCs into the decision-making process.

The third phase of KNPRRP was designed to take an adaptive management approach to managing Kruger's rivers. This phase promoted stakeholder involvement to bring about corrective action. (Pollard et al. 2011). Feedback loops and self-management are considered to be key parts of adaptive management; to this end, KNP has divided the basins into distinct regions and organizational structures. The sub-basins of the rivers that run through KNP were divided into catchments based on the unique characteristics of each region. SAM established Catchment Management Agencies (CMAs) which include Catchment Management Committees, Forums (CMCs & CMFs) and Water User Associations (WUAs) to represent local businesses and residents who utilize water resources. These were modeled after earlier forums used to manage drought and damming issues in the 1990s. Water users report to CMAs who correspond with the National Water Resources Infrastructure Agency (NWRIA) office for that catchment area. When information is shared with members of the catchment, the NWRIA office receives feedback from dam operators, park officials and CMAs to establish appropriate benchmarks or criteria for TPCs. (Pollard et al. 2011)

Developing and altering TPCs is a process that requires continual refinement. This is an example of what Conklin defines as the jagged-line approach, or simultaneously refining decision-makers' understanding of the problem while seeking solutions . As opposed to the waterfall approach, which Conklin describes as "a picture of already knowing" (2008: 6), the jagged-line approach represents learning. Throughout the process of SAM, "problem understanding continues to evolve until the very end of the experiment" (Conklin 2008: 6). As monitoring continues, feedback from managers and scientists will focus on the relevance of the TPCs in place. When more data is generated and stakeholders learn about the river systems, TPCs can be altered to represent natural boundaries or thresholds in flow rates (McLoughlin et al. 2011).

Though monitoring is a cornerstone in the SAM process, the relevance of data is important throughout the decision making process. Due to the need for relevant data, the Rapid Response System was implemented to allow information to be prioritized based on "worry zones" so managers can respond appropriately. Improving the speed of assessment and response to changes in TPCs is dependent on addressing the most pertinent issues first. Likewise, conveying information in a way that furthers social learning is one of the goals of AM. Managers require information in simpler terms than KNP scientists who need data of biophysical conditions.

Within KNP, the managers of the park historically had a distrust of scientists; while they allowed scientists to continue research, the managers hesitated to wait out the scientific process when managing their short-term crises. Scientists, on the other hand, have little on-the-ground experience and tended to ignore short-term problems, concentrating on long-term trends. Through KNPRRP, these scientists and managers experienced social learning, defined as "people modifying their behavior in response to lessons learned when undertaking thoughtful and often collective action" (Rogers 2006: 278). The managers began to benefit from the long-term perspective scientists put forth; scientists learned to apply their knowledge to short-term management issues (Pollard 2011).

Evaluation & Recommended Alternatives

Despite the long history of problems with water flow within KNP, there is evidence that management has improved water quality and quantity. Since July 2009, KNP has been utilizing the 'Rapid Response System.' This system, with its constant re-assessment of data and strategies, is ideal for monitoring Kruger's IFR's. However, the number of sampling stations is rather small, and incidents in which management actions have little effect frequently go uninvestigated. An increase in the number of monitoring stations across the park would provide researchers and managers with a better idea of what is happening across the park. In addition, researchers need to be more involved in the rapid response system. Furthermore, when flow rates force management to take action, the results of that action should be observed and documented for further analysis.

The formation of entities like the Crocodile River Catchment Forum demonstrates the introduction of new and more holistic strategies to manage water quality. Mitigation and public awareness of the issue are the only feasible tools for making real improvements that take into account the social complexity presented by managing rivers over a very large area. The TPC monitoring systems currently in place do a good job of problem monitoring and investigation. According to McLoughlin, the introduction of TPCS has "contributed immensely to improving the management of water quality in the Crocodile River catchment. Sewage pollution remains a problem however, but improvements are occurring via actions of the Crocodile River Catchment Forum" (2011).

Riparian buffers provide essential habitat for the charismatic mega-fauna that attract tourists to the park. All biota within the park depend on water, and thus the preservation of riparian zones is essential to park management. With the latest revision of the geomorphic TPC to, "monitor only in the most sensitive sites along the river where increases in sedimentation could be flagged the fastest, the system has become streamlined for effective response" (McLoughlin 2011). The process now includes assessing change in the width of the active channel (in-stream habitat availability) and functioning of exposed bedrock habitats important for biota. "In 2008, the TPC was tested successfully along the Olifants River. Pertinent sediment-sensitive sites were demarcated and geo-referenced using a Geographic Information System. Mean width of the active channel is measured using pre-selected transects across the mapped active channels. A geomorphic scoring system (developed using expert knowledge) is used to calculate a Rocky Habitat Index (RHI) in selected areas of the river. A once-off historical analysis of trends is carried out to set first estimates for TPCs associated with active channel width and the RHI (linked to an ecological category) that can then be monitored against, in future, to audit the TPCs" (McLoughlin, Deacon 2011).

To ensure the success of SAM, stakeholders in KNP will have to continue to recognize the variability in the systems they are managing. River ecosystems will change over time requiring managers to redefine their benchmarks and thresholds. Micromanaging issues at the catchment level will become increasingly important in appeasing the needs of the region as the biogeochemical properties of individual catchments shift. Industries and populations of South Africa will continue to grow and change as well forcing SAM to account for these changes. New stakeholders will enter the region making it important for the NWRIA to include these parties into the decision making process. Likewise, the growing need of water resources for surrounding residents will require decision makers to recognize this influence on parameters, such as flow rate.

Additional methods for improving conditions in KNP's rivers include public education and increased citizen involvement. Public outreach programs could teach residents about how their consumption and living practices impact water quality. Agricultural extension programs could teach farmers about sustainable tilling practices and utilizing riparian zones to prevent fertilizer and pesticide runoff, as well as reducing runoff through best management practices.

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