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S. Suriyanarayanan · H. P. Shivaraju · David Jenkins  
Editors

# Water Management in Developing Countries and Sustainable Development

 Springer

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# Foreword

According to the World Water Report 2023, approximately 26% of the world's total population does not have access to safe drinking water, and 46% lack access to safely managed sanitation. While water constitutes 70% of earth's matter; only 2.5% of it is freshwater and barely 1% of that is accessible to the masses. Population explosion and rapid urbanization have led to an increasing demand of this vital resource, while its recycle rate remains fairly constant. Many major cities across the world are on the verge of losing their freshwater reserves and might be running completely dry in the future decades.

Water crises have enormous global financial implications, including decreased agricultural productivity, increased health costs, and economic losses due to water-related disasters. The “UN Agenda—2030” recognizes the necessity of water resources in sustainable development and the vital role that safe drinking water; sanitation and hygiene play in progress to health, education, and poverty eradication. Hence, it is evident that sustainable management of water resources and access to safe water and sanitation are essential for unlocking economic growth and productivity especially in the Global South, and provide significant leverage for existing investments in health and education.

To avoid water crisis and to ensure the availability of freshwater for future generations; there is a need to reform the existing policies regarding water conservation and also to implement them effectively. Such policy reformulation should consider all the sectors consuming water such as agriculture, industries, and other domestic uses. We must acknowledge the fact that the water we have today can only be recycled and therefore, there is an urgent need to take appropriate measures, to conserve water and avoid its overuse or wastage. It is estimated that at current rates, progress toward achieving all the targets of the Sixth Sustainable Development Goal (SDG 6): “*access to clean water and sanitation for all,*” is off-track and the rate of implementation needs to be quadrupled, or even more. Therefore, cooperation of governments, corporations, civil society, and other stakeholders is required to promote water resource management and subsequently achieve the water-related Sustainable Development Goals (SDGs).

We must further realize that in this “Anthropocene Epoch,” we are the only species possessing the capacity to reflect on our behavior and change that is required to secure our health, economic, and social well-being. It is clearly understood that providing healthy and meaningful livelihoods is a major challenge and therefore, all of us must act together and identify the technological, economic, political, and social measures that will set a significant step toward the achievement of a desirable and more sustainable future.

Under this backdrop, I believe that a book of this kind brought out by the NAM S&T Centre will serve as a valuable source of knowledge, insight, and innovative solutions for water management. Chapters written by a diverse group of specialists from different parts of the world, take us on a journey through the intricate subject of water management, demonstrating various issues and optimal solutions that are within our capabilities. The authors have not only analyzed the problems but have also offered pragmatic solutions through looking into the fundamentals of water sustainability, highlighting the contemporary issues of water pollution, guiding us through novel approaches and infrastructure and lastly providing the best practical applications and prospective future directions toward combating water scarcity and establishing a sustainable water secure future.

I strongly believe that this work toward water conservation would show a guiding path for the water management sector and will lead to the adoption of several innovative and salient strategies and techniques in eliminating water crises, and that the information provided in the book will help the academicians, decision and policy-makers, practitioners, and concerned citizens to collaborate and strive for a more equitable and sustainable future for all in regard to water security.

I wholeheartedly congratulate the efforts put in by the NAM S&T Centre, the editors, and the authors for their commitment in bringing out such a book of utmost global importance which will enable the stakeholders and others engaged in water management sector to share their ideas and practices with a view to attaining water security across the globe.



Dr. Satish R. Wate  
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# Preface

Proper access to freshwater is essential for sustaining human health, prosperity and security, poverty eradication, and preservation of ecosystems. Yet, billions of people worldwide are confronted with serious freshwater challenges, arising from water scarcity, poor water quality, lack of sanitation facilities—leading to severe water-borne diseases and water-related disasters. Population growth, increasing living standards, changing trade policies, and adverse climate disruption have resulted in an increasing demand for freshwater. Estimates show that with current practices, by 2030, the world will face a 40% shortfall between forecast demand and available supply of water and as much as two-thirds of the world’s population could be living in countries subject to water stress, a majority of them being in the developing countries.

While the countries are working very hard together toward the achievement of water-related goals of the “United Nations’ 2030 Agenda for Sustainable Development,” especially Goal 6: Access to Water and Sanitation for All; the trends and present status of access to water and sanitation remains a cause for global concern. According to the SDG Report 2022, approximately two billion individuals globally lack adequate access to safe drinking water, while around half of the world’s population is currently facing significant water scarcity. Further, in the developing world, more than 90% of sewage water is discharged directly into rivers, lakes and coastal waters without any treatment. Degraded water quality is also decreasing the amount of safe water; hence proving a clear linkage between water quantity and water quality. Therefore, there is an urgent need to minimize the water consumption and develop approaches to effectively manage and sustainably use the existing water resources to satisfy social, economic, and environmental needs.

To strengthen water security against this backdrop of increasing water demand, water scarcity, growing uncertainties, greater extremes, and fragmentation challenges; we need to invest in strengthening of institutional infrastructure, clear assessment of the freshwater resources, application of integrated water resources management, common and shared interest among the stakeholders and their effective participation, comprehensiveness and global coverage of all forms of freshwater, information management as well as infrastructure development. Ensuring the rapid

dissemination and appropriate adaptation or application of these advances will be a key toward strengthening global water security.

The book, through its 24 chapters contributed from 14 countries namely, Cameroon, China, Cyprus, India, Indonesia, Italy, Namibia, the Netherlands, Norway, Portugal, South Africa, UK, USA, and Zimbabwe, intends to provide sustainable water resource management strategies that present innovative ways to conserve both quality and quantity of water in developing countries. The issues addressed through these approaches are sustainable water management which means using water resources in a way that meets current, ecological, social, and economic needs without compromising the ability to meet those needs in the future, reducing wastewater contamination, enhancing and restoring water quality and quantity, and management of environmental flows.

The concept of developing such a book was put forward considering the alarming cases of water crises that are being witnessed by several developing countries and therefore, providing sustainable water management solutions that could aid in promoting water security across the globe. The contents of this book will be of great interest to scientists and researchers, practitioners, water resource managers, environmentalists, policy and decision-makers, international institutions, governmental and non-governmental organizations, educators, as well as students.

We would like to appreciate the sincere efforts of all the authors who have kindly accepted our invitation to write the chapters, revise the contents based on reviewers' comments and submit the final version well in time in spite of their busy schedule.

The Editors are thankful to Dr. Amitava Bandopadhyay, Director General; Mr. Madhusudan Bandyopadhyay, Senior Adviser; and Ms. Abhirami Ramdas, Research Associate, NAM S&T Centre and other staff members at the Centre for all the technical and administrative support rendered toward the publication of this book.

We are grateful to Dr. Satish R. Wate, Former Director, CSIR-National Environmental Engineering Research Institute (NEERI), Nagpur and Former Chairman, Recruitment and Assessment Board (RAB), Council of Scientific and Industrial Research (CSIR), New Delhi, India for writing the "Foreword" of this book in spite of his extremely busy schedule. We also express our gratitude to Dr. Loyola D'Silva, Executive Editor, Springer Nature, Singapore and his team for making this endeavor a success.

Mysuru, Karnataka, India  
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Plymouth, UK

S. Suriyanarayanan, Ph.D.  
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David Jenkins, Ph.D.



# Introduction

According to the UNESCO report presented during the United Nations 2023 Water Conference in New York, 26% of the global population lacks safe drinking water, while 46% do not have access to well-managed sanitation facilities. Freshwater is a limited resource, making water management a very important factor for societal survival and functioning. Water scarcity is becoming a major global challenge due to rapid population growth, urbanization and increasing pressure from agriculture, industry, and energy sectors. The changes in landscapes, adverse effects of climate change, growth in food and energy production, mass migration of people to urban centers and severe competition for water by the municipal, agricultural, industrial, and energy sectors are altering the quantity and quality of the freshwater resources on which we solely depend to survive, both physically and economically. To face the looming water crises, we need to tackle the strategic policy and management issues as an integrated part of the solution toward accomplishing water sustainability.

Ever since COVID-19 pandemic started, it is clear that safely managed drinking water, proper sanitation, and hygiene issues are vital to sustain human health. Decades of misuse, poor management and, over-extraction and contamination of freshwater and groundwater supplies have exacerbated water stress and deteriorated aquatic ecosystems. Therefore, there is an urgent need to establish strong national and international mechanisms in order to prevent severe consequences of the existing global water crises and to ensure sustainable and equitable distribution of water to all.

Gaps in access to water supply and sanitation, growing population, water-intensive patterns of growth, increasing rainfall variability, and pollution are making water as one of the greatest risks to economic progress, poverty eradication, and sustainable development. Achieving the UN Sustainable Development Goals (SDGs) for water, especially Goal 6—“Access to Water and Sanitation for All,” requires an integrated approach by the stakeholders and policymakers to manage and allocate water resources.

In order to address the above issues, the Centre for Science and Technology of the Non-Aligned and Other Developing Countries (NAM S&T Centre), New Delhi is bringing out this publication for dissemination of knowledge and information to

the scientists, researchers, managers, policymakers and other stakeholders engaged in the “Sustainable Water Management” sector.

The book through its twenty-four chapters underscores the concept and principles of sustainable water resources management, recent advances in water treatment and management, case studies and directions for future research and development, and policymaking for sustainable water resources management and highlights the best management practices for water resource allocation, groundwater protection and water quality assurance for the Global South. The book intends to provide information on sustainable water resource planning and governance, water infrastructure planning and implementation, optimum regulations to conserve both quality and quantity of water in developing countries.

The book brings together the scientific communities from 14 countries namely, Cameroon, China, Cyprus, India, Indonesia, Italy, Namibia, the Netherlands, Norway, Portugal, South Africa, UK, USA, and Zimbabwe to share their knowledge and expertise on various water management practices and technologies needed to meet water requirements while maintaining and restoring the ecosystems that provide us with life sustaining services, so that the utilization of water resources are planned and protected for the present and future.

I am immensely grateful to Dr. Satish R. Wate, Former Director, CSIR-National Environmental Engineering Research Institute (NEERI), Nagpur and Former Chairman, Recruitment and Assessment Board (RAB), Council of Scientific and Industrial Research (CSIR), New Delhi, India for kindly agreeing to our request to write the Foreword of this book in spite of his very busy schedule.

I am thankful to Dr. Loyola D’Silva, Executive Editor, Springer Nature, Singapore for his kind support and guidance toward bringing out this book and Ms. Shalini Monica C. Selvam, Project Coordinator, Springer Nature, India for managing all the technical and administrative tasks for the publication process.

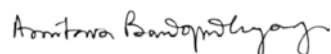
I would like to express my sincere gratitude to the Editors of this book, Dr. S. Suriyanarayanan, Associate Dean (Research), JSS Science and Technology University, Mysuru, Karnataka, India; Dr. Shivaraju H. P., Associate Professor, Department of Environmental Sciences, Faculty of Life Sciences, JSS Academy of Higher Education and Research (JSS AHER), Mysuru, Karnataka, India; and Dr. David Jenkins, Associate Professor, Nanomaterials and Devices, School of Engineering, Computing and Mathematics, Faculty of Science and Engineering, University of Plymouth, UK, for their initiatives and efforts and sparing their valuable time in reviewing the papers for this book and taking charge of this publication project.

We express our gratitude to Prof. B. Suresh, Pro-Chancellor, JSS Academy of Higher Education and Research (JSS AHER), Mysuru and Dr. Surinder Singh, Vice-Chancellor, JSS AHER, Mysuru for their encouragement and kind support in bringing out this publication. We are also thankful to Dr. Vishal Kumar Gupta, Dean (Academics), JSS AHER, Mysuru for his cooperation and support in this publication project.

I also acknowledge the valuable support of the entire team at the NAM S&T Centre and am especially thankful to Mr. Madhusudan Bandyopadhyay, Senior Adviser for his support and guidance, and Ms. Abhirami Ramdas, Research Associate for her contributions in taking this publication project forward.

I also record my appreciation for the assistance and support rendered by my colleagues Mr. Rahul Kumra, Assistant Administrative Officer and Mr. Pankaj Buttan, Data Processing Manager, NAM S&T Centre toward bringing out this book.

I believe that this book would serve as a valuable resource and reference material for water resource managers, scientists and researchers from various R&D institutions, hydrologists, ecologists, environmentalists, administrators, professionals from the water industry, government officials, policymakers, students, and people in general concerned with water resources management to make decisions to allocate water resources and to develop innovative and cost-effective measures and approaches to achieve sustainable water management.



Amitava Bandopadhyay, Ph.D.  
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