About the Pacific Institute for Studies in Development, Environment, and Security

The Pacific Institute is one of the world's leading research and policy nonprofits working to create a healthier planet and sustainable communities. Based in Oakland, California, we conduct interdisciplinary research and partner with stakeholders to produce solutions that advance environmental protection, economic development, international security, and social equity—nationally and internationally. Since the Institute's founding in 1987, we have worked to change policy and find real-world solutions to problems like water shortages, habitat destruction, global warming, and environmental injustice, with the fundamental idea that adequate, safe, clean water are closely connected to every vital resource issue of our time. We have moved the focus of water thinking away from narrow approaches and toward more integrated and sustainable water practices and concepts through rigorous independent research, extensive policy engagement, and intensive outreach to the public. The Pacific Institute has formulated a new vision for long-term water planning in California and internationally, developed a new approach for valuing well-being in local communities, worked on transborder environment and trade issues in North America and beyond, analyzed standards in global environmental protection, clarified key concepts and criteria for sustainable water use, offered recommendations for reducing conflicts over water in the Middle East, Latin America, and Central Asia, championed the human right to water, assessed the impacts of global warming on freshwater resources, and created programs to address environmental justice concerns in low-income communities and communities of color. Our research has reached tens of millions of people through reports, projects, speeches, testimony, and media; more than 100 research papers, reports, and testimonies are available free on the Pacific Institute websites at www.pacinst.org and www.worldwater.org.

THE WORLD'S WATER

Volume 7

The Biennial Report on Freshwater Resources

Peter H. Gleick

with Lucy Allen, Michael J. Cohen, Heather Cooley,
Juliet Christian-Smith, Matthew Heberger, Jason Morrison,
Meena Palaniappan, and Peter Schulte

Washington | Covelo | London

Copyright © 2012 Pacific Institute for Studies in Development, Environment,
and Security

All rights reserved under International and Pan-American Copyright Conventions.
No part of this book may be reproduced in any form or by any means without
permission in writing from the publisher: Island Press, 1718 Connecticut Ave., NW,
Suite 300 Washington, DC 20009.

ISLAND PRESS is a trademark of The Center for Resource Economics.

ISBN 978-1-59726-998-8 (cloth)

ISBN 978-1-59726-999-5 (paper)

ISSN 15287-7165

Printed on recycled, acid-free paper ♻️

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Contents

Foreword by Robert Glennon xi

Introduction xiii

ONE Climate Change and Transboundary Waters 1

*Heather Cooley, Juliet Christian-Smith, Peter H. Gleick,
Lucy Allen, and Michael Cohen*

Transboundary Rivers and Aquifers 2

Managing Transboundary Basins 4

Transboundary Water Management Policies and Climate
Change 7

Case Studies 10

Conclusions and Recommendations 18

TWO Corporate Water Management 23

Peter Schulte, Jason Morrison, and Peter H. Gleick

Global Trends that Affect Businesses 24

Water-Related Business Risks 25

Key Factors that Determine Extent and Type of Risk 28

Risk and Impact Assessment 30

Strategies for Improved Corporate Water Management 34

Conclusions: A Framework for Action 41

THREE Water Quality 45

*Meena Palaniappan, Peter H. Gleick, Lucy Allen,
Michael J. Cohen, Juliet Christian-Smith, and
Courtney Smith*

Current Water-Quality Challenges 46

Consequences of Poor Water Quality 54

Moving to Solutions and Actions 65

Mechanisms to Achieve Solutions 66

Conclusion 67

FOUR Fossil Fuels and Water Quality 73

Lucy Allen, Michael J. Cohen, David Abelson, and Bart Miller

Fossil-Fuel Production and Associated Water Use 74

Fossil Fuels and Water Quality: Direct Impacts 76

Impacts on Freshwater Ecosystems 84

Impacts on Human Communities 87

Conclusion 92

FIVE Australia's Millennium Drought: Impacts and Responses 97

Matthew Heberger

Water Resources of Australia 98
 Impacts of the Millennium Drought 102
 Responses to Drought 106
 Conclusion 121

SIX China Dams 127

Peter H. Gleick

Dams in China 129
 Dams on Chinese International Rivers 130
 Exporting Chinese Dams 133
 Growing Internal Concern Over Chinese Dams 135
 International Principles Governing Dam Projects:
 The World Commission on Dams 136
 Conclusions 140

SEVEN U.S. Water Policy Reform 143

Juliet Christian-Smith, Peter H. Gleick, and Heather Cooley

Background 143
 International Water Reform Efforts 144
 Common Themes and "Soft Path" Solutions 149
 A 21st Century U.S. Water Policy 150
 Conclusions 154

WATER BRIEFS

One Bottled Water and Energy 157

Peter H. Gleick and Heather Cooley

Energy to Produce Bottled Water 158
 Summary of Energy Uses 163
 Conclusions 163

Two The Great Lakes Water Agreements 165

Peter Schulte

History of Shared Water Resource Management 165
 Conclusion 169

Three Water in the Movies 171

Peter H. Gleick

Popular Movies/Films 171
 Water Documentaries 174
 Short Water Videos and Films 174

Four Water Conflict Chronology 175

Peter H. Gleick and Matthew Heberger

DATA SECTION

Data Table 1: Total Renewable Freshwater Supply, by Country	215
Data Table 2: Freshwater Withdrawal by Country and Sector	221
Data Table 3: Access to Safe Drinking Water by Country, 1970–2008	230
Data Table 4: Access to Sanitation by Country, 1970–2008	241
Data Table 5: MDG Progress on Access to Safe Drinking Water by Region (proportion of population using an improved water source)	251
Data Table 6: MDG Progress on Access to Sanitation by Region (proportion of population using an improved sanitation facility)	254
Data Table 7: Under-5 Mortality Rate by Cause and Country, 2008	257
Data Table 8: Infant Mortality Rate by Country (per 1,000 live births)	264
Data Table 9: Death and DALYs from Selected Water-Related Diseases, 2000 and 2004	270
Data Table 10: Overseas Development Assistance for Water Supply and Sanitation, by Donating Country	273
Data Table 11: Overseas Development Assistance for Water Supply and Sanitation, by Subsector (total of all donating countries)	275
Data Table 12: Organic Water Pollutant (BOD) Emissions by Country (% from various industries), 2005	278
Data Table 13: Top Environmental Concerns of the American Public: Selected Years, 1997–2010 (% who worry “a great deal”)	282
Data Table 14a: Top Environmental Concerns Around the World	285
Data Table 14b: Concern for Water Issues (% “very concerned”) for Seven Major Countries	288
Data Table 15: Satisfaction With Local Water Quality, by Country, 2006–2007	289
Data Table 16: Extinct (or Extinct in the Wild) Freshwater Animal Species	292
Data Table 17: U.S. Federal Water-Related Agency Budgets	303
Data Table 18: Overseas Dams With Chinese Financiers, Developers, or Builders (as of August 2010)	308
Data Table 19: Per-Capita Bottled Water Consumption by Top Countries, 1999–2010 (liters per person per year)	339

WATER UNITS, DATA CONVERSIONS, AND CONSTANTS 341

COMPREHENSIVE TABLE OF CONTENTS 351

Volume 1:	The World’s Water 1998–1999: The Biennial Report on Freshwater Resources	351
Volume 2:	The World’s Water 2000–2001: The Biennial Report on Freshwater Resources	354
Volume 3:	The World’s Water 2002–2003: The Biennial Report on Freshwater Resources	357

Volume 4:	The World's Water 2004–2005: The Biennial Report on Freshwater Resources	360
Volume 5:	The World's Water 2006–2007: The Biennial Report on Freshwater Resources	364
Volume 6:	The World's Water 2008–2009: The Biennial Report on Freshwater Resources	368
Volume 7:	The World's Water Volume 7: The Biennial Report on Freshwater Resources	372
COMPREHENSIVE INDEX		377

Foreword

The hydrologic cycle teaches that we can neither make nor destroy water. We're drinking the same H₂O as the dinosaurs did. But if that's true, how can there be a water crisis? There are two reasons. First, Mother Nature can be cruel; the worldwide distribution and management of water is very uneven, which partly explains why more than one billion people lack access to safe drinking water. Second, we're using water faster than Mother Nature replenishes it. Diversions from rivers, pumping from wells, and pollution by farms, cities, and industry all compromise the supply of water. Each of these activities has contributed, over the span of many years, to the current crisis. And each has been documented, and expertly analyzed, in the pages of *The World's Water* since the first volume appeared in 1999.

Now, as Peter Gleick and his colleagues at the Pacific Institute release Volume 7 in the series, global climate change has upped the ante—increasing the threat to our water supply. Air and ocean temperatures continue to reach record highs, glaciers and polar ice-caps are rapidly melting, and extreme events—floods, droughts, hurricanes, and typhoons—are increasing. In the United States, ominous predictions about flows in western rivers presage frightening shortages. Chapter 1 in this volume tackles the challenges facing transboundary water resources in the face of climate changes.

On the demand side, population growth and rising energy use drive the need for more water, even in a relatively water-rich country like the United States. At long last, we are recognizing the connection between water and energy production—a link explored in Chapter 4 of this volume. Gleick and his colleagues give us a frightening statistic: 22 percent of all water used is for industrial purposes, including fossil-fuel extraction and power generation. As the demand for energy worldwide spirals upward, it will take even more immense quantities of water to satisfy the demand for power. Even the Internet is fueling this upsurge, with companies such as Intel and Google using large volumes of water to produce their semiconductor chips and to run their “server farms.”

This last point illustrates a profound reality: water is not only a necessity of life and an environmental amenity; it also drives economies. Water is a critical input not just for obvious companies, such as Coca-Cola and other food producers, but also for industrial concerns, ranging from the steel industry to high-tech companies. Gleick and his coauthors argue that shortages have finally begun to force businesses to manage water more responsibly. If they don't, it is not just a moral stain or a public relations problem but a real threat to their bottom lines. Chapter 2 examines the risks that water poses for companies and explains how better management can reduce those risks.

In addition to corporate responsibility, how else can we prevent the water crisis from becoming a catastrophe? We have a menu of options, but the status quo is not one of them. In the United States, the usual response to water shortages is to divert more water from rivers, build more dams, and drill more groundwater wells. These traditional alternatives are not viable solutions. Other ideas—surreal ones—include towing icebergs

from the Arctic, importing water from British Columbia, and seeding clouds. These ideas reflect a misguided hope that there is a new oasis out there, somewhere, that will obviate the need to examine carefully how and for what we use water. More sensible approaches include conservation, desalination, and reuse of treated municipal effluent. Yet even communities that have embraced these measures still face ominous water futures.

As the final chapter in this volume argues, what we in the United States desperately need is a “21st century water policy.” Rather than foolishly trying to create new supplies of water, we must use the resources we have more effectively. And that means using (1) price signals to encourage water conservation and (2) market forces to encourage the reallocation of water from lower-value to higher-value uses. In addition to economic tools, Gleick and his coauthors throughout this volume examine what we can learn about water management reform from other countries (from Australia to South Africa to Russia and beyond), and how the U.S. government can play a more constructive role in protecting our water supply.

In short, we have options to prevent the crisis from turning into a catastrophe. Now, we need the moral courage and political will to act. And—as always—we need reliable data and expert analysis to guide our reform efforts. For more than a decade, *The World's Water* has provided those critical insights. Readers who regularly anticipate the biennial release of the series will find Volume 7 a treasure trove. It includes not only amazingly comprehensive data, with detailed charts and graphs about the world's freshwater resources, but also provocative and original essays. This book is a resource in itself.

Robert Glennon

*Author of Unquenchable and Water Follies
Morris K. Udall Professor of Law and Public Policy
University of Arizona*

Introduction

Welcome to the latest volume of *The World's Water*. With this volume, we are modestly changing how we name and number the series, moving away from the “year” identifiers and renaming them by volume. This book is thus Volume 7—the seventh in the series produced since 1999. Our goals remain the same: to help improve global understanding of the water challenges and the availability of solutions. Alas, the world water crisis remains: basic human needs for water and sanitation remain unmet for far too many, with serious adverse health and community impacts. Climate change has become increasingly apparent, with growing evidence of impacts on hydrology and our built water systems. Ecosystems continue to deteriorate in many parts of the world. And tensions over water allocations and use are growing, not diminishing. But if there is any good news, it is that these crises in water are also receiving more attention from policy makers, scientists, the media, and members of the public, and that there are effective solutions to these problems. So, I believe that the need for *The World's Water* remains. New thinking about solutions and sustainable water planning and management, better data, case studies, and efforts to raise awareness, are all needed. As with the first six volumes, I and my colleagues explore a subset of the many pressing water issues based on timeliness, urgency, and our own experience and priorities. There is no shortage of topics to address, and as always, it is a challenge to try to choose among them for inclusion in the books. In Volume 7, we tackle some new topics and revisit and update some older ones. We provide a Comprehensive Table of Contents and an integrated index across all seven volumes, to help readers find information in other volumes that might be useful for their research or other efforts.

Chapter 1 offers an overview of the rapidly unfolding connections between climate change and transboundary water resources, including both surface and groundwater. This chapter summarizes work the Pacific Institute recently completed for the United Nations Environment Programme and expands the long line of studies produced at the Institute on the links between climate and water. Chapter 2 summarizes major new work on understanding and classifying water-related risks for the corporate sector and how to define responsible and sustainable corporate water management. This work exemplifies our belief that the corporate sector must develop improved standards around water management and use more rapidly and work with affected communities far more closely than has been the case in the past. This volume also offers a comprehensive overview and perspective on water-quality challenges globally (Chapter 3), also based on work done for the United Nations Environment Programme. Water quality is often the lonely stepchild of more extensive work on water quantity and availability, yet some of the most serious water challenges are related to contamination. Indeed, many water-availability problems have, at their root, water-quality origins. We also offer some suggestions about new approaches for more quickly and comprehensively addressing water-quality problems. Chapter 4 expands on the issues of water quality in

the specific context of producing fossil fuels. We have previously written about the links between water and energy (in Volumes 1 and 2 related to hydroelectric dams, in Volume 5 in a chapter on desalination, and elsewhere). This new chapter expands that work to address a serious water-quality threat related to energy policies and activities, including the new and increasingly worrisome implications associated with “fracking” natural gas formations. Chapter 5 explores the dramatic consequences of the long, severe drought recently experienced by the people and ecosystems of Australia. The responses of that nation offer insights into how difficult long-term climatic changes may be to address, the complications of developing water markets and policies for reallocating water, and the kinds of institutional changes that serious disruptions of expected water availability can cause. Chapter 6 expands on a topic touched on in earlier volumes: the water catastrophe rapidly unfolding in China. Chinese water challenges have often been a topic in these books: the first volume included a comprehensive assessment of the Three Gorges Dam project, then under construction, and the status and implications of that project were reevaluated in the most recent book, Volume 6. Volume 6 also included a comprehensive chapter on China’s water crisis. Chapter 6 in the current volume focuses on China’s dam policies, both within the country and outside its borders where massive Chinese investments and construction projects are under way, with controversial impacts. The final chapter looks at the need for a comprehensive reform of United States water policy at the federal level, drawing on lessons from recent international experience with water policy. This chapter is an advanced look at some of the work being done at the Pacific Institute to redefine U.S. water policy in a more comprehensive way.

As in the previous volumes, the major chapters are supplemented with shorter “Water Brief” reports on items of interest. Heather Cooley and I offer a summary of the energy implications of bottled water—reporting on our research into the overall energy costs of producing, transporting, and using bottled water. Peter Schulte provides an overview of the new Great Lakes water agreements as a good example of both the need for and the value of international cooperation over shared water resources. The third Water Brief offers some fun reading—for readers interested in how water is portrayed in the movies, I provide a summary of diverse dramas, comedies, action films, and more where water is a fundamental component of the plot. Some of the earliest movies ever made portray conflicts over water in the western United States; more recently, water has appeared regularly in science fiction, comedies, and post-apocalyptic movies where themes include access to water, attacks on water systems, or evil corporate world dominators bent on controlling water or the world economy. Add some of these to your Netflix list! And send us examples we have missed. We also bring to the readers, again, our tremendously popular Water Conflict Chronology, with many new historical examples of conflicts related to water going back millennia. This chronology is now available in a wonderful new format online at www.worldwater.org, where readers can sort water conflicts by time, location, type of conflict, and more, and see the results in active maps.

Finally, Volume 7 of *The World’s Water* again offers a wide variety of important, useful, and popular data on water in a series of Data Tables. In this volume, we present updated data on access to water and sanitation around the world, water availability and demand, the mortality rate in children under five years of age from water-related diseases, progress toward the Millennium Development Goals for water, a dataset on trends in overseas development assistance for water, insights into public opinion on

critical water issues based on polls from a diverse set of organizations, information on water quality, and far more. We also provide a sobering look at the list of freshwater animals now considered to be extinct—a measure of the serious impacts humans have on our aquatic environments.

Special thanks to all of the coauthors, especially to Lucy Allen. Lucy contributed serious substance to several of the chapters, and she did a remarkable job of collecting, vetting, correcting, and writing up most of the data tables. Finally, this project has always benefited from the enthusiastic support of Todd Baldwin, my editor at Island Press. Todd has now moved on to different professional pastures, and I miss our regular interactions, his thoughtful comments and insights, and his help, but I look forward to continuing to work on *The World's Water* with Emily Davis at Island Press.

Peter H. Gleick
Oakland, California, 2011