Synthesis

> **The Law of Vanishing Civilizations: The Tenth Water Law of the West should be called the Hohokam Law of Water and Gravity. Under this law, if there is no rain, there is no water to flow down hill. What went up—the buildings and the civilization—may crumble to dust if Mother Nature decides to hold a long drought. Lying beneath the streets of Phoenix are the ruins of the ancient Hohokam Indian metropolis that vanished prior to 1400 AD. Phoenix is the second city to be built on the same site in reliance on the erratic flows of the Salt River. Californians prayed for rain for the last six years (apparently successfully) because they didn't have enough water to flush their toilets. Many Southern Californians had been heard to ask 'What do you mean this used to be a desert?'**
>
> **—Hugh Holub, 1999**

At the end of 2005 a southern African river, the Olifants, stopped flowing into its downstream reaches for the first time in recorded history. Unlike the Salt River of Phoenix, the downstream reaches of the Olifants do not support an urban metropolis, but a major reservoir of biodiversity and an ecotourism flagship, the Kruger National Park. Park managers, tracking rainfall and upstream withdrawals, foresaw this outcome months - even years - prior to its occurrence, but believed the problem would be easily solved by the usual means whenever river flows fell below a certain threshold of potential concern (Rogers and Biggs 1999): a negotiated release from a dam upstream. This time, however, the dam manager refused the request, an unexpected outcome (H. C. Biggs, *pers. comm.*). Because the South African Water Act is not yet fully implemented, the park was without any clear legal recourse to persuade higher levels of authority to intervene on its behalf in what had become a battle for water between multiple government departments, each trying to fulfill its mandate (Macleod 2006). In the no-man's-land in which South African water law now finds itself, praying for rain may be as good an option as any.

Why, when today's scientific and technological capabilities are presumably advanced far beyond the knowledge base on which the Hohokam civilisation relied, does modern society still resort to myopic management responses – or no responses at all? This question, of much philosophical interest to scholars across disciplines (Tainter 1998, Janssen et al. 2003, Redman and Kinzig 2003, Diamond 2005), is closely linked to the central question explored in the previous five chapters of this thesis: why is sound management so elusive, and how can social-ecological systems thinking improve management? Here I explore some potential answers to this question, synthesising the findings of the five chapters and the considering the contribution each makes to our current understanding of water from a social-ecological systems perspective.

Chapter 2 presents a framework for understanding why management responses in complex systems may succeed or fail based on congruence of impact, awareness, and power scopes. While congruence of impact, awareness, and power is more likely to accompany effective responses, it can never be complete. Decentralisation and devolution of power to Catchment Management Agencies (CMAs) will not achieve perfect congruence, for example, because CMAs will inevitably be affected by processes operating at other scales. A concern emerging now is the scale mismatch between broader water management by the CMAs, and the responsibility for water supply, which is given to municipalities under the Water Services Act of 1997 (Pollard and du Toit 2005). Water managers must recognise that institutional structures of any type may be inadequate to deal with the full suite of social-ecological system dynamics in operation, many beyond their control (Wilson 2006). They must instead be prepared to respond adaptively, to improvise in the so-called theatre of water management. A further crucial aspect of management is also highlighted: the changing context within which societal responses to problems arising in complex adaptive systems must be developed. Maintaining flexibility – though this may contradict elements of the historical command-and-control approach to water management – is therefore the fundamental 'effective' response for water managers to adopt. Managers should also consider where the negative impacts of responses can best be absorbed within the system, where there is both awareness and power to respond effectively – in other words, where both ecological and social resilience are highest. The absorption capacity of the lower Olifants River in the Kruger Park, for example, needs to be weighed up against the resilience of mining interests upstream and that of downstream communities in Mozambique.

One way to enhance congruence and enable more effective management responses is through the use of scenarios, which allows stakeholders to develop a common understanding of a problem that impacts them - often the first step required to influence power. In **Chapter 3**, the utility of scenarios is demonstrated for dealing with situations of uncertainty encountered in resource management and conservation. Scenario analysis for the Gariep basin illuminated spatio-temporal trade-offs between ecosystem services and human well-being that were not so apparent otherwise, demonstrating the importance of designing a scenario analysis so that it captures the cross-scale processes and links of interest to decision makers (Biggs et al. 2006). While scenarios are often used in situations of uncontrollable uncertainty (Peterson et al. 2003), the Gariep experience suggests that scenarios are apt to yield the greatest benefits to social-ecological systems management when they are designed to inform a focal policy issue that stakeholders have some power to change. The great virtue of scenarios lies in their ability to impart a sense of ownership in stakeholders of the processes they believe will shape the future. The scenario development process ultimately underscores the necessity of considering the future in a social-ecological systems context, because it is in the complex interactions between people and nature that uncertainty in ecology and conservation has its roots.

A major area of uncertainty in South African water management revolves around the decentralisation of functions from the national department to CMAs. **Chapter 4**'s exploration of the decentralisation of water management through an agent-based modeling approach shows that decentralised decision-making almost always shifts the balance of winners and losers. Of the three dominant 'centralised' water management paradigms that are explored in the model, none does particularly well in balancing the Water Act principles at the national level or in all water management areas. In both cases, trade-offs among efficiency, equity, and sustainability are made except in areas where water resources are abundant. On the other hand, the ability of water users to learn and employ a diversity of management systems tends to yield the most sustainable outcomes. This finding is in agreement with other examples from the literature (Holling and Meffe 1995), yet of particular interest is that ecological sustainability is best achieved in the model when sectoral water users have difficulty fulfilling their demands, suggesting either that restraints on use are needed to maintain ecosystems in good condition or that severe reallocation measures need to be put in place. The most promising solution to ensure that sustainability is prioritised appears to be a national-level *Some, for All, Forever* framework, within which learning is able to take place. Rather than adopt a 'one-size-fits-all' policy, Catchment Management Agencies and local organisations must approach their specific problems with unique perspectives and fresh insight, appropriate for specific conditions in the Water Management Area (WMA).

If learning is such an important prerequisite for a robust water management system, how do agents learn, and what needs to be done to enhance learning? Extending the use of the model used in the previous chapter, the subject of 'learning dilemmas' - social-ecological system properties and human perceptions that challenge learning's three pillars of capacity, understanding, and willingness - is pursued in **Chapter 5**. What agents learn also depends on the measures that they select to provide information about the real world, and their ability to update or change these measures when conditions change. The model experiments show that mismatches are commonplace between social-ecological system properties and human cognitive abilities to process information about these properties. These social-ecological system properties need to be kept in mind in efforts to increase learning. Where learning is difficult due to social-ecological system conditions, monitoring systems must be designed so that they capture key patterns in these conditions. This may also require a redesign of existing institutional structures (Wilson 2006).

In **Chapter 6**, the immense challenge of linking theory to action is addressed. Resilience is identified as an intriguing theoretical concept for South African water management, but existing frameworks to analyse resilience are not yet adequate for taking the South African Water Act forward. The usefulness of two frameworks is examined for the implementation of the act and its vision of a future in balance: the Millennium Ecosystem Assessment's conceptual framework and the adaptive cycle. While these frameworks both have limitations, their exploration by South African water managers as part of a broader study of resilience could provide a mechanism for breaking down the traditional social science-natural science divide in water management. The two frameworks are in many ways complementary; managers that use these frameworks, however, should be prepared to modify them as needed to handle specific management challenges or questions (van Wyk et al. 2001). In this sense, the practical challenges encountered in implementing the Water Act may help to put resilience theory to the test. The Olifants River incident suggests nothing flawed about the Water Act itself, but points to a weakness in the overarching South African water management system in which the Water Act is only a single, albeit central, component. Its significance notwithstanding, additional checks and balances need to be in place (MacKay 2003); unwavering dependence on the Water Act to do its job, and the expectation that it will never fail, does not promote discovery of resilient pathways.

In short, the answer to the question raised at the beginning of this chapter is that the problems experienced in the Salt and Olifants Rivers are essentially both management failures rooted in a lack of understanding of linked social and ecological dynamics. Experience shows that some objectives have been served quite well by misinterpreting or disregarding these dynamics (Wilson 2002, Allison and Hobbes 2004) – in a world where natural resources appear limitless, impacts can be transferred elsewhere in space and time, and competition and conflict are minimal, the consideration of the social and ecological implications of one's actions is often counterproductive for meeting one's immediate goals. Water in South Africa has definite physical limits; however, societies are not typically doomed by such a limitation alone, but rather by perceptions of the limitation and options available for overcoming these limits (Tainter 1998, Diamond 2005).

It is also arguable that in both examples, a lack of understanding was closely coupled with a deeply-entrenched disconnect between science and management that hampered the emergence of an adaptive learning environment. Even in simpler, traditional systems, such a disconnect – typically between those with information and those with decision-making power – could have profound implications for the long-term welfare of the society and its resource base (Redman and Kinzig 2003). In present times, there is a call to move from "knowledge transfer," which tends to impart knowledge of scientists to managers in a unidirectional fashion, and is often contested or ignored, to "knowledge interfacing and sharing," whereby both parties take ownership of knowledge and use it to pursue common objectives (Roux et al. 2006).

Recommendations for water management and future research

Human behaviour is a great obstacle to change, but also a positive mechanism for it. While suggestions for modifying human behaviour are beyond the scope of this thesis, confronting it is a critical first step for changing water management (Folke 2003). Several recommendations follow from the analysis presented herein, which the South African water sector and researchers can begin implementing immediately:

1) Foster information sharing and exchange - within WMAs, between WMAs, across sectors, and internationally. There are numerous ways this may be done, which include both physical and virtual fora (MacKay et al. 2003), and need not be limited to national boundaries. There is a great deal to be learned from information sharing and exchange with countries such as France, for example, that have devolved management to

catchment-scale agencies (Buller 1996; Perret et al. *in press*) as well as other middle-income countries such as Mexico that have begun similar decentralisation processes (Wester et al. 2003). Certain challenges faced by South Africa in particular do need to be considered, as the greater focus on participation requires that stakeholder views are adequately captured in decision-making and research (van Wyk et al. 2001). As Chikozho (2005) notes in describing the process of CMA establishment in the Inkomati WMA, disadvantaged communities often have much less developed networks than the organised commercial sectors, for example, and thus the difficulty of getting genuine and legitimate representation from disadvantaged communities should not be understated. In addition, 'participation fatigue' may thwart progress on this front, and may be especially acute in WMAs like the Inkomati, in which the process has been ongoing for more than seven years. In such cases, participant turnover is likely to be high, which poses another challenge to moving forward. Stakeholder engagement will need to be approached in innovative, novel ways that are able to capture participants' imaginations and retain their active involvement in the process (scenarios, discussed below, are one such possibility).

2) Conduct participatory scenario planning exercises with water users at national, CMA, and local levels. Because of the multi-tiered, nested structure of the new institutional arrangements for the South African water sector, a simple, but multiple-scale scenario analysis involving key representatives of the national ministry, one or two neighbouring CMAs, and local catchment management committees and water user associations representing all sectors would be a highly useful exercise (Biggs et al. 2006). The first CMAs that are established should seize the opportunity to implement a scenario activity that can serve as a 'pilot' for the whole country, which subsequently-established CMAs can then learn from and refine.

3) Evaluation and redesign of monitoring systems. Monitoring must be spatially aligned with major processes and institutions. Spatially, it should be undertaken collectively by the Department of Water Affairs and Forestry (DWAF), CMAs, local institutions, as well as regional and international institutions. Monitoring must also be temporally aligned with these processes. A shift in emphasis is needed to slow variables or driving forces and

governing structures that determine system outcomes (Carpenter and Turner 2001, Lynam and Stafford-Smith 2004). While the River Health Programme is commended for its contribution in the area of monitoring ecological integrity, the need to monitor social aspects of water and drivers of change in water resources such as land use has been identified as a gap (van Wyk et al. 2001). Indicator development, which has been aligned with State of the Environment reporting initiatives in the past, also needs to shift to an integrated catchment management framework that involves institutions across scales (Walmsley et al. 2002).

4) Raise awareness of and train water managers and users in social-ecological systems and resilience thinking and approaches. The ideas of social-ecological systems and resilience theory are not always readily accessible to those with training in a traditional discipline or the public at large, due to the relatively abstract concepts and the lack of a tangible icon to represent these ideas. Thus, a creative infusion on how to approach this will be needed. One possible insertion point for communicating ideas about social-ecological systems may be the Working for Water Programme, whose public education efforts have begun to make a positive impact on people's awareness of invasive alien plants (Le Maitre et al. 2004). In simplest terms, water managers and users need to be envision the 'big picture' of water resources and not simply their small sub-area of the WMA (Chikozho 2005).

5) Encourage higher efficiency in the agricultural sector, the most consumptive water use and relatively unproductive in economic terms. This is a frequently-heard recommendation for achieving the Water Act principles, but until the problem of agricultural inefficiency is addressed in a more holistic way little progress is likely to be realised. The social implications of a reduction in agricultural water use (i.e. employment) are not trivial (MacKay 2003) and do need to be dealt with in an integrated fashion. Job creation will need to be supported in other sectors, such as tourism, and more funding allocated for poverty reduction programs which also emphasise ecological sustainability, like Working for Water (van Wilgen et al. 2005). Government agencies with overlapping, and especially those with conflicting mandates, including the Department of

Environmental Affairs and Tourism and Department of Agriculture, will need to work together with DWAF to ensure synergy in this area.

6) Maintain legal flexibility. For all the merits of the South African Water Act, it is not without flaws. Amendments may be needed as experience is gained, and the act should be seen as a living document with limits. Furthermore, potential conflicts between the Water Act and other laws, such as the Water Services Act (Pollard and du Toit 2005), and those pertaining to land reform, may need to be reconciled. However, the creation of a Water Tribunal to hear appeals is a promising step (MacKay 2003).

Conclusion

The view that the human and natural worlds are interdependent is clearly encapsulated by the South African Water Act, but the implications of this are not always completely understood. My attempt in this thesis has been to dig deeper into the social-ecological system 'well' of thought to identify and explain how this perspective may assist the water sector during this current transitional era in several specific ways. Certainly the ideas, approaches, and recommendations discussed here also apply to other challenges in ecosystem management and other parts of the world, and cross-comparison might prove fruitful.

"All the world's cultures, past and present, are to some degree available to us," Wilbur (2000) observes. Modern society now has the advantage of instantaneous communication across much of the globe. We also have hindsight, including a greater awareness of the past, and a good deal of foresight, thanks to advances in technology and cognitive tools like scenarios and modeling. The Hohokam, and even recent past generations of South Africans, have not had the same fortune. Of course, hindsight has limits in a rapidly-changing world, but meticulously and thoughtfully applied, stands to greatly enrich the knowledge base for current decision making.

Every society eventually succumbs to Holub's Tenth Law in one way or another – it collapses, disperses, or transforms (Tainter 1998). One day, future societies will read about South Africa in the early 21st century and its pivotal water policy. Will they read a story of success or failure, and what will it teach them about the future still to come?

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