

Wetland Landscapes and Catchment Management

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19.1 Evolving world views

As available and accessible freshwater remains a tiny fraction of global water resources, with wetlands, lakes, and rivers just a small part of this, it becomes increasingly important that these resources are managed effectively and equitably, not only for human use, but also for all other ecological components of the earth system (Naiman and Dudgeon 2011; Schmitz and Sendzimir 2018). For several decades, it has been recognised that human appropriation of global biological resources, including rivers (Gregory 2006), is out of proportion with our species niche (Meadows et al. 1972). More recently the concept of the *Anthropocene* (Crutzen 2006; Vörösmarty et al. 2013) has gained acceptance, underlying the fact that human impacts on the Earth's natural biological, geomorphological, and chemical systems is now measurable, marking the beginning of a new epoch characterised by deforestation, mass extinctions, unregulated waste and plastic pollution, carbon dioxide emissions, and sea level rise.

There are two main causes for the imbalance humans have with their natural environment: exponential human population growth and its consequent consumption, and rapid technological change. These factors can clearly be attributed to human intelligence and ingenuity, but also to what was described by the early economist Adam Smith as our '*unlimited wants*', (Smith 1776), and by philosophers such as La Rochefoucauld as '*amour-propre*', or *self-interest* (La Rochefoucauld 1665; Box 19.1). Although hundreds of years have passed since the concepts were first recognised, they are still highly pertinent, and at the heart of the modern environmental crisis. Human nature and its insatiable pursuit of personal gain, poor environmental stewardship, and economic development remain the major threat to the future functionality of freshwater systems and the vital services they provide to human populations (Green et al. 2015).

More recently, these long-established perspectives have been reinforced by a growing body of science, neatly encapsulated in the concept of 'Planetary Boundaries' (Rockström et al. 2009; Steffen et al. 2015). In response, the global community has constructed a set

Box 19.1 Old philosophies still apply to drivers of human nature

Unlimited wants: ‘the pursuit of social recognition, self-worth, success and power’
Adam Smith (1776)

Self-interest: ‘Man’s natural tendency for self-love and self-interest can distort his perception of himself, and the world around him, leading him to become blind and insensitive to others, and prone to misguided judgements.’

La Rochefoucauld (1665)

Box 19.2 Sustainable Development Goals and freshwater systems

SDG goal 6

Ensure availability and sustainable management of water and sanitation for all.

Target 6.5. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.

Target 6.6. By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes.

SDG goal 15

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Target 15.1. By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains, and drylands, in line with obligations under international agreements.

Target 15.5. Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

of Sustainable Development Goals (UN 2015) through which human behaviour, and our impacts on the Earth System, can be moderated. Two of these goals (Box 19.2) are highly relevant to the management of freshwater systems (Vörösmarty et al. 2013).

19.2 Freshwater governance

Hydrologically, a catchment is an integrated, interlinked waterbody, but in practice, this is not the case in social or political terms. Few river systems in the world come under the jurisdiction of a single geopolitical, institutional or governance body. Within a single catchment, most rivers can flow through several different administrative areas, including local, state, or national authorities, irrigation boards, electricity companies, landowners, and agricultural organisations, as well as different national jurisdictions in neighbouring countries.

Water governance has been defined as the ‘range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services’ (GWP 2009). When considering, however, the challenges of managing water at the catchment scale, these multiple systems, and the potential

discord between them, can severely compromise efforts in catchment management or prove extremely expensive to sustain.

The term 'catchment management' is used widely in the literature. Specifically, it refers to the fact that *hydrological systems within any single watershed are fully connected, both above and below ground, from source to estuary*. Countries across the world have adopted the catchment system as the foundation for managing their freshwater and wetland resources. For example, in the countries of the EU, this provides the foundation of the EU *Water Framework Directive* (EC 2000), and as a result, catchment management plans have become a mandatory component of EU water policy.

In other parts of the world, governments have adopted this approach: catchment management agencies have been created and catchment plans put in place. In countries as diverse as Canada, Mozambique, Israel, Ukraine, and Chile, catchment management strategies have been implemented with varying levels of success under the dominant water management paradigm; namely, *Integrated Water Resource Management* (IWRM) (GWP 2009). Many of the world's largest rivers have *River Basin Commissions*, with a view to implementing IWRM and supporting cooperation between the multiple countries that rely on water resources in transboundary basins.

19.2.1 Challenges of management at the catchment scale

For those involved in whole catchment management efforts, data availability and scale are often major problems. Data definitions and methods of measurement can vary in both space and time, resulting in incommensurability of information. This has resulted from data being generated from a series of short-term independent projects rather than as part of long-term research programmes. Furthermore, in some places, where long-term water monitoring programmes have been undertaken, institutional change, and changes in information technology over the last 20 years have resulted in some long-term data sets being abandoned, with valuable data being lost.

This data loss has often been the unintended consequence of political change. For example, when the EU Water Framework Directive was put in place in 2000, a number of countries abandoned some of their long-term legacy data sets, due to resource limitations. In some less-developed countries, hydrological data sets that had been built up over decades in colonial times, have since been abandoned. In the case of hydro-meteorological data, problems have arisen due to equipment failure, theft of solar panels and copper cabling, and inadequate support to maintain crucial globally important monitoring networks.

A second challenge for those involved in catchment management arises from the existence of imprecise legislative frameworks. For example, although globally over 50 per cent of potable water comes from groundwater, water law often relates only to surface water. Furthermore, wetlands are often poorly defined in national water law, and thus may be overlooked in management regimes and decision-making (Sullivan and Fisher 2011). The legal principles of '*equitable and reasonable use*' and '*do no harm*' have become accepted as important underpinnings for water policy and, indeed, current efforts to strengthen water law by building in protection and joint management of ecosystems, are encouraging (McIntyre 2014).

At the operational level, the need for environmental water requirements (Horne et al. 2017; Acreman 2016) has become a major issue worldwide. Several countries have

expanded their legislation to support environmental flows, particularly in South Africa, Tanzania, Costa Rica, and Australia. Elsewhere, however, although environmental flow assessments have been undertaken, few have been implemented due to methodological, operational, and institutional barriers—see assessment and implementation framework proposed by Opperman et al. (2018).

Finally, recent work has shown that land–atmosphere teleconnections exist which may result in changes in water quantity and quality in any river basin influenced by land-use changes in other areas outside the specific basin (Wang-Erlandsson et al. 2017), suggesting that the concept of managing water resources at the catchment scale may be ambiguous. Atmospheric teleconnections are, however, still poorly understood, and until more progress is made in this aspect of atmospheric science, the use of the catchment scale remains valid for the purposes of water management.

19.2.2 Beyond the catchment—challenges in transboundary basins

Globally, some 60 per cent of human populations depend on water from 261 shared river basins, with an urgent need for more streamlined transboundary water governance at the catchment scale (UN Water 2015). Although globally there have been over 3,600 water-sharing treaties agreed on since 805 AD, there is little widespread legislation to support water management across international boundaries. The 1997 UN *Convention on the Law of the Non-Navigational Uses of International Watercourses* has been signed by only 36 countries, and although this means it has now been ratified into law, there is no guarantee that the majority of the world's transboundary riparian states will adhere to it. The UN *Water Convention* (UNECE 2013) goes some way to address the type of water conflicts that often arise in transboundary catchments (McIntyre 2014), but international water law needs to be further strengthened through a greater uptake of these two conventions, and stronger linkages with the *Ramsar Convention on Wetlands*.

The importance of wetlands in transboundary cooperation can be well demonstrated in the case of the Okavango basin. In this huge wetland area (530,000 km²), which provides a crucial hydrological resource for Botswana and its neighbours, the formation of the basin commission OKACOM has the objective to secure sustainable management of the basin by building cooperation between the riparian states and their local government agencies (Philip et al. 2008).

Another important example of a transboundary basin is the Mekong river, which flows through six countries in Asia, providing livelihoods for over 70 million people (Mekong River Commission website <http://www.mrcmekong.org/>). Along most of its length (5,000 km), hundreds of wetlands provide water storage, flow regulation and flood prevention functions, and support valuable fish habitat. Today, however, these wetland ecosystems are being impacted by reductions in flows, increases in sedimentation, and changes in water temperatures. Large-scale dam construction in all the riparian countries have contributed to this degradation, with potentially irreversible impacts. The Mekong River Commission has not been able to reverse the trend of river degradation, which is a serious threat to food security across the region (see '10 rivers at risk' and 'Securing water for people and environment' at <https://www.worldwildlife.org/>).

Initial optimism about these river basin commissions has been relatively short-lived. In the Mekong, for example, failure to engage upstream riparian countries

has resulted in increased threats to the vast wetlands of the Mekong Delta in Vietnam, and around Lake Tonle Sap in Cambodia, due to the number of large dams being constructed upstream. In the Nile basin, little real progress has been achieved in spite of the millions of dollars that have been spent to develop benefit sharing under the Nile Basin Initiative and the debates surrounding the construction and filling of the Grand Ethiopian Renaissance Dam (Wheeler et al. 2016). In Australia, where the Murray–Darling system has been managed for over two decades, conflict between stakeholders has increased over the way water resources should be used (Sullivan 2013), and in recent years, a number of incidences of illegal water acquisition, involving thousands of gigalitres of environmental water, have been reported.

19.3 Ecosystem services

19.3.1 Benefits from ecosystem services

Wetlands generate many ecosystem services (MEA 2005; Ramsar 2015; Sullivan et al. 2009). The ecosystem services concept is generally understood to describe the *benefits provided by nature to households, communities, and economies* (Gómez-Baggethun et al. 2010). The concept has been further developed for wetlands than for any other ecosystem (Maltby and Acreman 2011; See chapter 15 of this volume), with provisioning and regulating services being the most dominant. Provisioning services provided by wetlands include the supply of clean drinking water both for humans and animals, irrigation water, and food and fibre from other wetland resources (Russi et al. 2013). Cultural ecosystem services such as recreation and tourism, generation of scientific knowledge, educational opportunity, and spirituality are all important in wetlands (Chan et al. 2011), along with the provision of habitat for biodiversity (Harper and Quigley 2005).

Wetlands also provide regulating services such as flood mitigation, storm protection, water purification, sediment transport, erosion control, and carbon storage. Global reviews have found that wetlands consistently improve a range of water-quality indicators, including total phosphorus, nitrogen, nitrate and nitrites, ammonia, reactive phosphorus, chemical and biological oxygen demand, and suspended sediments (Fisher and Acreman 2004; Newman et al. 2015).

Many examples of these processes can be found across the world. In the Nakivubo Swamp, on the edge of Lake Victoria in Uganda, waste water and untreated sewage are received from the capital Kampala (Kansiime and Nalubega 1999), and acting as a buffer, the wetland removes nutrients and other pollutants so effectively that the city's water supply intake can be sited just 3 km away along the lake. Similarly, in the Orange River basin in South Africa, as the river flows slowly for 20 km through the Seekleivoi wetlands, in the heavily populated area of Soweto, important water purification functions are performed. Such benefits can be valued financially through comparison with costs incurred through the construction and operation of a wastewater treatment plant (Bonjean and Sullivan 2009). In spite of all these benefits, the rate of global wetland loss has become acute (Davidson 2014).