CONFRONTING WATER INSECURITY

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CONFRONTING WATER INSECURITY

Global Institutions and the Transformation of Water Science, Policy, and Practice

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Preface

I have been motivated to write this book for four reasons.

The first is that I know from direct experience the impacts that water insecurity has on the lives and livelihoods of the world's most vulnerable people, and I am concerned about the future of the water resources on which life on this planet depends. Water is a limited and finite resource, and there are significant issues of equity: 3.6 billion people lack safely managed sanitation, and 2 billion do not have access to safe drinking water. Water for irrigated agriculture is a major contributor to global food security and rural livelihoods, yet this can threaten the sustainable use of water for other purposes because it consumes or pollutes substantial amounts of water. And floods and droughts can have devastating impacts on national economies and human lives and livelihoods, especially in the poorest countries.

Second, this book offers something new and different that adds value to the outstanding books on water issues published in recent years. It focuses strongly on multilateral cooperation and global institutions and their work to confront water insecurity. It provides an account of what global institutions and cooperation did over the eighty years from 1945 to 2024 to advance science, policy, and practice for global water security, including successes and failures. And it offers insights into how and why the ideas and global institutions that are part of today's landscape came about—and what the future might look like.

Third, this book is timely, coming at a moment when global thinking and action to address global threats are more necessary than ever but increasingly misunderstood and distrusted—and when the value of multilateral cooperation itself is increasingly questioned. I hope this book will help build understanding

of the vital role of multilateral cooperation and global institutions in addressing shared global challenges that all the world's countries must confront.

And fourth, I have been moved to write this volume because I have been fortunate to have had direct experience with global institutions working on water issues and know for myself the roles of global institutions and multilateral cooperation in water science, policy, and practice. I believe this experience enables me not only to write about the events in question but also to offer perspectives on where global institutions have succeeded and failed and how they may do a better job in the future.

For all these reasons, I am enthusiastic about this book. The book has given me the opportunity to bring together past, present, and future into a coherent whole; to identify patterns and relationships that I had not previously recognized; to bridge the worlds of science, policy, and practice that so often follow separate tracks; and to connect water security to the broader challenges that must be faced in the twenty-first century. And writing this book has been particularly meaningful to me because the story of transformation it describes toward a more systemic visualization of water as an issue of global concern mirrors, in many ways, my personal trajectory.

I hope that this book will speak to the global community of scientists, policy makers, and practicing water managers who are currently tackling global water insecurity and whose work has largely gone unheralded; it is their story, after all. At the same time, I hope it will be meaningful to students and young professionals seeking to advance global water security, as a record of what has gone before and a pointer toward all that remains undone. I hope too that the account will be of wider interest to readers concerned about global environment and development issues and how human society can better address current and future global challenges that arise from humanity's complex relationships with the natural world.

Acknowledgments

This book would not have been possible without the contributions, assistance, and support of many people and institutions around the world.

In writing this book, I relied heavily on my own direct experience with global institutions and that of the many scientists, policy makers, and practitioners with whom I have interacted over several decades. I am grateful to all these colleagues for teaching me about water insecurity and sharing with me what they were doing to combat it.

Among these colleagues, I am especially grateful to David Major, my teacher, mentor, associate, and friend since the early 1970s, who played a vital role in getting me started in the world of international institutions and global water. David strongly encouraged me to write this book and, once I had started writing, shared valuable notes and made numerous very helpful suggestions from the proposal stage through to completion.

I wrote the proposal and first draft of this book from 2020 to 2023, when I was serving as chair of the Board of Governors of the International Water Management Institute (IWMI). I am grateful for the wisdom and insights of the exceptional board members with whom I worked during this period. I am especially grateful to Mark Smith, IWMI's director general during this time, for our many conversations on water science, policy, and institutions that helped stimulate and enrich the narrative. And in 2024, after I had completed my term as board chair, Mark read the entire initial draft manuscript and provided detailed comments on the text and excellent suggestions on how best to structure the narrative and conclusions.

As a nonhistorian writing about the history of water science and policy, I needed help from a knowledgeable historian of science and technology. I found

that help in Helen Curry, who read the initial draft manuscript in its entirety, wrote a comprehensive critique, made helpful suggestions for strengthening my analyses and arguments, and brought articles and books to my attention that proved exceptionally valuable.

Jacques Rey, who has firsthand experience with many of the institutions and events described in the book, read the entire draft manuscript and shared thoughtful reflections and observations. These have helped me to improve the structure of the book, highlight some underlying aspects of the story that I had not fully recognized, and strengthen the book's arguments.

Julia Marton-Lefevre also reviewed the entire initial draft manuscript and provided valuable feedback. In addition, the many stimulating discussions on the relationship between science and policy in international institutions that took place during the meetings of the International Science Council Steering Group, which Julia established in 2021 to advise the council on its strategy in the intergovernmental system, helped me to develop the overall storyline of the book and its conclusions.

Alan AtKisson, Maggie Catley-Carlson, and the late Bill Cosgrove all reviewed the initial draft manuscript and provided valuable feedback. Leanne Burney offered important perspectives on the work of UN-Water and the UN Secretary General's Advisory Board on Water and Sanitation. Kristen Lewis and Molly Nance gave me excellent advice and comments on the original draft proposal, and Kristen also critically reviewed one of the book's chapters. Josh Newton shared his 2014 PhD thesis, whose chapter on the history of global water governance was especially useful. Letitia Obeng provided helpful perspectives on the work of the World Bank in water and sanitation. Pat Rosenfield provided unique inside knowledge of the 1977 UN Water Conference and the International Water Decade. And Pat Wouters generously lent her expertise in international water law to strengthen the text on transboundary waters.

This book in some ways is an outgrowth of two talks I gave some years back: a 2017 colloquium on "Tackling Global Water Challenges" at the University of Nebraska–Lincoln (UNL), in which I discussed the major water challenges facing the world over the last several decades and my experience in helping to start global water institutions to tackle them; and a 2018 presentation to the IWMI Board on IWMI's creation and subsequent evolution. Both these talks brought home to me that there was a larger arc of history whose story needed to be told—one that spanned not just one global institution but rather

all global institutions and their collective roles in transforming water science, policy, and practice since their creation. I am grateful to David Jones, then head of the Biological Systems Engineering Department at the University of Nebraska–Lincoln, and Claudia Sadoff, then IWMI director general, for inviting me to give these talks.

In writing this book I was fortunate to be able to draw on numerous outstanding books, reports, and articles on aspects of the account, which are listed in the bibliography. In this regard, I benefited greatly from the historical documents available in the UN Digital Library System, the IRC Resources Library, and the International Water Law Project.

My career experiences provided much firsthand knowledge that helped inform the book's narrative. In writing chapters 2 and 4, I benefited from my work from 1970 to 1977 in integrated river basin development and water planning as a staff member with Argentina's Secretariat for Water Resources, as a visiting research engineer at MIT, and as a member of the MIT faculty. I also drew on my work on irrigation management as a program officer with the Ford Foundation in New Delhi and New York from 1977 to 1986 and as director general of IWMI (then called the International Irrigation Management Institute) from 1987 to 1994.

In writing chapters 5 and 6, I drew on my experience from 1995 to 2001 as director of UNDP's Sustainable Energy and Environment Division in New York and my work in that role to coordinate UNDP's global activities in freshwater management and to join with the World Bank and the Swedish International Development Agency to establish and help support the Global Water Partnership (GWP). For the sections on accountability of global institutions in chapter 6, I drew on my later roles as member and chair of the Inspection Panel of the World Bank from 2007 to 2012.

In writing chapter 8, I drew on my experience in the 2000s at the Earth Institute at Columbia University, when I also served as cochair of the UN Millennium Project Task Force on Water and Sanitation, chair of the GWP Technical Committee, and chair of the Water Supply and Sanitation Collaborative Council (WSSCC). And in writing chapter 9, I drew on my roles from 2012 to 2017 as founding executive director of the Daugherty Water for Food Global Institute at the University of Nebraska and as member and chair of the IWMI Board from 2018 to 2023. All these roles enabled me to work closely with exceptionally knowledgeable colleagues who helped shape the ideas and initiatives discussed in this book.

While researching and drafting this book, I was ably supported by the University of Nebraska. I am grateful to UNL for computer support and digital access to libraries across the world, which made it possible for me to retrieve needed materials. The University of Nebraska Press provided outstanding backing for this project from the proposal stage through to final publication. Bridget Barry, editor in chief of the University of Nebraska Press, was especially helpful, responding promptly and positively to my initial book proposal in 2021 and thereafter swiftly answering all my queries and providing thoughtful feedback and advice on the draft chapters as I completed them. I also greatly appreciated the outstanding support provided by Kayla Moslander, UNP associate project editor and project editor for the book, and by Joseph Webb, who did a superb job as copyeditor for the manuscript. Grateful thanks are also due to Emily Casillas, acquisitions editor; Erika Rippeteau, grants and development coordinator; Leif Milliken, rights and permissions coordinator; Lacey Losh, designer; Terry Boldan, production coordinator; Tish Fobben, direct mail manager; and Sarah Kee, publicist. I am grateful too for the careful UNP-commissioned reviews of the original book proposal in 2021 and the complete draft manuscript in 2024. And I must acknowledge with thanks the financial support received from the University's Robert B. Daugherty Water for Food Global Institute for the preparation of the book's index (ably carried out by Amron Lehte) and the strong encouragement and helpful feedback I received from the institute's executive director, Peter McCornick.

My most special thanks go to my wife Julia and our children Alexandra, James, Christopher, and Jessica, who have been my companions throughout my voyage in the world of global water that has resulted in this book. Julia has been by my side throughout my professional life, from my first appointment at the Water Resources Secretariat in Argentina in 1970 to the present day, and provided loving support and understanding over the entire period I was writing this book. James and Jessica encouraged and inspired me throughout the writing process, as did Alexandra and Christopher, who also volunteered to review the initial draft proposal and manuscript and provided valuable comments. I dedicate this book to Julia and to our children and their wonderful families, with all my love and gratitude.

Abbreviations

In providing a broad account of the role of global institutions in transforming water science, policy, and practice, this book includes many necessary institutional and other acronyms. This list of abbreviations is therefore provided for the convenience of readers. Spelling follows that used in official institutional documents.

ACC	Administrative Committee on Coordination of the United Nations
ADB	Asian Development Bank
AfDB	African Development Bank
AGWA	Alliance for Global Water Adaptation
BCE	Before Common Era
BGS	British Geological Survey
BMZ	Federal Ministry for Economic Cooperation and Development, Germany
CBD	United Nations Convention on Biological Diversity
CE	Common Era
CEO	Chief Executive Officer
CFS	Committee on Food Security
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CLTS	Community-Led Total Sanitation
COP	Conference of the Parties
CPWC	Co-operative Programme on Water and Climate
CSD	Commission on Sustainable Development of the United Nations
CWIS	Citywide Inclusive Sanitation

ECA	Economic Commission for Africa of the United Nations
ECLAC	Economic Commission for Latin America and the Caribbean of the United Nations
ECOSOC	Economic and Social Council of the United Nations
ECWA	Economic Commission for Western Asia of the United Nations
ESCAP	Economic and Social Commission for Asia and the Pacific of the United Nations
FAO	Food and Agriculture Organization of the United Nations
GA	General Assembly of the United Nations
GEF	Global Environment Facility
GLAAS	Global Analysis and Assessment of Sanitation and Drinking-Water
GNP	Gross National Product
GPS	Global Positioning System
GWP	Global Water Partnership
HLPE	High-Level Panel of Experts on Food Security and Nutrition of the CFS
IAHS	International Association of Hydrological Sciences
ICID	International Commission on Irrigation and Drainage
IDA	International Development Association of the World Bank Group
IDB	Inter-American Development Bank
IDRC	International Development Research Centre
IDS Sussex	Institute of Development Studies of the University of Sussex
IFAD	International Fund for Agricultural Development
IFI	International Financial Institution
IHD	International Hydrological Decade
IHP	International Hydrological Programme of UNESCO
IIMI	International Irrigation Management Institute
ILA	International Law Association
ILC	International Law Commission
IMF	International Monetary Fund
IMO	International Meteorological Organization
IPCC	Intergovernmental Panel on Climate Change
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IRRI	International Rice Research Institute
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
IWRA	International Water Resources Association
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme for Water and Sanitation
MDG	Millennium Development Goal
MEA	Millennium Ecosystem Assessment
MHM	Menstrual Hygiene Management
MIT	Massachusetts Institute of Technology
NGO	Nongovernmental organization
NWC	National Water Council, UK
OECD	Organisation for Economic Cooperation and Development
Rio+20	UN Conference on Sustainable Development (twenty years after Rio Earth Summit)
SDG	Sustainable Development Goal
SDG 6	SDG on water and sanitation
SIDA	Swedish International Development Agency
SIWI	Stockholm International Water Institute
SOAS	School of Oriental and African Studies of the University of London
SOES	School of Environmental Studies of Jadavpur University
SWA	Sanitation and Water for All
SWOT	Surface Water and Ocean Topography (satellite)
TAC	Technical Advisory Committee of the CGIAR
TNC	The Nature Conservancy
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UN-DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization

UNL	University of Nebraska-Lincoln
UNSGAB	United Nations Secretary-General's Advisory Board on Water and Sanitation
UNWC	United Nations Watercourses Convention
USAID	United States Agency for International Development
VERC	Village Education Resource Centre of Bangladesh
VIP	Ventilated Improved Pit Latrine
WASH	Water, sanitation and hygiene
WHO	World Health Organization
WIN	Water Integrity Network
WMO	World Meteorological Organization
WSSCC	Water Supply and Sanitation Collaborative Council
WWC	World Water Council
WWF	World Wildlife Fund

CONFRONTING WATER INSECURITY

Introduction

Transformational Change in the Quest for Water Security

Securing water to meet human needs and cope with extreme water events has been a driving force for humanity throughout the ages. From the earliest times, human societies have recognized that water was a force both life-giving and destructive. They have faced up to the fact that the water that was vital to their lives varied significantly not only from one location to another but also from season to season and from year to year. At times, water could be scarce, while at others it could be devastatingly overabundant, wiping away human lives and sources of sustenance.

This dual requirement to obtain sufficient supplies of water to meet needs and control water's destructive power is a consistent theme in the history of the relationship between water and society—a quest for what is now commonly referred to as *water security*. The notion behind the term is not unlike that embodied in the terms *food security* and *energy security*. Like food and energy security, water security is vital for achieving a broad range of societal goals at household, community, state, province, national, and global levels. The notion of water security, however, differs from that of food or energy security in the extent to which water security requires managing the destructive as well as the life-giving powers of water. To encompass both aspects, water specialists today generally define the notion in ways that recognize both water's opportunities and its threats.[1]

Water security must reflect a society's water needs and uses, which vary from place to place and have evolved significantly over time. Water has always played a critical role as the lifeblood of the natural environment and is thus fundamental to all life on earth. But as societies have become more complex, the nature and extent of their multiple requirements for water have grown in variety and intensity. Water for human consumption and hygiene

was the first and most basic requirement, and using water to irrigate crops also became important as a primary means of securing and stabilizing food supplies once societies became sedentary. Rivers, canals, and lakes became principal means of transporting goods and people efficiently and economically. Water became essential for such purposes as safely disposing of human excreta through appropriate sanitation systems, extracting valuable minerals and other geological materials, producing energy, cooling and disposing of wastes in industrial processes, and maintaining urban gardens, fountains, and public baths. Today, water plays a vital role in virtually every facet of society, and water security is a prerequisite for the achievement of most societal goals, including conserving biodiversity and mitigating and adapting to climate change, reducing poverty and improving health conditions, and ensuring food and energy security.[2] Water insecurity, by contrast, can have a devastating effect on human development and the environment through its impacts not only on the use of water for domestic purposes and agricultural production but also on human health, ecosystems and biodiversity, and economic growth.

Water has thus come to play multiple roles in human societies. Water is an environmental good, an essential component of the natural environment on which all life depends. It is a social good, vital to the health and well-being of each member of society. It is an economic good, crucial to a society's productive capacity. And water is a cultural good, deeply embedded in religious and spiritual beliefs that value water as intrinsic to life.[3]

A society's water security is affected by its natural hydrologic environment, which is changing over time. It is determined in some measure by whether its water resources are plentiful or scarce and reasonably constant or highly variable. But a society's water security is also determined by the actions it takes in response to its water environment. Such actions encompass both the *management* of water—to buffer the destructive power of water, cope with its variability, ensure that water is available where and when it is needed, and safeguard sustainability—and the *use* of water to meet needs.

Evolution of Water Infrastructure and Institutions

Historically, societal actions to ensure water security have revolved around two types of instruments: infrastructure and institutions. This coupling of infrastructure and institutions has been a constant throughout history, with

investments in infrastructure and technology associated with institutions, policies, and management systems for water allocation, distribution, and conservation.

Water Technology and Infrastructure

Human societies have built infrastructure to manage and use water ever since becoming sedentary. There are many wondrous tales of ancient civilizations and their astounding feats of engineering.[4] Indeed, the ability to harness water for productive use, control flood waters, and cope with droughts became the hallmark of the most successful early civilizations. In ancient Mesopotamia and the Nile, Indus, and Yangtze Rivers, for example, canals, embankments, dikes, reservoirs, and drainage canals were built to manage the highs and lows of river flows for irrigation and to ensure water supply, drainage, and wastewater management in urban areas.[5]

Some of the infrastructure investments by early civilizations aimed at coping with droughts and floods, especially in climatic conditions characterized by long dry periods and short wet seasons. The Nabateans, for example, who inhabited northern Arabia and the southern Levant and emerged as a distinct civilization between 400 and 100 BCE, built catchment systems to capture runoff and large underground cisterns to store rainwater during the wet winter months and avoid evaporation losses during the hot and dry summer months.[6] And in the Maya civilization, which developed in lowland Mesoamerica between 400 BCE and 900 CE in an area where rainfall could be intense, the focus was largely on managing the effects of extreme rainfall events—floods, hurricanes, erosion, landslides, and mudslides.[7]

The technologies and infrastructure for water management and use in ancient societies evolved considerably over time, aided by technological innovation. In what is now West Asia and North Africa, much of this innovation revolved around technologies for moving or lifting water.[8] In more recent times, the Industrial Revolution helped spur innovation in technology for water use and management; for example, the development of powerful systems to lift and move water made it possible to pump substantial amounts of water from the ground, and new earthmoving and other machinery made the development of infrastructure for water control more available, all of which multiplied human capacity to manage floods and droughts and to access and distribute water for human use.[9] The Industrial Revolution also enabled the use of water to

generate power; a key innovation was the hydroelectric turbine, which started with the development of a small turbine in France in the late 1820s and over time led to the building of large hydroelectric dams and thus a new type of water-powered industrialization.[10] The nineteenth century also brought about important innovations in water supply and treatment as well as in sewerage in Europe, North America, and Japan.[11]

Water Institutions and Management Systems

Like infrastructure and technology, institutions and management systems for the allocation, distribution, and use of water, including policies and governance arrangements, also evolved. From their inception, ancient civilizations needed to put in place social institutions to organize labor-intensive infrastructural development—sometimes involving slavery—and to manage, operate, and maintain these systems once built. As vividly described by Giulio Boccaletti in *Water: A Biography*, these social institutions were generally tailored to societal needs and the hydrologic environment.[12] In Ancient Egypt, whose wealth derived from the abundant water supplies in the Nile, the river was managed as a system, with irrigation and flood control infrastructure complemented by centralized grain storage systems and grain distribution via river transportation. In water-scarce areas such as the Southern Levant, an adaptive focus was on trade with water-abundant regions, which required social systems that fostered cooperation and collaboration.

Institutions and management systems have historically also been important for irrigation systems. Examples of institutional mechanisms for the management of irrigation, developed centuries ago but still functioning today, abound. One is the Subak water management system in Bali, Indonesia, originated in the ninth century CE, in which over one thousand farmer associations called Subaks, each consisting of between fifty and four hundred rice farmers, collectively share responsibilities for maintaining a communal irrigation system and controlling and distributing its waters.[13] Another is the Water Tribunal of the Plain of Valencia in Spain, which was created to settle disputes among farmers on the distribution of irrigation water and may have originated as far back as the tenth century CE.[14]

The Role of Climate

Historically, climate has played a significant role in shaping infrastructure and institutions for water security. Finding ways to cope with natural climate variability has been a central part of efforts to achieve water security throughout the ages. Most ancient civilizations evolved in tropical and subtropical areas with short wet seasons followed by long dry seasons and often faced severe droughts and floods, with acute impacts on their populations. Infrastructural and institutional systems developed by ancient civilizations consequently focused on ways to manage significant differences in water supply between wet and dry seasons and from year to year, often through water storage. By contrast, innovations in infrastructure and management systems during and after the Industrial Revolution were mostly developed in temperate regions with less variable hydrologic conditions.

Climatic events also appear to have helped induce social and technological innovation to adapt to new conditions, though sometimes they contributed to societal collapse.[15] But climate conditions were relatively stable over most recorded human history.[16] In the main, therefore, societies did not have to cope with long-term changes in river flows or rainfall patterns. Indeed, until recently hydrologists assumed that rainfall, streamflow, and other hydrologic variables were *stationary*, meaning that their statistical properties in the future would be like those of the past, which helped the planning and design of water systems.[17] Hydrologists also assumed that the global hydrological cycle—the complex process by which water in solid, liquid, and vapor forms moves within the Earth and atmosphere—was itself stable and not impacted by human activity.[18]

Further, throughout much of recorded human history, in most parts of the world overall requirements for water resources were generally low in relation to availability, and water could be used with few limits. This remained true even though water use began to increase significantly in some countries in the nineteenth century. By and large, although in most locations water was sometimes scarce, water replenishment from rainfall and other sources was greater than the amount of water extracted, and most societies were able to remain within their hydrologic means. They could therefore focus on using water to best advantage without raising concerns about long-term water scarcity or the sustainability of water use.[19]

As will be seen, in the years that followed, all this had to change.

New Challenges in a Globalized World

After World War II, a renewed spirit of international cooperation arose, and with it the creation of the United Nations and an emerging awareness of the need to address major global problems in a coordinated way. Though at the time water did not figure prominently in global discussions, its fundamental relevance to issues of global concern had never been greater. Water played vital roles in health, food and agriculture, industrial development, and other areas that were beginning to merit international attention.

At the same time, there were large disparities in water security between industrialized and developing countries. The Industrial Revolution enabled countries that could capitalize on economic and technological advances to take their quest for water security to another level, greatly improving their ability to manage and use water effectively for productive purposes. But this growth in water security in industrialized countries had perverse effects. With increasing water security, urban dwellers in industrialized countries became complacent about water. Water was something that came out of a tap and was in plentiful supply—and thus taken for granted. If one lived in a big city in a water-secure industrialized country, water was not thought about much. And although water was sometimes a subject of great local concern, it was rarely considered of global concern except when there were major water-related disasters.

But while industrialized countries enjoyed high levels of water security and did not consider water a priority, developing countries—especially those emerging from years of colonial rule during which the needs of local populations had been neglected—struggled to ensure that their people had even the most basic drinking water and sanitation services. Many could not ensure that small farmers had the means to access water to irrigate their crops, which could have changed their lives as well as increased domestic food production; whereas during the colonial period some colonial powers had invested in water infrastructure and institutions in their colonies, the focus had been largely on increasing export crop production.[20] Moreover, most newly independent countries were in the tropics and faced both floods and severe droughts, with acute impacts on their most vulnerable populations. And they had been left behind on the technological and institutional fronts, given that most advances in water security since the Industrial Revolution had been developed in regions with less variable hydrologic conditions. Developing countries had a

lot of catching up to do. But many had weak institutional capacities and little capital to invest in infrastructure.

As if this were not enough, three additional sets of challenges for global water security began to emerge in the second half of the twentieth century and the first quarter of the twenty-first.

One was that some countries and regions began reaching or exceeding their hydrologic limits, raising alarms about water scarcity and the sustainability of water resources. In the decades following the end of World War II, water consumption for an increasingly diverse set of purposes, including irrigation, started to expand significantly in many countries, driven largely by population growth, economic development, and rising incomes and aspirations. Water-use levels in a growing number of river basins began to reach their hydrological limits, which meant that additional water demands in one part of the basin could not be met without a corresponding reduction in water consumption elsewhere.[21] In an increasing number of locations, the amount of water consumed began to approach or exceed the amount replenished from rainfall and other sources.[22] Such societies, unable to live within their hydrologic means, could no longer focus only on the supply side of water; they needed to be equally concerned with the management of water demand. The sustainability of water resources and the need to reduce pressure on water resources began to receive more attention.

A second major challenge to water security that became increasingly evident in the latter part of the twentieth century and the beginning of the twenty-first was climate change. While human societies had long been concerned with managing natural climate variability, during this period it became increasingly clear that long-term changes in climate would translate into changes in rainfall and streamflow patterns that would affect both the supply of and the demand for water resources. Scientific evidence showed that the impacts of climate change would largely be felt through changes in water regimes, with more frequent and severe droughts and floods, more extreme rainfall events, changes in water flows and availability, and rising seas.[23] And increases in the frequency and severity of floods and droughts across the world brought home the impacts of climate change on extreme water events and made clear to citizens and businesses alike exactly why water insecurity represented a gigantic risk to society.

A third and closely related challenge to water security began to become apparent in the first quarter of the twenty-first century: human activities and practices, including changes in land and water use, were beginning to place the entire global hydrological cycle on an unsustainable course, with significant implications. And the long-held assumption that human activities in one location do not affect water security elsewhere unless linked by rivers or aquifers began to be questioned.

A Transformative Global Response

The water-related challenges that emerged after the middle of the twentieth century were unprecedented in nature and impact. Since the old approaches were not well suited to dealing with these new challenges amid an increasingly complex relationship between water and society, a different vision and approach was needed, one that demanded a more comprehensive and integrated set of attitudes and methodologies and encompassed a broader range of disciplines and societal objectives. The new approach needed the involvement of a far broader array of stakeholders. And it required the engagement of a broader set of institutions, in which new global institutions played important roles, supporting and complementing those traditionally played by national and subnational institutions.

The emergence of these global players began with the creation of the World Bank in 1944, the founding of the United Nations in 1945, and the subsequent establishment in the years that followed of various UN agencies and other international development institutions. Shortly after they were created, some of these organizations began providing scientific, technical, and financial assistance to advance water security in the developing world. While the nation state remained the key player, these global institutions began to play increasingly significant roles to support water security at national and subnational levels.[24]

Initially, much of the work of the new global institutions focused on the two most pressing water issues facing countries emerging from colonization: increasing the number of people with access to safe drinking water, sanitation, and hygiene services and improving access to irrigation by small farmers to increase food security and rural incomes and livelihoods. Over the following decades, the focus broadened to address wider concerns around water scarcity and sustainability, with the result that the use and management of water for

specific purposes became increasingly considered in the broader context of the management of water systems. In addition, as the reality of climate change became apparent, an increasing focus was on the links between water and climate change. Through it all, the global institutional architecture for water security evolved considerably.

Taken as a whole, the response to the new challenges represented a transformative change in the way in which water challenges were viewed, shifting from an exclusively national or subnational concern to one that recognized water security as both a local and global challenge, considered the global hydrological cycle as a global common good that must be conserved, and required a coordinated global approach based on international cooperation. Not coincidentally, this growing awareness of water as a global environment and development concern was accompanied by an increasing appreciation of other connected global threats that arise from society's relationship to the natural world, from climate change and the loss of biodiversity to the spread of infectious diseases.

At the same time, water management came to be viewed in a more comprehensive, multidisciplinary, multiobjective, and multistakeholder way. The new challenges that arose since the middle of the twentieth century were multifaceted and complex, requiring not only the recognition of water's global and local nature but also tradeoffs among objectives and stakeholders and consideration of a multitude of social, economic, and environmental issues. This broader vision brought changes in thinking and practice that led to increasingly systemic approaches to the use and management of water and the linking of water management with broader issues of societal concern, such as ecosystems management and climate change. And it helped spur efforts to address such contentious issues as those around large dams and the privatization of water-service delivery, which elicited strong emotions and sharply different views and required considering the views of many stakeholders, incorporating the perspectives of various disciplines, and balancing social, economic, and environmental objectives.

This move toward a more systemic visualization of water as an issue of global concern was guided by the increasing belief in the power of science and technology to advance understanding of water and its management and to help shape water policy and practice. Advances in science and in water policy and practice were in turn accelerated by breakthroughs in information systems

and technology, which made it possible to obtain, integrate, and process data from various sources and monitor and manage water systems in ways not possible before.

Finally, this shift in thinking and action on water security also nurtured—and was nurtured by—the emergence of a global movement around water, involving an ever-expanding ensemble of scientists, policy makers, and practitioners who began to meet frequently in global forums and networks. In turn, the vision and mindset of these individuals, in addition to global understanding of water security and its relationship to human and societal development, were also transformed. In the process, water became a more pressing issue for the public, for the media, and for governments, private companies, civil society organizations, and universities and research centers across the world.

Narrative Arc of This Book

This book tells the story of the role of multilateral cooperation and global institutions in the transformation of global water science, policy, and practice from 1945 to 2024. The transformation took place in three stages, described in parts 1, 2, and 3 of this book.

Part 1: International Development Stage

The first stage of transformation extended from the creation of the UN system in the mid-1940s to the early 1970s. In this first stage, the role of global institutions in science, policy, and practice for water security took place in the context of decolonization and the Cold War, with a focus on social and economic development—then a relatively new concept. This stage saw the building of an international institutional architecture for development, which included the UN and its specialized agencies, funds and programs; the incorporation of existing international institutions into the UN system; the founding of bilateral development agencies by industrialized countries; and the creation of regional institutions. (These developments are described in chapter 1.)

During the first stage, many of the new international institutions and their partners became actively engaged in water development, management, and use. Some concentrated on generating knowledge on the water resources needed for social and economic development, developing better methodologies for planning and designing water systems, and advancing integrated river basin

development. Others focused on improving access to safe drinking water, sanitation, and hygiene and developing and managing irrigation systems to improve food security and rural livelihoods (chapter 2).

Part 2: Sustainability Stage

The second stage of the transformation process extended from the early 1970s, when decolonization had been largely completed, to the end of the millennium. This stage saw a strong effort within the UN system to reconcile environment and development perspectives. During this stage, the first UN Conference on the Human Environment was held, the World Commission on Environment and Development was launched, and the Earth Summit was convened in Rio de Janeiro; at this summit, world leaders agreed on a new agenda for international action on environment and development and endorsed new global conventions on biodiversity, climate change, and desertification. (These developments are described in chapter 3.)

During this second stage, global efforts to improve water security began to address the sustainability of water resources in the face of rapid growth in water consumption and increasing water scarcity. However, during the initial fifteen years of this stage, global water science and policy remained largely within a development-oriented framework. During this initial period, the first ever UN Water Conference was held in Mar del Plata, Argentina, in 1977. This was followed by the 1981–90 International Water and Sanitation Decade and the launching of important initiatives for improving the management of irrigation systems (chapter 4).

Global water actions in the early 1990s were dominated by the Earth Summit and a preparatory conference on water and the environment held in Dublin, Ireland. The discussions on water at the Dublin conference and the Earth Summit, which yielded the *Dublin Statement and Conference Report* and a full chapter on water in the summit's main outcome document, *Agenda 21*, underscored the need for systemic approaches and were to mark a turning point in water science, policy, and practice (chapter 5).

The period from the Earth Summit to the end of the 1990s saw important shifts in water and sanitation policy and in water use for agriculture, which reflected new concerns around water scarcity and sustainability and the principles embedded in the *Dublin Statement* and *Agenda 21*. During this period, new debates around public and private roles in water and sanitation and the social

and environmental impacts of irrigation emerged. And new water-oriented global institutions were created that expanded the global institutional architecture for water (chapter 6).

Part 3: Global Goals Stage

In the third stage, covering the first quarter of the new millennium (2000–2024), global water efforts took place in the context of a changing world order, which swung from an initial strong consensus on the value of international cooperation to a severe weakening of such cooperation. At the UN Millennium Summit in 2000, world leaders agreed on the Millennium Development Goals (MDGs) to guide international action from the period 2000–2015, and at a special UN conference held in Rio de Janeiro on the twentieth anniversary of the 1992 Earth Summit, they agreed to move toward a set of Sustainable Development Goals (SDGs), formally approved in 2015, to guide action from 2015 to 2030. Subsequent years, however, saw increasing deterioration of international cooperation and significant setbacks in progress toward the SDGs. (These developments are described in chapter 7.)

During the first half of this stage, the role of global institutions in science, policy, and practice for water security evolved within the general framework of the MDGs. These years saw a strengthening of UN institutional arrangements for water security, new institutions entering the global water arena, a significant upswing in the priority accorded to sanitation and hygiene, new concepts and initiatives for water management for agriculture and beyond, new ideas on the integrated management of water resources, a strengthening of legal frameworks for transboundary water management, and significant advances in knowledge about the relationships between water and ecosystems and between water and climate change (chapter 8).

During the second half of this stage, attention shifted to the development of an SDG on water, and once this goal (SDG 6) was approved in 2015 along with all the other SDGs, science and policy for global water security shifted to reflect the targets and indicators embedded in this new goal. This period saw new ideas and initiatives on urban sanitation and on the links between water and food security; advances in knowledge on water scarcity, sustainability, and water productivity; a turning point in transboundary water management; and scientific advances that showed that human action was threatening the stability of the global hydrological cycle. These years also brought progress

on global policies linking climate change with water security, a milestone UN conference on water, and the convening of a Global Commission on the Economics of Water. Ironically, these advances came precisely at a time when the value of multilateral cooperation to address global challenges began to be increasingly questioned in some quarters (chapter 9).

Conclusions

The year 2024 marked the culmination of an eventful eighty years of transformational developments in global water science, policy, and practice, during which water multilateralism and global institutions helped expand knowledge of water challenges and solutions, broaden disciplinary perspectives, and move science-informed water policy forward. At the same time, billions of people still lived water-insecure lives, and the world still lacked an effective long-term global institutional architecture to enable countries to confront future threats to water security. Science, policy, and practice for global water security were again at a point of inflection—brought about by new challenges and opportunities and a changing world order—that required a renewal of innovative thinking and action and a reimagining of best approaches, which the successes and failures from 1945 to 2024 could help inform.