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Sustainable Solutions for Urban Water Security

Innovative Studies

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Preface

How our society responds to the growing problem of urbanization induced environmental changes is a pressing issue with urban sustainable development. One way to understand this issue is through the case of water, one of the most precious resources in urban areas. Water resources face widespread deterioration due to unsustainable urbanization. The fundamental growth and development of human societies are dependent on water resources, and so the ecosystems on which human population directly depend on. In fact, an increasing number of researchers and professionals are now engaged in finding out solutions to this vast problem with huge social implications. However, the results largely remain not practiced on the ground and urban areas continue to adversely affect freshwater environments. But the interest in studying urban areas more with successful case studies, capturing the diversity of possibilities associated with urban water management—from increasing and protecting biodiversity in urban ecosystems to engineering solutions that are based on long-term benefits—is on the rise. This book captures notable sustainable solutions backed up by robust theoretical and scientific background analyzed as keys to these successful practices.

The foundations of the book were laid through the project Asia Pacific Network for Global Change Research (APN), titled "Climate Change Adaptation through Optimal Stormwater Capture Measures: Towards a New Paradigm for Urban Water Security" (Project ID: ARCP2014-20NMY-Mishra). Another major factor has been with the author's interests in understanding and explaining urban water resource problems to professionals (academicians, policy-makers) as well as common citizens, thereby address and better equip water resource management policies in urban areas. The chapters in this book cover a wide range of issues regarding urban water security, with a focus on various success stories. We concentrate on success stories in detail mainly as we think they give hope for the future generations and provide examples, and showcase our ability to adapt in difficult situations such as degradation of a most vital resource. The most important feature of this book is the theoretical and conceptual viewpoints backed up by case studies of real-world situations, which mainly came through our experiences in the field of water resource management. Throughout the book, it is emphasized that sustainable water

resource management in urban areas plays a pivotal role in a broad range of issues relater to water security such as social stability, economic and environmental well-being. The book thus can also be taken as a handbook of workable answers to the problem of not only urban water resource management alone but also a nexus that relates urban sustainability through water issues.

Finally, we hope that this book will be an important step toward informing urban policy decisions regarding water security issues. We also hope that the combination of these valuable steps, together with other similar studies, will open new pathways for the urban society to deal with sustainable water resource management.

Pokhara, Nepal — Binaya Kumar Mishra
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Hayama, Japan — Pankaj Kumar
Canberra, Australia — Chitresh Saraswat
July 2020

The original version of the book was revised: The funder information has been added. The correction to the book is available at https://doi.org/10.1007/978-3-030-53110-2_10

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This book has been successful due to the Water and Urban Initiative (WUI) research program at United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), where we conceptualized the idea after debating hours on the current research gap and situations we learned during working at different projects. There is great amount of exposure of discussion and work with the colleagues, work and administration at UNU-IAS who helped us to refine our thinking. Most importantly, the programs, teaching and discussion at the University of Tokyo Integrated Research System for Sustainability Science (IR3S) 1, Japan, the Japan Society for the Promotion of Science (JSPS), School of Engineering, Pokhara University, Nepal, The Fenner School of Environment & Society, Australian National University, Canberra, Australia, Department of Sustainability Studies, Hosei University, Japan, and Natural Resource and Ecosystem Services, Institute for Global Environmental Strategies (IGES), Japan. Without their support, this book would not have been a reality, especially as a lot of the information and case studies discussed in the book come from the authors'

research works in these institutions. The authors would like to thank all the people involved at Springer for making this project a success, particularly Dr. Petra van Steenbergen, Ms. Amudha Vijayarangan, Ms. Margaret Deignan and Ms. Bhagyalakkshme Sreenivasan, who consistently supported us throughout the writing process.

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Contents

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Binaya Kumar Mishra is currently engaged as a full-time professor at the School of Engineering, Pokhara University, Nepal. Prior to this, he worked as a research fellow at the United Nations University, Institute for the Advanced Study of Sustainability (UNU-IAS), Tokyo. He is involved in research and teaching activities for Bachelor (Civil Engineering) and Master (Hydropower Engineering; Public Health and Disaster Engineering) programs. His research and teaching interests include water resources management; climate and ecosystem change adaptation; hydrologic and environmental modeling and applications of GIS and remote sensing. Prior to joining Pokhara University, he briefly worked as an associate professor at the Central Campus of Engineering, Mid-Western University, Nepal. Earlier, during October 2009–March 2018, he worked as a researcher and faculty member at different academic institutions in Japan. He also worked as an irrigation engineer at the Ministry of Irrigation; a senior lecturer at Kathmandu Engineering College, Tribhuvan University, and a consulting engineer at Kathmandu, Nepal, during 1999–2006. His research works have been published in several books, journals, reports and proceedings.

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Pankaj Kumar is currently working in the Institute for Global Environmental Strategies (IGES), Japan, as a senior policy researcher in the field of water resources and climate change adaptation. Prior to this, he worked as a research fellow at the United Nations University, Institute for Advanced Study of Sustainability (UNU-IAS), Tokyo, for four years. Recently, his research work focused on 'hydrological simulation and scenario modeling for clean urban water environment in South-East Asian developing cities' a transdisciplinary work aimed to enhance community resilience to global change and provide policy-relevant solutions. He holds a doctoral degree in Geo-Environmental Science from the University of Tsukuba, Japan. In parallel, he had work experience as Chapter Scientist for Working Group-II of Fifth Assessment Report (AR5) of IPCC. Currently, he is also working as a scoping expert for nexus assessment for IPBES. He has several peer-reviewed journal articles and chapters of international repute to his credit.

Chitresh Saraswat is an interdisciplinary researcher and doctoral scholar in the Fenner School of Environment & Society, Australian National University, Australia. Trained as an environmental geographer and computer scientist, he focuses on accelerating transitions toward water sustainability in the Global South. His research interests span across water governance, innovation and sustainability transitions. He has over ten years of research and industry experience, both nationally and internationally. He has developed this through roles with United Nations agencies, energy and water utility and corporate (IT) sector firms. He received a Master of Science degree in sustainability from the United Nations University, Institute for Advanced Study of Sustainability (UNU-IAS), Tokyo, and Joint Diploma (sustainability science) from Graduate School of Frontier Sciences, the University of Tokyo and UNU-IAS, Tokyo, Japan. He has published several peer-reviewed outputs in journals with international repute and books in the research areas of sustainability, water management, security and governance and cyber-physical systems.

Chapter 1
Urban Water Security: Background and Concepts

1.1 Background

Currently, more than 1.1 billion people have inadequate access to clean drinking water globally, and approximately 2.6 billion people lack basic sanitation (Pink 2016; Jain 2012). Water is the foundation of life and a basic necessity for everyone, but lack of access is gradually becoming a crisis for millions of people around the world that is responsible for poor health, destruction of livelihoods and unnecessary suffering for the poor (Hanjra and Qureshi 2010). Therefore, overcoming the water crisis is one of the greatest challenges faced by our generation (IPCC 2007), and developing clean potable water, efficiently managing wastewater and providing basic sanitation facilities are the foundations for sustainability and human progress (UN-Water 2010; Tremblay 2010). Successfully achieving these goals would catalyze progress in many sectors such as public health, energy security, climate resilience and poverty reduction, as well as accelerating the pace toward achieving the Sustainable Development Goals (SDGs), which were recently approved in the 71st Session of the United Nations General Assembly (Sachs 2012). From the Millennium Development Goals (MDGs) to the SDGs, the focus of the water security concept has shifted from only water supply and demand in cities toward the perception of water as an economic resource shared between countries (Connor 2015). This shift also emphasizes the concept of water governance, inlcuding its capacity to manage water efficiently and equitably (Conca 2006; Gareau and Crow 2006). Therefore, the definition of water security is rapidly changing to include ensuring every person has reliable access to sufficient safe water at an affordable price to enable a healthy and productive life, as well as maintaining water-related ecological systems for future generations (Cook and Bakker 2012). However, water stress is rapidly increasing in the developing parts of the world, including countries in Sub-Saharan Central Africa, Western South America, Australia, Southeast Asia, China and the world's most water-stressed region, the Middle East, where the water availability per person is less than 1100 cubic meters. In the past several years, the water situation has improved, but at least

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650 million people still lack access to clean drinking water. The rapidly developing regions of Asia, Africa and South America face groundwater overexploitation and skewed water supply due to explosive population growth and negative impacts from climate change (Cook and Bakker 2012). Overall, the Asian region is also one of the most rapidly urbanizing parts of the world, with the urban population growing at the alarming rate of 2.3% annually, which is greater than the global average of 2% (Cohen 2006). Approximately, 16 megacities with populations of 10 million inhabitants or more, more than half of the world's megacities, are located in this region (UN DESA 2014), and it is estimated that the urban population of the continent of Asia will exceed the rural population by the year 2022 (ADB 2008). Recently, the Asian Water Development Outlook Report by the Asian Development Bank predicted that more than 1.7 billion people worldwide will lack access to basic sanitation by the year 2050; approximately 3.4 billion people will be living in water-stressed areas (AWDO 2016); and water demand will increase by 55% (Chellaney 2011).

Figure 1.1 shows the future global water stress scenario by the year 2040; most of Australia, Northern and Southern Africa, the USA and Western South America will face water stress in the form of a high withdrawal to supply ratio (40–80%) (WRI 2015), and a large part of Asia will face extremely high (>80%) water stress. Managing water scarcity to this extent requires new definitions of water security that emphasizes the importance of maintaining the ecological systems that provide water (Wagener et al. 2010) and increasing the significance of water governance in solving the problem. In this scenario, it is very important to design a wide range of sustainable water security solutions that address the multiple instances of increasing water scarcity around the globe and effectively address local constraints. Figure 1.2 indicates the urgency and necessity for a range of sustainable solutions by showing

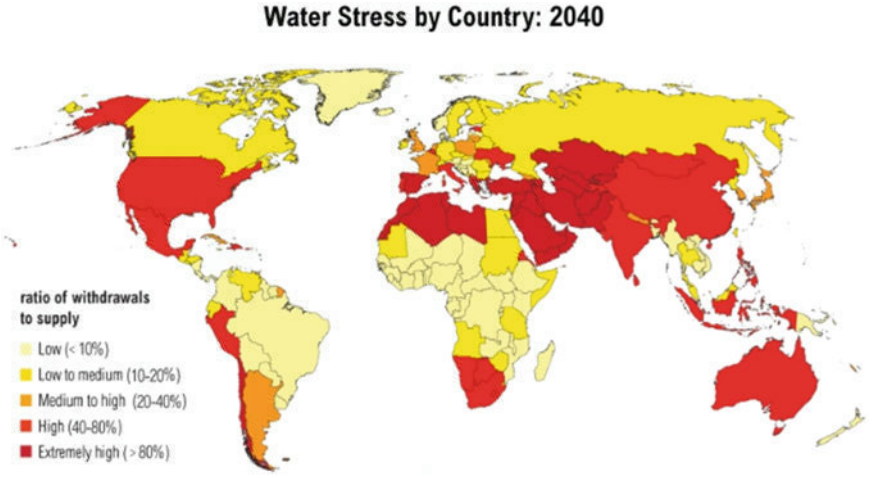

Fig. 1.1 Projected country-level water scarcity for the year 2040. Projections are based on a business-as-usual scenario using SSP2 and RCP 8.5. *Source* WRI 2015

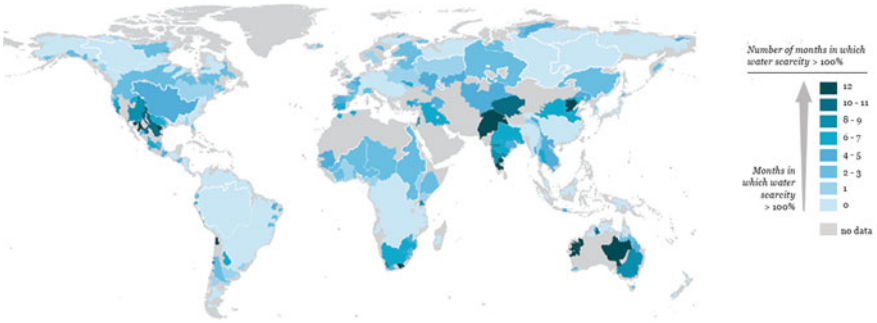

Fig. 1.2 Number of months in which severe water scarcity was observed in more than 400 river basins from 1996 to 2005. *Source* WWF 2012

the number of months in which water scarcity reached 100% from 1996 to 2005 in more than 400 river basins around the world (Fig. 1.2) (WWF 2012). Thus, there is an urgent need for a sustainable solution to achieve water security based on local considerations. The Southern USA, the Western coast of South America, most of South–Eastern Australia, North–Western India, Pakistan and other nearby regions are already facing the highest degree of water scarcity; therefore, localized sustainable solutions to reduce water stress are needed immediately.

One important dimension of effective sustainable water solutions is dealing with societies that have persistent water inequalities, the growing development divide and the competition for scarce resources. The inhabitants of many developed nations, as well as high-income regions and cities, enjoy the delivery of several hundred liters of water per day at a very low price, but in other parts of the world, poor households in both rural and urban areas do not have an adequate supply of safe drinking water (UNICEF and WHO 2011). Similarly, within the agricultural and industrial sectors, small famers have the least access to water in wealthy areas. Jenson (2016) recommended solving these water issues through the development of equitable water policies, investment in water infrastructure, public–private partnerships and institutional approaches (Jenson 2016), and the concept of strong and adaptive water governance was effectively explored by Huitema et al. (2009), who defined adaptive water management comprising four institutional prescriptions. To manage water resources, there is first a strong need for a collaborative governance system along with a high level of public participation in decision-making. The authors recommended an experimental approach toward water-related resource management and highly emphasized water management at the regional scale, but they also raised concerns about the complexities associated with collaboration and participation in the management of water resources, the problem of real-world experimentation and the inadequacy of governance structure at the regional level (Huitema et al. 2009; Lankford et al. 2013).

UN report on global water quality perspective based on changes in the nitrate concentrations at various river mouths during 1990–1999 and 2000–2007 is shown

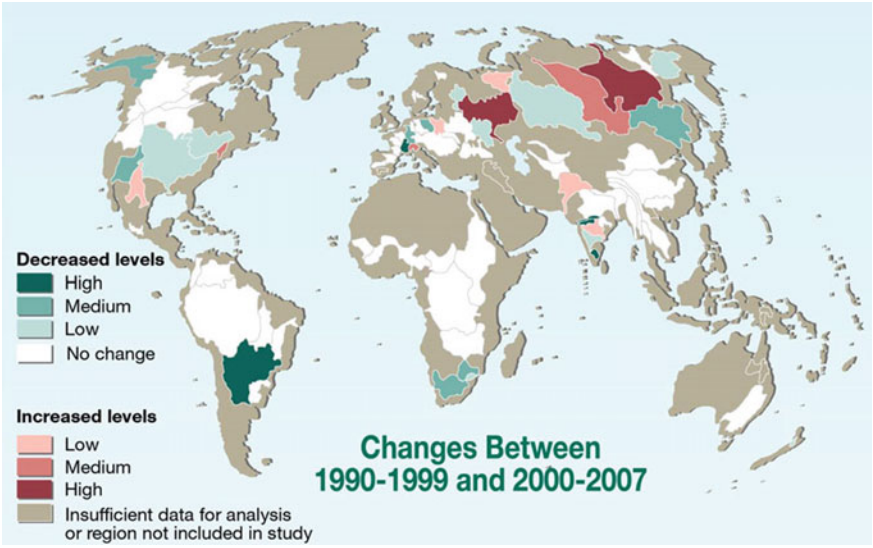

Fig. 1.3 Water quality issues around the world: nitrate concentrations at the mouths of rivers. Adapted from the United Nations Environment Program (UNEP); The Water Program 2008, and the National Water Research Institute, Environment Canada, Ontario 2008. *Source* United Nations Environment Program (UNEP) (2016)

in Fig. 1.3. Here, the results raise concerns over another dimension of water security, which is related to water quality or water pollution and the complexities of designing sustainable solutions to deal with stormwater, wastewater, water quality and the pollution of freshwater (Gleick and Ajami 2014).

Most of the wastewater and stormwater generated in cities are discharged with 85–90% of its full load of pollutants and toxic compounds (Henze et al. 2001), and high concentration of contaminants/pollutants here is primarily responsible for degrading the quality of both surface and groundwater resources as well as the associated coastal regions (Winter et al. 1998). Furthermore, water pollution affects the economic future of communities and puts human well-being at risk. Therefore, a new water security paradigm must consider treated wastewater as a resource rather than a form of waste (Asano 2002).

It is widely acknowledged that holistic approaches to address water security challenges are needed that include social, economic and environmental dimensions at multiple scales (WSSD 2002). This chapter explores a range of water security dimensions while capturing the dynamic and constantly evolving paradigms related to the subject, and it offers a holistic outlook for addressing water challenges by recommending a portfolio of sustainable solutions to geographically distributed water security challenges. The premises of this study are based on the analysis of case studies from different geographical regions, and it is argued that water security is directly related to the growth of a country's gross domestic product (GDP) or in other words, its economy. Thus, water management and economic growth are strongly related.