SPECIAL FEATURE: FRESHWATER ECOLOGY: THE BIOFRESH PROGRAMME

# Going with the flow

Oxford University's Dr Paul Jepson and Rob St John argue that policy should consider water to be both an instrumental resource and the basis of dynamic ecosystems...

ater: a resource so integral to life on Earth and our civilisations that it is difficult to determine where the boundaries of policy and management should be. The foci of our existing water policies are easy to identify: drinking water supply, sanitation, irrigation, power generation and, increasingly, water security.

However, we must question whether such instrumentally driven policy areas are truly representative of the full range of needs for water management. Moreover, the myriad of life that exists within the medium of  $H_20$  before it is transformed into the liquid used by humanity must also be examined. Should water policy, therefore, also consider the diversity of life that inhabits freshwater ecosystems before it is harnessed, filtered and transformed into the inert substance used by humanity? The crucial question, however, is how do we understand the relationship between water as an instrumental resource and water as the basis of dynamic, diverse and living ecosystems?

From a science policy perspective, this point has yet to be addressed in a meaningful way. However, it is pivotal as we look ahead to form policies that will successfully assure the health and sustainability of the global water system in an increasingly populated and environmentally stressed world.

## **Diversity of freshwater ecosystems**

134

Freshwaters are incredibly diverse habitats. David Dudgeon, at the University of Hong Kong, estimates that they support

over 10% of all animals and over 35% of all vertebrates on Earth, despite covering only 1% of its surface.<sup>1</sup>

Sadly, however, no other component of global biodiversity is declining as fast as freshwater habitats. Between 1970 and 2000, for example, populations of more than 300 selected freshwater species declined by 55%, while those of terrestrial and marine systems each declined by around 32%.

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Ask any ecologist whether conserving the diversity of this life is important, and they will almost certainly agree. Push them to provide empirical evidence of sufficient weight to stimulate policymaker's attention, however, and they are likely to struggle. Freshwater biodiversity data is largely sparse, scattered and incomplete. This creates a problem now that ecosystem conservation in general has become a priority, and is consequently organising ecosystems within new legal and policy frameworks, such as the Convention on Biological Diversity. This paucity of data and evidence may be why freshwater ecosystem conservation has yet to be given serious attention by policymakers.

#### Improving ecosystem service provision

The ecosystem service framework offers an opportunity to extend the boundaries of water related policy by both giving greater policy profile to biodiversity and quantifying the wide-ranging services and benefits that freshwater life produces.<sup>2</sup>

Unfortunately, the causal links between freshwater ecosystem diversity and the provision of ecosystem services are poorly understood by scientists. Research in this area is hampered by a lack of integrated, multi-scalar data, which would enable cross-scalar analysis of the status and distribution of the biodiversity they support and the wider ecosystem services they provide. However, evoking the precautionary principle, we can look to studies that give initial evidence of the benefits of freshwater biodiversity in maintaining instrumental and non-instrumental services and function association water and its provision.

Whilst the causal links are not yet comprehensively proven, it is suggested that healthy freshwater ecosystems sustain a range of provisioning, regulating, supporting and cultural services that operate independent of human, engineering and technological interventions.<sup>3-5</sup>

# Water as a hybrid resource

Whilst compelling to an extent, available case studies lack the scientific basis to gain significant traction in water policy. As Dudgeon suggests, the lack of evidence for a close relationship between freshwater biodiversity and ecosystem service provision is largely due to the lack of adequate data on the status and function of freshwater ecosystems.

# <sup>6</sup>This paucity of data and evidence may be why freshwater ecosystem conservation has yet to be given serious attention by policymakers.<sup>9</sup>

Science aside, perception may be at play here. Technocratic and engineering solutions have dominated water policy because of their success in alleviating thirst, providing sanitation, and expanding food production and industrial processes. Piping water from a source, capturing rain in tanks, damming rivers, and building canals and irrigation systems have transformed human wellbeing and fostered civilisation. It is therefore not



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surprising that water policy is framed in terms of engineering access to the liquid resource. These traditions have made water a highly politicised resource, demanding significant policy and management attention.

However, the Earth's water system is dynamic: it flows, meanders, accumulates, permeates and lives. What we do not know is whether the aspiration of vibrant human civilisations and individual and collective rights to water can be satisfied by treating it as an inert, resource-orientated liquid, rather than as a living and dynamic resource.

Theoretical developments in ecology, supported by the ongoing deconstruction of the human-nature dualism in the social sciences, suggest that we need policies that embrace the living essence of water. Water should be viewed as a hybrid policy concept: at once both a resource and a dynamic, living system. These conceptualisations are rarely mutually exclusive, and there is increasing evidence that the maintenance of a diverse and dynamic aquatic ecosystem has the potential to improve the delivery of instrumental ecosystem services.



Water as a hybrid policy concept does not mean that we should consider it in the traditional, academic sense of the term 'hybrid' – as a totality composed of different or incongruous elements. Rather, it suggests that we recognise that water has many various and important roles in life on earth, not all within the exclusive purview of humans. In academic jargon the label for the discussion is 'relational materialism', which means that something is formed by the relations within which it resides. Along its flows, water is part of different systems of relations, and water policy needs to identify and manage the key systems that are implicated in maintaining such flows.

#### Understanding distributions, trends and patterns

Water is a fluid and hybrid resource with multiple different uses and meanings to different users across a wide range of scales. The challenge for freshwater ecosystem assessments was nicely outlined by Perrings et al as to 'provide conditional predictions of the consequences of specific policy options, at well-defined spatial and temporal scales'.<sup>6</sup> In other words, how do we translate research on understanding and quantifying freshwater ecosystem function, process and service provision into a form helpful to policymakers?

Developments in information technology offer the prospect of new forms of analysis that will enable scientists to study the role of freshwater biodiversity in water systems and to provide evidence-based advice on the interaction between aquatic and human systems. Once developed, such work will enable new forms of water governance that embrace the interactions between healthy, diverse aquatic ecosystems and the need for resource-based water use.

A crucial first step is under way. Existing freshwater biodiversity databases, most of which are nationally constructed, are currently being compiled into a data infrastructure, enabling new forms of analysis across multiple scales. For freshwater biodiversity, this is proving to be more time-consuming than expected. The challenge of creating 'interoperability standards' – agreeing and adopting a common taxonomy for instance – was anticipated. More unexpected was the prevalence of proprietary attitudes towards data, the degree of fragmentation and just how much is still in books and museum catalogues.

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This eco-informatics network will be assembled by 2012. Scientists are preparing to put some of the basics in place. One such task is integrating locality data on freshwater taxa with spatial data (for example, hydro shed boundaries) to enable exploratory broad analyses. Another highly relevant analysis for policy will be to map freshwater biodiversity trends, and overlaying socioeconomic and environmental metrics to explore correlations. Yet another will be integrating these data into climate change models to base changes on in freshwater biodiversity under future climate scenarios.

## Managing water as a hybrid resource

Regardless of the available information, one of the more challenging, and no doubt political, implications of managing water as a hybrid resource is that the ecosystem itself may need to be treated as a stakeholder with binding rights to water. Whilst this initially seems challenging; the concept of environmental flows<sup>7</sup> has been adopted by countries seeking a progressive approach towards water allocation decision-making (eg South Africa and the EU).

Environmental flows describe the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and wellbeing that depend on them. As such, the environmental flow concept provides a promising framework to enhance informed, equitable and sustainable decision-making in water management.

## Challenging and important times

Given that water is a dynamic, transboundary resource with multiple uses, meanings and modes of management, freshwater biodiversity conservation is in need of increased attention from policymakers, not only for moral or aesthetic reasons, but also potentially for its role in maintaining and enhancing ecosystem services, such as water purification.

The initial evidence presented is incomplete, but points towards a pressing need for research into the status, trends and distributions of global freshwater biodiversity, and how the relationship between diversity and ecosystem service provision.

The creation of global, interoperable freshwater databases has the potential to provide the framework to study these questions, and so underpin effective policies for sustainable, integrated water management. However, understanding the hybridity and complexity of water systems brings extra challenges for water governance.

Regardless, it is clear that there is a pressing need for a wider, more holistic approach to water policy, supported by a strong data-led evidence base.

- <sup>1</sup> Dudgeon D et al (2006), Freshwater biodiversity: importance, threats, status and conservation challenges, Biological Reviews 81: 163–182
- <sup>2</sup> Millennium Ecosystem Assessment (2005), Ecosystems and Human Well-Being: Synthesis (Island, Washington, DC)
- <sup>3</sup> Dudgeon D et al (2006), Freshwater biodiversity: importance, threats, status and conservation challenges Biological Reviews 81: 163–182
- <sup>4</sup> Holmlund C M and Hammer M (1999), Ecosystem Services Generated by Fish Populations, Ecological Economics 29: 253-268
- <sup>5</sup> Dudgeon D (2010), Prospects for sustaining freshwater biodiversity in the 21st Century: linking ecosystem structure and function, Current Opinion in Environmental Sustainability 2: 422-430
- <sup>6</sup> Perrings C et al (2011), The biodiversity and ecosystem services science-policy interface, Science 331: 1139-1140
- <sup>7</sup> Poff et al (1997), The natural flow regime, BioScience 47(11): 769-784



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