Preface

Throughout history cities and water have had what amounts to a kind of "love–hate" relationship. To have cities, one must have reliable and abundant freshwater sources. However, where we choose to build cities – and what cities become after they grow – can place enormous strain on locally available water resources. Growth and development can also severely degrade the quality of water consumed by other users, as well as the condition of the surrounding natural environment. As a result, since the inception of the earliest cities, urban governments have embarked on one of two principal strategies to compensate for these challenges: they find ways to bring water from considerable distance to quench their population's thirst or – to paraphrase one of the major characters from the movie *Chinatown* – they annex neighboring areas with freshwater in order to acquire rights, and access, to additional supplies.[1]

By the late twentieth century, another set of options began to emerge – applying various technical "fixes" to enhance local supply, ranging from desalination to stormwater harvesting, water banking, improving end-use efficiencies through installing low-flow appliances, and reuse of wastewater. While these remedies can make urban life better, and provide ample, clean, potable water to residents, they are not "cost-free." In some instances (for example, desalination) they may be economically expensive and provide potable water supplies costing far more than conventional sources. Moreover, while generalizations are not always reliable indicators, it would appear that the far larger and more complex a proposed solution to these problems becomes (for example, large water recycling facilities), the greater the likelihood that other environmental and public acceptance challenges may arise – including the safety and security of the water produced and the perception that the remedy or solution is not fair and equitable, and will not "fit" into an urban environment without undue adverse impacts to aesthetics, noise pollution, neighborhood character, and a host of other issues.

In short, adoption of these technologies may pose political and social conundrums at least as dramatic as the problems they are designed to solve – and that's what this book is intended to address: the economic, legal, institutional, environmental, and political challenges generated by efforts to establish water-sensitive cities, including the barriers that must be overcome in transitioning to a more adaptive or water-sensitive approach.

A water-sustainable city is one that adopts – successfully – these and other technologies to support growth and development. However, we contend that to become truly water sustainable requires that established technologies are supplemented by low-energy – and low carbon footprint – approaches such as biofilters for extracting contaminants and recharging groundwater basins and aggressive conservation measures to reduce demand. Both may also impose fewer adverse effects on the environment, thereby improving water productivity, lowering energy (and carbon) footprints, and improving human and ecosystem health.

Low-energy, low carbon footprint approaches go by many names, reflecting their diversity in size, scale, cost, and application. What they all share in common, however, is an emphasis on resilience: ensuring that under adverse as well as "normal" conditions, cities will have a dependable, reliable, safe and sufficient supply of clean and usable water. Put another way, a resilient city, from the standpoint of water, is one that is able to reduce its vulnerability to harm from supply disruptions from various hazards, including climate change (Padowski et al., 2015). To achieve this goal, these alternative approaches share another feature in common – one that distinguishes their philosophy and method of implementation from more "conventional," large-scale approaches. The critical feature of these so-called resilient water systems is to closely integrate water management to land-use and urban planning. In part, they seek to do this by fusing centralized and decentralized systems for water supply and treatment, and they emphasize diversity of supply sources throughout entire urban watersheds (Daigger, 2009; 2011; Pahl-Wostl et al., 2007; Gersonius et al., 2013; Gleick, 2003).

Such approaches in the United States have been referred to as low-impact development (LID). In the United Kingdom, they go by the name Integrated Urban Water Management (IUWM). And in Australia, the terms Water-Sensitive City (WSC) and Water-Sensitive Urban Design (WSUD) have become popular labels. A variety of naming conventions continue to be debated in the water community, in part reflecting the evolution of philosophies over urban drainage and other issues of water management (Brown et al., 2009; Wong et al., 2011; Fletcher et al., 2013a).

To investigate these issues, this book focuses on two interrelated issues of critical importance to cities and the environment. The first of these is how our rapidly urbanizing planet impacts global water availability and quality. The second is the ways in which various threats to freshwater – including global climate change and pollution – impact water infrastructure, public health, and societal welfare in cities. We contend that while the world's freshwater faces enormous pressures from drought, weather variability, and unceasing demands for more food and energy, large cities generally – and megacities in particular – compound these stressors in two distinct ways.

First, cities are often located some distance from the water sources needed to maintain their teeming populations, compelling them to divert water from outlying rural areas. These areas, in turn, often produce the food and fiber needed to support the former. And second, soaring birth rates, in-migration (the latter often from these same outlying areas which are suffering from water and food shortages), and growing suburban sprawl, place extra burdens upon water infrastructure – exacerbating health and hygiene problems, and worsening risks from sea-level rise and flooding.

While the phenomenal growth of megacities, a trend which began in the late twentieth century, has become a defining nexus for numerous environmental problems including air pollution, growing greenhouse gas emissions and natural habitat destruction until recently, the effects of urbanization on the world's freshwater have been little studied. These effects are worthy of our attention for two reasons. First, megacities are increasingly contributing to water conflicts between themselves and their outlying regions and, by implication, worsening water disputes among neighboring countries. And second, while the magnitude of these problems is severe, the problems themselves are not really new – many are traceable to cities in antiquity. One innovation of this book is that we seek to link current problems to these historical antecedents.

Our thesis is that global climate change and population growth demand creative, low-energy, multi-disciplinary, and multi-benefit approaches to sustaining water resources. This thesis draws upon the work of the principal author and his collaborators through a bi-national project funded by the National Science Foundation. This project, the Partnerships for International Research and Education (PIRE), is a joint effort of investigators at UCI, UCLA, UC San Diego, and the Southern California Coastal Waters Research Project (SCCWRP) in the U.S., and scientists at the University of Melbourne and Monash University in Australia. Over the past three years, we have undertaken efforts under this project to catalyze, through research and education, the development and deployment of low-impact alternatives for improving water productivity while protecting human and ecosystem health.

Not only does this project link five different universities in two water-stressed regions of the world (the southwest U.S. and southeast Australia), but our Australian partners are world leaders in these topics, as evidenced by the world's first distributed application of these technologies in an urban catchment (Little Stringybark Creek), a university–industry Cooperative Research Center on water-sensitive urban design valued at $117M, the world's largest Wastewater Stabilization Pond, and a world-class facility for visualizing interfacial momentum and mass transport. By facilitating joint research and knowledge sharing, the PIRE has accelerated education and training in this critical area of water sustainability, and has diffused knowledge about sustainability options to U.S. middle-school and high-school students, undergraduate STEM majors, graduate students, post-doctoral researchers, and practitioners.

Part I of this book comprises four chapters. Chapter 1 examines our uncertain water future and considers the possibility of a water-sustainable city and how that city might differ from contemporary metropolises in regard to its use and management of water. Chapters 2, 3, and 4 respectively consider some major lessons from an urban ecology of water – a historical view of urban water management; the roles of civil engineering, law and institutions in urban water management; and different approaches that have been adopted – both traditional as well as contemporary – in managing urban water problems.

Part II explores the water–energy footprint of some large cities and how urban form can impact water use. This section considers two interrelated issues: (1) the relationship between water and energy in large cities (what is sometimes referred to as the water–energy nexus); and (2) how cities value water – an emphasis on the economic valuation of water use. Chapter 5 looks at the water–energy nexus through the lessons of the PIRE project especially, while Chapter 6 discusses ways in which the value of water can be measured, as well as economic and non-economic tools for valuing and managing it – including how to induce conservation. Other economic tools available to manage urban water more efficiently are also discussed.

Part III proposes a way forward, with a dual focus on technology and policy. Chapter 7 examines the urban stream syndrome and how it can be alleviated – an especially important topic in the contemporary city with respect to managing both ecological and societal needs for water. Chapter 8 discusses so-called low-energy and, thus, low-carbon options for water supply, along with innovations in infrastructure. These approaches are all critical to meeting the challenge of better using available water resources in cities. Chapter 9 examines the future of water governance and management for achieving a water-sensitive city. Finally, we will conclude (Chapter 10) with some thoughts regarding future research needs for decision-makers.

NOTE

1. The character, played by John Huston, stated: "if you can't bring the water to Los Angeles, then you have to bring Los Angeles to the water," referring to plans to acquire the San Fernando Valley and annex it to the city. Such a plan, in less fictitious form, occurred in the early twentieth century when Los Angeles acquired the water rights to the Owens Valley and built an aqueduct to divert water to the city some 250 miles distant.