

Introduction to Water Resources and Environmental Issues

Second Edition

How much water does the world need to support growing human populations? What are the potential effects of climate change on the world's water resources? These questions and more are discussed in this thoroughly updated and expanded new edition. Written at the undergraduate level, this accessible textbook covers the fundamentals of water resources, water law, allocation, quality and quantity, and health issues, and provides examples of potential personal actions and solutions. There is a keener focus on climate change, as many of the predictions made in the first edition have now come to pass.

This new edition features improved artwork, more active learning prompts, more positive examples of beneficial changes, basic introductions to scientific approaches, and a discussion of emerging contaminants and LiDAR technology. It contains strong teaching features, with new “In Depth” and “Think About It” sections to encourage class discussion, and homework questions to test students' understanding.

Karrie Lynn Pennington has studied the interactions of land use, water quality, and quantity for over 30 years. The last 22 years were with the Natural Resources Conservation Service of the US Department of Agriculture (USDA) in the Mississippi Delta where, as in many places around the world, human actions changed the natural ecosystem into farmland, providing a classic example of land-use conversion for study.

She received her bachelor's degree in biology from the University of North Texas and completed her Master of Science in soils from the University of Idaho where she taught until moving to Tucson, Arizona. She taught for three more years at the University of Arizona (UA) before deciding to obtain her Ph.D. at UA. After completing her Ph.D. in soil and water science she moved to Mississippi, finishing her postdoctoral work with USDA's Agricultural Research Service. She is now retired.

Thomas V. Cech was born and raised on a farm near Clarkson, Nebraska. He graduated from Kearney State College with a Bachelor of Science degree in mathematics education, and later received a Master of Science degree in community and regional planning from the University of Nebraska, Lincoln. He was Executive Director of the Central Colorado Water Conservancy District in Greeley, taught undergraduate- and graduate-level water resources courses at the University of Northern Colorado and Colorado State University, and is now the Co-Director of the One World One Water (OWOW) Center at Metropolitan State University of Denver, Colorado.

“A comprehensive primer on our most precious, yet often neglected, resource. With systematic reviews of the critical challenges, this volume offers accessible treatment of thorny problems and provides useful summaries and additional readings. A must-read for students, scholars, and practitioners to safeguard water – the foundation of life.”

Professor Christopher A. Scott, *University of Arizona*

“So glad to see this new edition! It’s fully updated with contemporary trends and terminology. Particularly insightful are the ‘Think About It’ features embedded within each chapter, encouraging the reader to consider different facets of evolving water resource issues. Overall, it continues to be a well-organized, highly readable, and comprehensive treatment of a critically important resource.”

Professor Ned Knight, *Linfield College*

“An encyclopedic journey into the connections between water issues and an array of topics, including human geography, public health, ecology, geology, history, and policy. It provides something for everyone – spectacular black-and-white photos, an introduction to virtually all aspects of water science, human interest stories, and great discussion questions.”

Professor Kathy Jacobs, *University of Arizona*

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Second Edition

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Preface

The stream of time moves forward, and mankind moves with it. Your generation must come to terms with the environment. You must face realities instead of taking refuge in ignorance and evasion of truth. Yours is a grave and sobering responsibility, but it is also a shining opportunity. You go out into a world where mankind is challenged, as it has never been challenged before, to prove its maturity and its mastery – not of nature, but of itself. Therein lies our hope and our destiny.

Rachel Carson, 1962 commencement address, Scripps College in California

We all live on one Earth, share one atmosphere, drink from the same waters. We are undeniably connected to our Earth and to each other. Global climate change affects all of us, in ways we do not recognize when we fail to make these connections and understand their significance.

We might not recognize that a global pandemic is a water issue, without considering that day-to-day actions that save lives require a source of plentiful, clean water. Washing hands, cleaning surroundings, and maintaining hydration are not possible without access to clean water. Without access to water, foods are not produced. Malnutrition leaves people more vulnerable to disease. The connections go on.

We might not recognize water as an issue of equality of justice, educational opportunity, medical care, or proper living conditions, but the connections are there for us to make if we will. Water supplies energy for development and is critical to many industrial processes that provide jobs. It makes agriculture possible in deserts. In areas where competition for water resources exists, we must consider the many people who depend on that same water for their fisheries and small farms; the family livelihoods that have existed for generations. How we choose to develop water can take those opportunities away forever, leading directly to more inequality. Unfortunately, the lack of inclusion of the many diverse peoples influenced by management of water resources has been apparent for many years. This generates inequality in the decision-making process which affects us all. Increasing diversity in the workplace, and in the policymaking process, are substantive changes which must occur.

The choices are not easy. We must draw upon creative problem solving and consider the needs of the Earth and humanity over development and profit. We will explore these issues more thoroughly in this text. It is our hope that students will follow the mandate presented to them by Rachel Carson.

Rachel Carson urged a generation to look at the interconnectivity of all of nature and realize that we are responsible for our part in challenging the distortion of truths which too often sacrifice our environment for commercial interests. Her warning about the misuse of chemicals in the 1950s and 60s mirrors today's warnings about increased greenhouse gases and global climate change. In this new edition, we examine more closely the connectivity of water resources issues and the associated environmental impacts of global climate change. We see the Earth's carrying capacity for humans already being strained by rising sea levels. We watch as the ferocity of storm events becomes greater and increase in destructive power. Extremes of weather – from drought to deluge – have countries facing environmental disasters ranging from deadly wildfires to more frequent floods. The human price for the neglect of our environment is already being paid, and without significant and timely action, the bill will only get higher.

Today our entire planet is in danger from global climate change. Our hydrologic cycle is being altered by choices from the individual to the global. We have known the dangers of the rapidly

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changing greenhouse gas concentrations in our atmosphere for over seven decades; with the solidifying of the fundamental science that was established in the 1950s and then well understood by the 1970s. Scientific evidence that has been agreed on by the majority of actively publishing climate scientists, 97 percent, assure us that we humans are the cause. Governments of the world have had decades to invoke actions to slow global warming, but efforts have been met with political roadblocks. Today we are seeing more action as most of the leading science organizations around the world have issued public statements expressing these concerns, including international and US science academies, the United Nations Intergovernmental Panel on Climate Change, and many more reputable scientific bodies around the world.

The Intergovernmental Panel on Climate Change (IPCC), formed in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), was charged with providing regular assessments of the scientific basis of climate change, its impacts and future risks, and options for possible solutions. Their 2019 special report states that a 1.5 degree Celsius (2.7 degree Fahrenheit) change in global temperature could be reached in the next 12 to 20 years. This, the report states, will result in widespread damage to ecological, economic, and human environments.

The cost of protecting national economies is too often promoted above the need to protect our environment. This political cry against reducing human global warming activities does not bode well for future generations. Today we need to reframe the discussion in terms of the morality of harming the human population and our environment. Rachel Carson provides a roadmap: We must face realities of our environment instead of taking refuge in ignorance and the evasion of truth. Greta Thunberg, a young Swedish environmental activist on climate change, has provided inspiration and motivation to millions showing that you can make a difference with actions and words. She challenges: “*We know the solutions; all we have to do is wake up and change.*” We all have a grave and sobering responsibility, but also a shining opportunity to improve the health of our environment and all of humanity.

We will continue to examine issues, as described in the first edition preface, and solutions the students of today can choose to study and implement. Volunteering to talk about water to 4th graders on their natural resource field days was uplifting. I ended my talk about water by asking the students “what is the most important natural resource?” When they answered “water,” I would say no – *you are* – because you have a brain and the ability to understand and change things that are wrong. Humans have endless creativity. We offer you the same hope that you will use that imagination and creativity to solve problems and find solutions.

In this Edition

- This updated text further examines water from global and historical perspectives – with its roles today and in the development of civilizations. These chapters have been updated to include issues of importance to Indigenous peoples, climate change influences on existing issues, and current global population issues involving the right to and the need for water.
- The text moves into areas of science, with the hydrologic cycle, water chemistry, and water quality providing the fundamentals. These areas have been expanded or updated to include new developments, and anthropomorphic influences on our hydrologic cycle.
- Subjects that require more understanding are presented as In Depth sections. These are intended to interest the curious student.

- The concepts of ecosystems are explored in chapters on watersheds, groundwater, lakes and ponds, rivers and streams, and wetlands. Sidebars and guest essays provide additional information and case studies.
- Human attempts to control natural systems are explored through the study of dams and structures. The importance of dams and reservoirs is considered as well as their consequences. This section includes updates on the global proliferation of dams since the first edition, in countries considered less developed, and water use in other energy production methods.
- The chapter on drinking water explores attempts to repair and restore damaged systems. Natural sources of pollution, as well as human-produced pollution, are discussed. Waterborne diseases and the complexities of their control are considered.
- Water law and water allocation are discussed. Who gets to use the water we have is a tremendously controversial subject, involving competing uses by cities, industry, endangered species, individuals, and the water source itself. Depleting groundwater or drying up a river is akin to killing the goose that laid golden eggs, but sometimes we don't think beyond right now.
- The roles of governments, and the various agencies they create, are presented primarily using the United States as an example. Case studies demonstrate positive and negative interactions of agencies all trying to do their jobs while competing for tax dollars.
- The final chapter summarizes the state of our Earth's water resources and encourages students to think about the future of water and humans as inseparable features. A final look at major issues – from global climate change to competing personal values – shows how much more there is to learn and the complexity of decisions that are still to be made.