Perspective: The challenge of ecologically sustainable water management

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Sustainable water resource management is constrained by three pervasive myths; that societal and environmental water demands always compete with one another; that

technological solutions can solve all water resource management problems; and that environmental solutions to protect and maintain freshwater resources are more expensive and less dependable than technological solutions. We argue that conservation and good stewardship of water resources can go a long way toward meeting societal demands and values. Furthermore, water requirements to sustain ecosystem health and biodiversity in rivers and their associated coastal systems can be well aligned with options for human use and deliver a suite of ecosystem goods and services to society. However, to achieve ecologically sustainable water management, we propose several key issues that must be addressed. The objective of this opinion paper is to stimulate discussion across traditional discipline boundaries with the aim of forging new partnerships and collaborations to meet this pressing challenge of ecologically sustainable water management.

Keywords: River ecosystems; Biodiversity; Ecosystem services; Restoration

1. Introduction

At the beginning of the United Nation's International Decade of Freshwater, the World faces an accelerating rate of global population increase and great uncertainty about the consequences of climate change. These issues are placing considerable pressure on freshwater resources and the ecosystems that they sustain. It has never been more important than now to re-evaluate approaches to water resource management.

In August 2004, a working group met on the Pite River in Sweden as part of the Second International Symposium on Riverine Landscapes, to identify key challenges that need to be addressed to improve the conservation and management of freshwater

resources worldwide. This was presented to and subsequently endorsed by over 70 delegates at the symposium who are active in the field of river research and management. The objective of this opinion piece is to stimulate discussion across traditional discipline boundaries with the aim of forging new partnerships and collaborations to meet this pressing challenge of ecologically sustainable water management.

Throughout the last century, we believe that options for sustainable water resource management were constrained by three pervasive myths, that:

1 Societal and environmental water demands always compete with one another;

2 Technological solutions can solve all water resource management problems; and

3 Environmental solutions to protect and maintain freshwater resources are more expensive and less dependable than technological solutions.

The prevalence of these myths has led to numerous environmental and social problems. Our technological approach to water management has disconnected rivers from their landscapes and led to a loss of biodiversity and essential ecosystem services, including the production of food and the decomposition of waste. Societies have been led to believe that both the desired quality and quantity of water can be provided through technology alone, with minimal environmental impact.

2. Ecologically sustainable water management

The truth is that conservation and good stewardship of water resources, through responsible management, can go a long way toward meeting societal demands and values. Furthermore, the water requirements to sustain ecosystem health and biodiversity in rivers and their associated coastal systems can be well aligned with options for human

use and deliver a suite of ecosystem goods and services to society (Postel & Richter, 2003).

One well-known example of an ecologically based approach to sustaining water resources is the New York City (USA) water supply system. Three large reservoir systems, containing 19 reservoirs and three controlled lakes, supply the drinking water for over 9 million persons in the New York City metropolitan area. Increased human development within these catchments (which encompass 5,000 km^2 when all tributaries are included) began to threaten drinking water quality for New York City. Instead of investing in an expensive (US$6–8 billion) water filtration facility, the State of New York implemented a variety of catchment protection strategies to help regulate input of non-point source pollutants from the expanding human population. These include increased protection of riparian buffer zones along rivers and around reservoirs; an aggressive land acquisition program where either land or conservation easements are purchased; the implementation of regulations prohibiting specific types of development practices in vulnerable areas (e.g. construction of impervious surfaces within ~90 m of a reservoir); and upgrading local wastewater treatment plants and septic systems throughout the catchments. Protecting and restoring natural ecosystem processes in the watershed is projected to cost US$1–1.5 billion, significantly less than the cost of building a water filtration plant (Ashendorff *et al*., 1998; Chichilnisky & Heal, 1998).

Another example of incorporating ecological catchment management approaches into water resource management comes from projects aimed at clearing invasive alien trees from catchments in South Africa. These trees use more water than the indigenous vegetation that they replaced and have a significant negative impact through reduced

stream flow and causing significant erosion after fire. In order to counteract these impacts, a proportion of funds generated from the sale of water (which were usually earmarked for the maintenance of water supply infrastructure) has been channeled into invasive alien plant clearing programs. Studies have shown that this approach is far more effective than the alternative of building new water supply schemes and has the added benefits of conserving biodiversity, reducing the risk of wildfires and providing employment opportunities for poor people in rural areas (van Wilgen *et al*., 1996; 1997).

There are also many examples of the growing adoption of riparian perspectives towards water resources that have resulted in the widespread rehabilitation and conservation of stream buffers and concomitant improvements in water quality and wildlife habitat in many catchments around the world (Naiman *et al*., 2005).

However, as the developed world expands their use of these more ecologically sensitive approaches, the same myths threaten sustainable water management in developing countries. While it is undeniable that past approaches to water resource development have generated considerable benefits in the developed world, they have come at a significant cost as well; not all have been economic successes and most are not ecologically sustainable. We need to find new ways of meeting societal needs for water that draw on important lessons from these past development efforts. If not, there is a risk that developing countries will be destined to repeat past mistakes, in part because of the mechanisms and rules that govern international funding of development projects and because of the transfer of western technology. Developing countries can least afford the likely long-term consequences of poor management of water resources, especially those

societies directly dependent on subsistence fisheries and other river and floodplain resources.

It is important to emphasize that we are not opposed to large water resources schemes *per se* but rather that we would argue against the development of such schemes as the sole component of water resource management. Water resource projects should be developed together with initiatives that promote sound catchment management and provide allocations for environmental flows to sustain ecosystem health of rivers and their estuaries. Furthermore, serious consideration should be given to alternatives to water resources projects before they are implemented, in terms of the distribution of costs and benefits and overall sustainability. The South African case study above shows how the use of funds saved by not developing new water supply structures can be redirected to benefit people through job creation and at the same time improve catchment stability, protect biodiversity and reduce fire hazard (van Wilgen *et al*., 1996; 1997).

3. Challenges for the water resource management community

We believe that ecologically sustainable water management (Postel & Richter, 2003), as an alternative to purely technical solutions, can offer substantial benefits to societies and to their quality of life, at a competitive cost. Nevertheless, to facilitate continued future successes in ecologically sustainable water management there are several key challenges to be met.

We believe that water resource practitioners must:

1 *Understand the aggregative effects of human activities within a catchment*. What is the optimal spatial configuration of development, protection and restoration that will

minimize impact on water resources and maintain essential ecosystem services and products?

2 *Embrace environmental uncertainty*. Natural systems are inherently dynamic and unpredictable. We must look for innovative ways to live with environmental variability within a natural range rather than trying to manage solely for stability and predictability.

3 *Accept that rivers and estuaries need environmental flows*. This is more than the provision of a minimal quantity of water. It requires the right quality of water at the right times in the right amounts to sustain ecosystem services and biodiversity. Such flows are essential for ensuring the provision of the goods and services that river ecosystems offer societies, including (but not limited to) the water in rivers.

4 *Manage connectivity of freshwater systems*. Global change continues to fragment river landscapes and their populations of plants and animals. It is important to maintain the flow of essential materials and organisms between catchments, rivers and coastal systems and yet minimize the transfer of contaminants and invasive species.

5 *Increase our knowledge of the consequences of biodiversity loss for ecosystem services*. Species in ecosystems are involved in a myriad of complementary processes (e.g. production, decomposition, nutrient cycling). Present global extinction rates are vastly greater than the rate of evolution of new species, and stream and river corridors are among the most threatened ecosystems in terms of biodiversity loss. Species that seem redundant provide an insurance for upholding ecosystem functions in a changing world.

6 *Assist with the development and evaluation of new technologies to manage water in heavily modified catchments*. This includes better use of remote sensing technologies

and sophisticated modeling tools to improve the efficiency of water use and reuse so that overall costs – both economic and ecological – are lowered.

7 *Discover innovative ways to facilitate the recovery of degraded ecosystems*. All sectors of the water resource community must work collaboratively to develop a more mechanistic understanding of how rivers provide ecosystem services, in order to provide effective strategies for restoration and rehabilitation.

8 *Improve our ecological understanding of the global water system.* More than ever before, fresh water is a global resource. The freshwater cycle and its consequences for people, cultures and the environment need to be understood as an integrated system – and much remains to be discovered. This includes improving our understanding of the environmental consequences of virtual water trading – the use of water resources in one region for the production of crops and goods and their export to other regions of the globe.

Will we remain hampered by past myths and will the world continue to suffer – not just economically, but socially and spiritually as well – because of our inability to manage catchments in a way that sustains the many ecosystems on which all life depends?

We challenge the community of water resource practitioners to embrace a holistic approach to water management to address the key issues identified above. Perhaps we can begin by acknowledging that the history of river management has often been marked by both hubris and conflict. Indeed, the Latin root of the word ‘rivalry’ – *rivalis* – is the same as that of the word ‘river’, referring to the inevitable conflicts that arose when humans from opposing riverbanks shared a common resource. But the past need not

dictate our future. We believe that a new path is not only possible, but is essential. It requires advances in understanding the way catchment ecosystems work as well as the social processes that can facilitate ecologically sustainable water management. Most of all, it will depend on a commitment to new, holistic thinking about fundamental connections between humans and their riverine landscapes.

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