



World Water Week 2015, WWW 2015

People and fresh water ecosystems: pressures, responses and resilience

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Abstract

Freshwater ecosystems are central to the global water cycle, in local generation of freshwater flows, and the healthy functioning and resilience of other ecosystems. Freshwater security depends on healthy ecosystems. Current human threats to freshwater ecosystems include rapid infrastructure development and land-use change, inefficient water use and over-abstraction, and pollutants. These threats, combined with increasing demand for water resources, exacerbate the sustainable development challenge. By 2025, two-thirds of the world's population may be living in conditions of severe water stress. It is essential to find solutions that provide for the maintenance of freshwater ecosystems while meeting human needs. This paper examines responses to three pressures to freshwater ecosystems: declining ecosystem services, hydropower and urban development. It explores opportunities for improved decision-making and enhanced resilience including: better evaluation of trade-offs and interlinkages; improved monitoring; decision-making that incorporates long-term perspectives and risks; and the leveraging of crises to advance change.

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Peer-review under responsibility of the Stockholm International Water Institute

Keywords: freshwater; ecosystem services; payment for ecosystem services; multidisciplinary; hydropower; urban development; resilience

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1. Introduction and aims

Freshwater ecosystems including lakes, ponds, rivers, streams, springs and wetlands are home to approximately 126,000 species. In addition to being an important home for biodiversity, these aquatic ecosystems provide provisioning, supporting, regulating and cultural ecosystem services that underpin the health, livelihoods and well-being of billions of people (Aylward *et al.*, 2005). Despite their importance, freshwater ecosystems are some of the most heavily altered ecosystems on earth (Carpenter *et al.*, 2011).

The shift to the Anthropocene, a rising population and climate change have all increased the threats to and demands on ecosystems (Vörösmarty *et al.*, 2010; Russi *et al.*, 2013). More specifically, these threats include:

- Agro-chemical runoff from agricultural and urban areas
- Loss of wetland area due to urban growth and agricultural expansion
- Overexploitation and pollution of ground water supplies for irrigation and drinking water
- Poorly planned and implemented dams
- Invasive species that kill off or reduce local biodiversity
- Poorly managed industrial and household pollution, affecting water resources and biodiversity.

The impacts of these threats are already being felt, and at increasing scales. Over 200 river basins, which are home to over 2.67 billion people, are experiencing annual states of severe water scarcity. Globally, wetlands are estimated to have declined by between 64 per cent and 71 per cent in the 20th century alone, with degradation continuing (Gardner *et al.*, 2015). Freshwater species have decreased by 50 per cent since 1970 and rivers are often deprived of flows or are heavily polluted (Gleick and Palaniappan, 2010). The Colorado, a principal river of the United States, suffers from invasive species, point source pollution and over-extraction (Kennedy *et al.*, 2013; Jones-Lepp *et al.*, 2012). In China, the Chinese Academy of Sciences estimates that 43 per cent of surface water is polluted beyond use (Liu and Yang, 2012) with one study finding that roughly 28,000 rivers have disappeared across the country in the last few decades – due in part to uncontrolled and unsustainable water extraction for industry and agriculture (Hsu and Miao, 2013). Meanwhile, Wang *et al.* (2011) highlight China's heavy reliance on irrigated agriculture, which has caused groundwater abstraction to increase from 10 km³ per year in the 1950s to more than 100 km³ per year by the 2000s. The over-extraction of groundwater in the Central Ganga Plain in India is also having significant social and environmental consequences (Ahmed *et al.*, 2014). These limited examples demonstrate the scale of the challenge, and the need for innovation, scientific support, and changes and improvements in behaviour, institutions and technologies governing the relationship between people and freshwater ecosystems.

For the earth to be a sustainable home for an estimated 9.7 billion people by 2050, and to cope with increasing demands for water, food, minerals, energy and fibre, we require a fundamental shift away from business as usual. This paper draws from presentations given at the 2015 Stockholm World Water Week workshop on Freshwater Ecosystems and Human Development organized by the CGIAR Research Program on Water, Land and Ecosystems (WLE), the International Union for Conservation of Nature, the Rockefeller Foundation and the Stockholm International Water Institute. The aim of this workshop was to explore the broad spectrum of benefits derived from ecosystems, the costs of human activity on these ecosystems, and the possible solutions and trade-offs associated with the sustainable management of ecosystems. This short paper explores three examples of potential threats and solutions for freshwater ecosystems as they relate to human development. First, it discusses advances in payment for ecosystem services (PES) as a potential solution to protect freshwater ecosystems. Second, it looks at the challenges and solutions for ecosystem management in urban areas. And third, it analyzes the threats and opportunities of hydropower development. It should be noted that this paper does not provide a complete list of the tools, approaches and challenges covered in the workshop, nor is it an attempt to provide a comprehensive review of the extensive literature available on freshwater ecosystems and human development (*c.f.* Aylward *et al.*, 2005).

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