1

Water Resources in the Twenty-First Century

COPYRIGHTED MATERIAL

In Earth's 45th millionth century a global crisis of freshwater scarcity is looming, a crisis that is accelerating thanks to our unbridled development and our burgeoning demand for food and energy, and as a result of the effects of climate change. Just 0.1% of the total global water volume of 1.4 billion km^3 is accessible freshwater; we are already withdrawing one-quarter of our accessible renewable water resource (RWR) however, much of which is already needed to sustain our ecosystems and biodiversity, themselves vital for our survival.

In this book, we argue that the world faces water security challenges of a scale previously unseen and largely unsuspected by its population. Estimates suggest that we need four times the current global rate of investment in new water supplies if we are to successfully meet projected water demand in 2030 (2030 WRG 2009). To have any chance of meeting future water demands, we believe there is a compelling need for water professionals to emerge from their comfort zones and to engage with politicians, decision makers and those stakeholders with influencing power. While we can and should continue to develop cost-efficient water technologies, water professionals must grasp this moment to put themselves at the centre of the often-siloed disciplines of science, technology, politics, environment and economics. New models of integrated water management are required to address complex multi-stakeholder demand patterns and water-related responsibilities.

1.1 A Looming Crisis

On 31 October 2011, a baby girl born in Manila was chosen to symbolise the 7 billionth human being on the planet. Although the rate at which the global population is growing has almost halved since the 1970s, in the last 40 years the world's population has still doubled. Alongside this increase, strong economic growth has seen standards of living rise dramatically in the developed world. Forecasts of population growth suggest that by 2050 there may be 9.5 billion humans sharing the planet, most of them living in our ever-expanding cities. We have already reached a point where more than half of all people live in urban areas, and this proportion is expected to rise to two-thirds later this century. The influence of these demographic trends on water resources in discussed further in Section 2.3.3 and in detail in Chapter 4 'Live'.

Water Resources: A New Water Architecture, First Edition.
Alexander Lane, Michael Norton and Sandra Ryan.
© 2017 John Wiley & Sons Ltd. Published 2017 by John Wiley & Sons Ltd.

Significant volumes of research have been carried out and continue to be conducted into potential scenarios of climate change and their projected impacts on RWR and water demand. The evidence is strong that the influences are real and that the impacts are already with us and set to intensify (Intergovernmental Panel on Climate Change (IPCC) 2013). Very broadly, predictions are for increased rainfall and runoff in higher latitudes and reduced rainfall and runoff in tropical and mid-to lower latitudes. The volumes of water stored in glaciers are expected to fall, thereby reducing annual meltwater flows and in turn affecting water supplies in dependent areas such as Peru and California. Higher temperatures will exacerbate water pollution problems in many rivers and lakes, and will increase evaporation from open waterbodies and soil. More intense rainfall events will result in more frequent stormwater flooding in urban areas as well as from rivers.

1.2 Human Interactions with Water in the Biosphere

It is estimated that the world's total RWR is between 33,500 km^3 and 47,000 km^3 per year (Millennium Ecosystem Assessment 2005). Vast amounts of this resource are, for all practical purposes, unavailable due to their remoteness relative to demand (for example in the Amazon Basin, Canada, Greenland and Russia). It has been estimated that only around 50% of the global RWR can be accessed (Millennium Ecosystem Assessment 2005).

Currently, we withdraw around 4,500 km^3 of our accessible RWR (2030 WRG 2009). In the last 40 years, global water withdrawals have almost tripled and this growth rate remains strong, increasing by over 60 km^3 each year. Despite these increases in withdrawals, demands for water are growing even faster and are expected to reach 6,000 km^3 a year by 2030 (2030 WRG 2009). Even with our increasing water supply rates, and allowing for more efficient use of water, meeting this demand is believed by many authors to be unlikely (2030 WRG 2009). It can be argued that even now we are reaching what some observers are calling 'peak water', the concept of the safe water withdrawal limit that must not be passed if we are also to leave enough water in our rivers to maintain their aquatic ecosystems and biodiversity, a vital and much underappreciated resource in their own right.

Now that more than 1 in 2 people live in urban environments, the need to address the pressures that urban lifestyles exert on water resources is paramount. Urban water managers already face challenges of aging water infrastructure, large energy demands, high maintenance and treatment costs, and increasingly stringent environmental regulations. Many are also facing population growth, and the impacts of climate change on water demand and on urban stormwater runoff.

Water management in cities and urban settings has experienced many developments in thinking in recent years. The International Eco-Cities Initiative identified as many as 178 significant so-called 'eco-city' initiatives at different stages of planning and implementation around the world (Joss *et al.* 2011), and most of these initiatives include a water management component. Examples include Curitiba (Brazil), Auroville (India), Dongtan (China), Masdar (UAE), Freiburg (Germany) and Stockholm (Sweden). The evolving aim is to move from urban systems which are heavy users of non-renewable resources and generators of waste to urban systems which reduce their water demand, use renewable resources and recycle their wastes into valuable products (see Figure 1.1).

Importantly, this aim applies as much to the resources of food, energy and other materials as it does to water; water is at the heart of urban sustainability, however. Already, most urban water utility managers are implementing measures which can be loosely classed as 'demand management': promoting the uptake of household appliances which use less water, advocating garden rainwater harvesting and considering the recycling of treated wastewater, for example. They also wish to minimise the costs and carbon footprint of their primary water supply systems, seeking water from sources which cost less to secure and at the same time offer resilience against the potential future impacts of climate change and weather extremes.

It is projected that future water withdrawals required to grow and process our food will reach 4,500 km^3 by 2030, compared to around 3,100 km^3 in 2010, unless significant efficiency gains are realised (World Economic Forum 2011). These withdrawals are around seven times higher than those for drinking water. At the current time, around 30% of the food eaten worldwide is grown under irrigation, accounting for 70% of all water withdrawals (World Economic Forum 2011). Irrigation underpins crop production, particularly commercial cropping, because it significantly increases crop yields over and above those which can be achieved by rainfall alone. While there are still vast tracts of cultivatable land on the planet with regular rainfall, the growing trend for crops to be grown under irrigation shows no sign of abatement. A special report in *The Economist* in February 2011 concluded that of all the constraints to 'feeding the 9 billion', that of finding sufficient water is the most intractable. The relationships between water and food are explored in detail in Chapter 5 'Eat'.

Figure 1.1 Inputs and outputs in an idealised urban resource system. *Source:* adapted from Rogers (1998).

1.3 An Inspiring Challenge

In his 2010 BBC Reith Lectures, UK Astronomer Royal Professor Sir Martin Rees said "This is a crucial century. The Earth has existed for 45 million centuries. But this is the first when one species, ours, can determine – for good or ill – the future of the entire biosphere".

This is a profound statement and one that has inspired the authors of this book. We believe that the future of the biosphere as a sustainable habitat for mankind will be framed by how effectively we manage our water: water in our rivers, lakes and aquifers; water in our soils; water which sustains our incredible biodiversity and ecosystems; and, most of all, the water that we humans use to live, eat and consume (Part II: chapters 4, 5 and 6, respectively).

In the subsequent chapters of Part III of this book we describe the fundamentals of water resources, the current state of water stress through our live, eat and consume activities, and how current policy, regulation and water management seek to address water scarcity and increasing water insecurity. In Part IV, our final collection of chapters, we propose a new way forward characterised by conceptual, physical and institutional integration of all aspects of the management of our planet's water, an approach which transcends current valiant yet largely unsuccessful attempts to implement Integrated Water Resource Management (IWRM). We term this new approach a New Water Architecture.

References

2030 Water Resources Group. 2009. Charting Our Water Future: Economic frameworks to inform decision making. 2030 WRG, London, UK.

Intergovernmental Panel on Climate Change (IPCC). 2013. Summary for policymakers. In Stocker, T.F., Qin, D., Plattner, G-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA.

Joss, S., Tomozeiu, D. and Cowley, R. 2011. Eco-Cities - A Global Survey: Eco-City Profiles. University of Westminster, UK.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Current State and Trends. World Resources Institute, Washington DC, USA.

Rogers, R. 1998. Cities for a Small Planet. Westview Press, Boulder, USA.

World Economic Forum. 2011. Water Security: The Water-Food-Energy-Climate Nexus. World Economic Forum, Washington DC, USA.