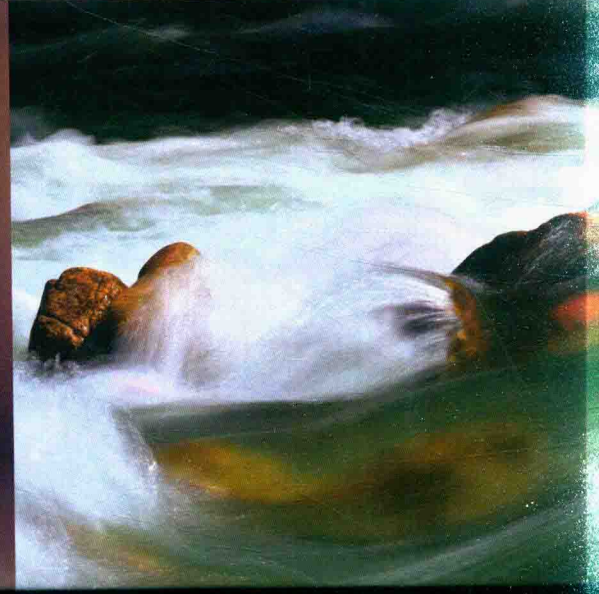
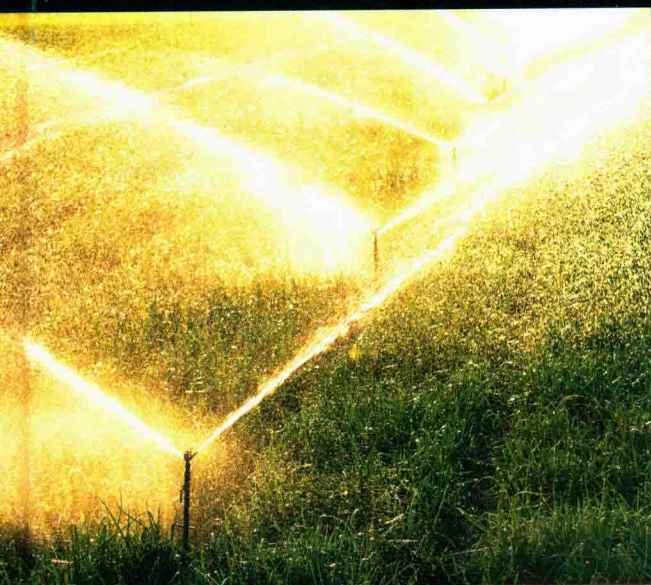


# HANDBOOK OF Water Economics

Edited by  
**Ariel Dinar • Kurt Schwabe**



# Handbook of Water Economics

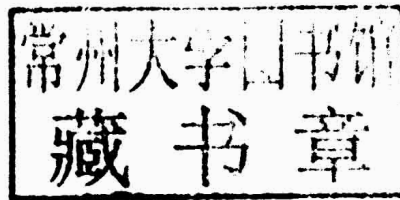
*Edited by*

Ariel Dinar

*and*

Kurt Schwabe

*University of California, Riverside, USA*



**EE** Edward Elgar  
PUBLISHING

Cheltenham, UK • Northampton, MA, USA

© Ariel Dinar and Kurt Schwabe 2015

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical or photocopying, recording, or otherwise without the prior permission of the publisher.

Published by  
Edward Elgar Publishing Limited  
The Lypiatts  
15 Lansdown Road  
Cheltenham  
Glos GL50 2JA  
UK

Edward Elgar Publishing, Inc.  
William Pratt House  
9 Dewey Court  
Northampton  
Massachusetts 01060  
USA

A catalogue record for this book  
is available from the British Library

Library of Congress Control Number: 2015935907

This book is available electronically in the **Elgaronline**  
Economics subject collection  
DOI 10.4337/9781782549666



ISBN 978 1 78254 964 2 (cased)  
ISBN 978 1 78254 966 6 (eBook)

Typeset by Servis Filmsetting Ltd, Stockport, Cheshire  
Printed and bound in Great Britain by  
TJ International Ltd, Padstow, Cornwall

# HANDBOOK OF WATER ECONOMICS

---

## Contributors

---

**Erik Ansink** is Senior Research Fellow at the Department of Spatial Economics and IVM, VU University Amsterdam, the Netherlands. He is the Managing Editor of *Water Resources & Economics*. He obtained his PhD from Wageningen University (Netherlands) in 2009 on the topic of game theory and transboundary water allocation. His main research topics are water resource economics and cooperative resource management, using a variety of research methods including tools and models from game theory, political economy and experimental economics.

**Kenneth A. Baerenklau** is Associate Professor of Environmental Economics and Policy at the University of California, Riverside, USA. He has 12 years of professional experience working on a variety of environmental policy issues, including several related to water quality and water resource management. Representative projects include assessing policies for reducing nutrient emissions from animal feeding operations; designing an incentive system to promote decentralized urban stormwater capture by private landowners; characterizing optimal long-term use of an agricultural aquifer subject to salinization; assessing the effect of water pollution on beach recreation; and multiple ongoing projects related to urban water pricing and conservation incentives. Baerenklau has served on the editorial boards for *Land Economics* and the *Journal of Environmental Economics and Management*. He holds bachelor's and master's degrees in civil and environmental engineering from Stanford University (CA) and a PhD in agricultural and applied economics from the University of Wisconsin, Madison.

**Edward B. Barbier** is the John S. Bugas Professor of Economics, Department of Economics and Finance, University of Wyoming (Laramie), USA. His main expertise is natural resource and development economics, as well as the interface between economics and ecology. He has served as a consultant and policy analyst for a variety of national, international and non-governmental agencies, including many UN organizations, the World Bank and the OECD. He has authored over 200 peer-reviewed journal articles and book chapters, written or edited 21 books and published in popular journals.

**Rosalind Bark** is a resource ecological economist, conducting interdisciplinary research at CSIRO's Ecosciences Precinct, Australia. Rosalind was previously a post-doctoral research scientist at the University of Arizona (Tucson, USA). Her primary research interests include river basin water reform; the valuation of water-dependent ecosystem services; indigenous water needs; water governance and risk issues.

**Hernán Bejarano** is Assistant Professor at CIDE, Center for Economic Teaching and Research, Mexico. He is a behavioral and experimental economist specializing in environmental and health economics and quantitative methods. He received his PhD in agricultural, environmental and regional economics from Pennsylvania State University (University Park) in 2013. Currently, Bejarano is a post-doctoral research associate at the Economic Science Institute at Chapman University (Orange, CA, USA). His current

research addresses the issues of how to design environmental markets and health institutions to improve individual intertemporal choices, reduce externalities and encourage social pressure to improve groups' performance. In the field or in the lab, his projects combine experimental tasks, surveys and econometric methods to identify how institutions, rules and individual intrinsic characteristics, such as risk preferences, discounting, personal experiences and cognitive abilities, affect choices such as market participation, investment decisions and bargaining strategies. He has published his research in the *B.E. Journal of Network Economics* and *Journal of Development Economic Studies*. His projects have been funded by competitive grants from the Penn State Institute of Energy and Environment, Latin American and Caribbean Environmental Economics Program (LACEEP), and the International Foundation for Research in Experimental Economics (IFREE).

**Kimberly Burnett** joined the University of Hawaii Economic Research Organization (UHERO) in Honolulu, USA as a research economist in 2008. She has authored over a dozen peer-reviewed articles in scientific journals and books on a wide variety of environmental management issues. Her earlier work focused on the management of invasive species, including *Miconia*, the brown tree snake, and the Coqui frog. Currently, she is developing system approaches for managing terrestrial, freshwater and marine ecosystems. Recent extramural projects include work on abatement of nitrogen pollution in submarine groundwater discharge, optimal management of a coastal aquifer with near-shore marine ecological interactions, and integrated watershed and groundwater management.

**Richard T. Carson** is a Professor in the Department of Economics at the University of California, San Diego, USA as well as Distinguished Research Professor at the University of South Australia's Institute for Choice. Carson served as President of the Association of Environmental and Resource Economics Association, and is an elected fellow of both the Association of Environmental and Resource Economists and the Agricultural and Applied Economics Association. Carson received his MA in international relations from George Washington University, and his PhD in resource economics and an MA in statistics from the University of California, Berkeley.

**Jeff Connor** is an ecological and environmental policy economist with CSIRO Land and Water, Australia. Before joining CSIRO, Connor worked at Oregon State University (Corvallis) and Willamette University in Salem, Oregon, USA. Jeff's research interests include water policy options, salinity management, water trade, hydrological economic assessment, adaptation, urban water and agricultural development. Jeff has won many awards and has published over 100 peer-reviewed publications.

**Osiel González Dávila** is a Research Associate at the Athens University of Economics and Business, Greece. His principal research interests lie in the fields of economics, environment and development. He holds an MRes in environment and development from the University of Lancaster (Lancashire, UK, 2008), an MSc in economics from the University of Essex (Colchester, UK, 2009), and he completed his PhD in economics thesis at the University of London (2013). He has worked as a researcher in EU FP7 projects: THESEUS and MERMAID. He has also worked as a lecturer in economics



at the School of Oriental and African Studies (SOAS), University of London, and as a guest teacher at the London School of Economics and Political Science (LSE), UK.

**Ariel Dinar** is Professor of Environmental Economics and Policy at the School of Public Policy, University of California, Riverside, USA. He teaches and conducts research on issues related to water economics, climate change economics, economics of regional cooperation and international water management.

**Diane Dupont** is Professor of Economics at Brock University (St Catharines, Ontario, Canada), where she held a Chancellor's Chair for Research Excellence and was the 2012 recipient of Brock University's Distinguished Research and Creative Activity Award. Her doctoral work in economics was completed at the University of British Columbia. Her publications have appeared in the *Journal of Environmental Economics and Management*, *Review of Economics and Statistics*, *Land Economics* and *Environmental and Resource Economics*, and she is co-author of a graduate-level textbook *The Economics of the Environment and Natural Resources*. She has served on the international scientific advisory committee for Worldfish Centre, Penang, Malaysia, and has been a board member for the Canadian Water Network and for the North American Association of Fisheries Economists. She is a Research Associate of the Centre for Water Economics, Environment and Policy at the Crawford School at the Australian National University, Canberra, Australia. She is currently an Associate Editor for *Water Resources Research*, *Canadian Journal of Water Resources* and *Water Resources & Economics*.

**Bradley Franklin** is a Post-doctoral Fellow at the International Water Management Institute (IWMI), based in New Delhi, India. At IWMI, Brad works with the USDA Economic Research Service on developing a set of hydro-economic tools that model surface and groundwater interaction to better understand the effects of water scarcity and variability on agricultural production in India. Other research topics that he has worked on include groundwater sustainability in California, irrigated perennial production in both California and the Murray–Darling Basin (MDB) of Australia, and environmental water trade in the MDB.

**R. Quentin Grafton** is Professor of Economics, ANU Public Policy Fellow and Director of the Centre for Water Economics, Environment and Policy (CWEPP) at the Crawford School of Public Policy at the Australian National University. In April 2010, he was appointed the chair holder, the UNESCO Chair in Water Economics and Transboundary Water Governance, and in August 2013 he was appointed Executive Director at the Australian National Institute of Public Policy (ANIPP). He is the recipient of several prestigious awards, including the National Water Commission Professor Peter Cullen Eureka Prize for Water Research and Innovation (2011), and the Vice-Chancellor's Award for Education, Excellence in Supervision (2010).

**Kristiana Hansen** is an Assistant Professor and Extension Water Resource Economist in the Department of Agricultural and Applied Economics at the University of Wyoming (Laramie), USA. Current research projects include hydro-economic modeling of reservoir management, payment for ecosystem services markets for water and species habitat, and the economics of reclamation after energy extraction. Hansen has a PhD in agricultural and resource economics from the University of California, Davis.

**Francesc Hernández-Sancho** has a PhD in economics and is an Associate Professor at the University of Valencia (UV), Spain. He is Head of the Water Economics Research Group (UV) and Director of the Master on Water Management (UV). He belongs to the excellence research micro-cluster 'Efficiency and economic and environmental feasibility for the generation of non-conventional water resources'. He is Vice Chair of the IWA SG on Statistics and Economics, and leader of the Water Economics Working Group. His research topics are: environmental economics, water reuse, cost efficiency, water management, water pricing and feasibility studies for water projects. He has participated in more than 20 research projects related to water economics. He has more than 60 articles in scientific journals and more than 25 books. He has presented more than 80 papers, especially at international congresses, participating in a large number of workshops and seminars.

**Harold Houba** is Associate Professor of Economic Theory at the Department of Econometrics, VU University Amsterdam, the Netherlands. He obtained his PhD from Tilburg University (Netherlands) in 1994 on the topic of game-theoretic models of bargaining. His research and teaching experience includes many topics in economic theory, such as auction theory and bargaining theory, with various applications including the analysis of market power, bargaining procedures and topics in water resource economics.

**Brian H. Hurd** is a Professor of Agricultural Economics and Agricultural Business at New Mexico State University in Las Cruces, NM, USA. Hurd conducts research and teaching on the economic assessment of climate change impacts and adaptation, non-market valuation of natural resources, and the economics of water resources and agro-environmental systems. He is a delegate to and has served on the Board of Directors of the Universities Council on Water Resources (UCOWR). He earned MS and PhD degrees in agricultural economics from the University of California, Davis, and graduated *magna cum laude* from the University of Colorado, Boulder, with a BA degree in economics and in environmental conservation.

**William K. Jaeger** is a Professor in the Department of Applied Economics at Oregon State University, Corvallis, USA. His research includes environmental and resource economics, taxation and public economics, agricultural economics and development economics. In particular, his work addresses water, land and energy policy issues, as well as issues related to economic growth and the environment. He has been a Fulbright Scholar at the University of Venice, Italy, and he taught for 12 years at Williams College in Williamstown, MA. He has also taught at the University of Washington (Seattle) and the University of Oregon (Eugene), and was a research economist and consultant to the World Bank.

**Per-Olov Johansson** is an Emeritus Professor at the Stockholm School of Economics, Sweden and has previously held professorships at the University of Oslo, Norway, and the Swedish University of Agricultural Sciences. He has published widely in macro-economics, public economics, environmental economics and health economics.

**Scott Kaplan** is a Research Assistant in the Department of Agricultural and Resource Economics at the University of California, Berkeley, USA. Scott's areas of expertise include technology adoption, biotechnology, biofuels, water, environmental policy



and climate change. Scott received his BS in environmental economics and policy, and environmental sciences at UC Berkeley in 2014.

**Keith C. Knapp** is a Professor of Natural Resource Economics in the Department of Environmental Sciences, University of California, Riverside, USA. He received his bachelor's degree in economics at Iowa State University (Ames) in 1972, and a PhD in natural resource economics at Johns Hopkins University (Baltimore, MD) in 1980. His general teaching and research areas are agricultural, resource and environmental economics. His specific research areas are agricultural production economics, salinity and drainage, groundwater usage and management, general natural resource management and environmental macroeconomics (growth, trade and sustainability).

**Phoebe Koundouri** holds a PhD (2000), MSc (1996) and MPhil (1995) in economics from the University of Cambridge (UK). She is the Vice President of the European Association of Environmental and Resource Economists (EAERE, [www.eaere.org](http://www.eaere.org)), and Associate Professor in the Department of International and European Economic Studies, Athens University of Economics and Business (Greece) and the Director of the research team on Socio-Economic and Environmental Sustainability (ReSEES, <http://www.aueb.gr/users/koundouri/resees/>). She is also Senior Research Fellow at the London School of Economics and Political Science, Grantham Research Institute on Climate Change and the Environment. Her research focuses on environmental and natural resources economics and econometrics. She has published 12 edited books and more than 250 articles in edited volumes and academic journals. She is co-editor of the official *Journal of the European Association of Environmental and Resource Economists*, associate editor and editorial board member in 17 academic journals in the field of economics, and has supervised a number of PhD students. Since 1996, Phoebe Koundouri has coordinated and/or participated in research and consultancy projects on natural resources and environmental management funded by the European Commission, World Bank, OECD, UN, NATO, WHO, as well as many other international and national organizations and governments of developed and developing countries.

**Bengt Kriström** is a Professor of Resource Economics (SLU-Umeå) and Research Director for the Centre for Environmental and Resource Economics (CERE) in Umeå, Sweden. His research is widely cited (top 1000 economists, according to a 2002 compilation) and includes over 60 papers and 15 books. He has been a consultant to several international organizations, including the Organisation for Economic Co-operation and Development (OECD) and, on numerous occasions, the Swedish government. He has organized the Ulvön International Conference on Environmental Economics since 1993.

**Adam Loch** is Senior Lecturer with Global Food Studies, University of Adelaide, Australia. Adam is a former cotton grower and water advocate in Queensland, and continues to research water policy, irrigation, water markets and trade in the Murray–Darling Basin. He has published over 30 peer-reviewed publications.

**María Molinos-Senante** holds a PhD in local development and territory, and she is with the Pontificia Universidad Católica de Chile and Centro de Desarrollo Urbano Sustentable CONICYT/FONDAP/15110020, Santiago, Chile. She is Secretary of the Specialist Group on Statistics and Economics of the International Water Association

(IWA). She has published 22 articles in JCR journals, and she has participated in five international projects related to water management. She has cooperated and done research stays in universities and research centers in Italy, Argentina and the UK. Her research is focused on the assessment of the economic feasibility of water interventions, including the economic valuation of environmental benefits.

**Subhrendu K. Pattanayak** designs and evaluates environmental health interventions by conducting advanced statistical analyses on data that he collects from households and communities in close collaborations with ecologists, epidemiologists, environmental scientists and other social scientists. Although he is formally trained as an applied economist, he has studied and applies methods from forest hydrology, ecology, epidemiology, sociology and political science. At Duke University (Durham, NC, USA), he is concurrently a Professor in the Department of Public Policy and Environment, with secondary appointments in economics and global health. He disseminates his research through presentations and peer-reviewed publications, within both economics and policy, but also more broadly in various environmental, climate and health science journals and conferences. For example, he has written and published several systematic reviews on environmental, health and development policies, including on the microeconomics of technology adoption generally and on water and sanitation services specifically. He has also published papers derived from primary analysis of household water and sanitation in South Asia. From his lectures on global environmental health and mentoring of multiple graduate students writing theses on these topics, Pattanayak has also learned about the history, culture, evaluations, impacts and political economy of household water and sanitation around the world. He has collaborated closely with policymakers in multi-lateral, national, state and local governments, as well as NGOs, academics and local research organizations in India, Indonesia, Mexico, Nepal, Sri Lanka and the USA. He is also a fellow and advisor of the South Asian Network of Development and Environmental Economists (SANDEE).

**Sittidaj Pongkijvorasin** is an Assistant Professor of Economics at Chulalongkorn University (Thailand). He has published research on a number of environmental and resource economics topics, including integrated water management, invasive species and sustainable growth.

**Steven Renzetti** is a Professor of Economics at Brock University in St Catharines, Ontario, Canada, and earned his PhD in economics at the University of British Columbia in 1990. Renzetti's research is principally concerned with the economics of water resources. His research has been published in leading peer-reviewed journals. Renzetti has extensive experience working with interdisciplinary teams and as an advisor to governments. He served on the International Joint Commission's Lake Ontario St Lawrence River Study Board as well as the Council of Canadian Academies' Expert Panel on Groundwater. Renzetti is currently scientific director for the Water Economics, Policy and Governance Network.

**James Roumasset** is a Professor in the Department of Economics at the University of Hawaii, Manoa, USA. His research spans a variety of topics, including water and watershed management, energy economics, the new institutional economics, development microeconomics and sustainable development. He has more than 150 articles and other distinct works listed on RePec, as well as four books and numerous book chapters.

**Kurt Schwabe** is an Associate Professor of Environmental Economics and Policy at the University of California, Riverside, USA. His areas of research include agricultural and urban water management and policy, salinity and drought management and nonmarket valuation of environmental resources. He received his undergraduate degree in mathematics and economics at Macalester College in St Paul, MN, a master's degree in economics at Duke University in Durham, NC, and his PhD in environmental economics at the North Carolina State University in Raleigh, NC.

**James Shortle** is Distinguished Professor of Agricultural and Environmental Economics, and the Director of the Natural Resources and Environment Institute, at Penn State University, USA. His research focuses on the economics and policy of water quality protection and restoration, agri-environmental externalities, and climate adaptation in water and agriculture.

**V. Kerry Smith** is an Emeritus Professor of Economics and Emeritus Regents Professor at Arizona State University (ASU) in Tempe, USA. Before his retirement, he served as a Regents Professor and W.P. Carey Professor of Economics. He came to ASU in 2006 after serving as Distinguished Professor and Director of the Center for Environmental and Resource Economic Policy in the Department of Agricultural and Resource Economics at North Carolina State University. Smith received his AB and PhD in economics from Rutgers University (New Brunswick, NJ). He presented the Frederick V. Waugh Lecture for the American Agricultural Economics Association (AAEA) in 1992, and at the 2002 AAEA annual meeting he was named an AAEA Fellow. In 2004 he was elected a member of the National Academy of Sciences. He is also a Fellow of the Association of Environmental and Resource Economists. Smith is a member of the American Economic Association, the Southern Economic Association, the Association of Environmental and Resource Economists, and several other professional associations. He has also held editorial positions with the *Journal of the Association of Environmental and Resource Economists*, the *Journal of Environmental Economics and Management*, *Land Economics*, *Review of Economics and Statistics* and other professional journals. His research interests include nonmarket valuation of environmental resources, the role of public information in promoting private risk mitigation, the linking of ecological and economic models, general equilibrium modeling and welfare analysis for market and nonmarket resources.

**Dale Squires** is Senior Scientist, NOAA Fisheries, in La Jolla, California, and Adjunct Professor of Economics at the University of California, San Diego, USA. He serves on the Scientific Advisory Committees of the International Seafood Sustainability Foundation and the International Pole and Line Foundation.

**Yacov Tsur** was born in Israel in 1951. He received a BSc in agricultural economics (1977) from the Hebrew University of Jerusalem; an MS in statistics (1981) from the University of California, Berkeley; and a PhD in agricultural and resource economics (1984) from the University of California, Berkeley. In 1993, he joined the Department of Agricultural Economics and Management at the Hebrew University of Jerusalem, Israel, where he is currently the Ruth Ochberg Professor of Agricultural and Resource Economics. Before joining the Hebrew University, he served on the faculty of the Department of Economics at Ben Gurion University of the Negev, Israel, and the Department of Applied

Economics at the University of Minnesota (Twin Cities). Tsur's research interests include resource management under uncertainty and catastrophic threats, with particular focus on water resource management. He has published widely in economics outlets and has been actively involved in advising the government of Israel and the World Bank on various issues concerning water resource management and regulation.

**Christopher A. Wada** is a research economist at the University of Hawaii Economic Research Organization (UHERO), USA. He earned a PhD in economics from the University of Hawaii in 2010 and joined UHERO shortly thereafter. Wada has co-authored a number of journal articles, book chapters and technical reports on a variety of topics in the realm of resource and environmental economics. His current research focuses on the economics of groundwater and watershed management.

**Jingjing Wang** is an Assistant Professor of Economics at the University of New Mexico (Albuquerque), USA. Her areas of research include environmental and natural resource economics, with an emphasis on water quality and water resource management. Her current research projects include controlling nutrient emissions from animal feeding operations, and estimating the effect of water education programs on residential water demand. Her publications have appeared in *Agricultural Water Management* and *Applied Economic Perspectives and Policy*. Wang received her BE in environmental engineering from Tsinghua University (China), her MS in environmental science from the University of California, Riverside, and her PhD in environmental and natural resource economics from the University of California, Riverside.

**Frank A. Ward** is Distinguished Achievement Professor of Water Economics and Policy in the Department of Agricultural Economics and Agricultural Business at New Mexico State University, Las Cruces, USA. His research and teaching has emphasized conservation, valuation and economically efficient use of water resources, with emphasis on irrigated agriculture and the environment. It also includes policy planning, program formulation for water resources development, analysis of river basins, transboundary water sharing and institutional strengthening. Additional contributions lie in economic evaluation of policies for development and allocation of water, including development of methods to conduct economic appraisals; formulating interdisciplinary approaches to investigations of water policy issues; concepts and methods of valuing key ecological assets. Ward has conducted river basin assessments that integrate hydrologic, agronomic, institutional and economic linkages to support sustainable river basin management and policy analysis. His recent work on integrated river basin analysis has been applied to the Rio Grande Basin of North America and to the Tigris–Euphrates (Iraq), Jordan, Nilufer (Turkey), Murray–Darling, Nile, Amu Darya (Central Asia), Zayandeh-Rud (Iran) and Balkh (Afghanistan). He has published extensively on water resources, including more than 70 peer-reviewed journal articles on water resources systems analysis and policy, environmental management and irrigation economics. He has authored two books on the economics of natural resources and the environment. He served as associate editor for *Water Resources Research* from 1991 to 2000 and the *Journal of Hydrology* from 2008 to 2011, and *Water Resources* and *Economics and Water Economics and Policy* from 2012 to the present. Selected recent research papers are posted at <http://agecon.nmsu.edu/fward/water/>.

**Sarah Ann Wheeler** is an Associate Professor with Global Food Studies, University of Adelaide, Australia. Her research interests are irrigated farming, organic farming, water markets, crime and gambling. Sarah is currently an associate editor of the Australian *Journal of Agricultural and Resource Economics*, a guest editor for a special edition for *Agricultural Water Management*, and on the editorial board of *Agricultural Science*.

**Dale Whittington** is a Professor in the Departments of Environmental Science and Engineering and City and Regional Planning at the University of North Carolina at Chapel Hill, USA and at the Manchester Business School, UK. He is the author of over 100 publications, including (with Duncan MacRae) a graduate textbook on public policy analysis, *Expert Advice for Policy Choice* (Georgetown University Press, 1997). He serves as a resource person and research advisor for three international environmental economics networks: Economy and Environment Program for Southeast Asia (EEPSEA); Latin American and Caribbean Environmental Economics Program (LACEEP); and the Center for Environmental Economics and Policy Analysis, South Africa (CEEPA). He is also an active participant in the Environment for Development (EfD) research network hosted by the Department of Economics at the University of Gothenburg, Sweden. Whittington is a member of the Technical Committee of the Global Water Partnership (GWP), and has served as consultant to the World Bank, Asian Development Bank, United States Agency for International Development, OECD, Hopi Tribe and numerous other organizations. In 2011–12 he was Distinguished Visiting Professor in the Department of Economics at the University of Gothenburg (Sweden). With Duncan Thomas (Manchester Business School), in the summer of 2014 Whittington taught the University of Manchester's Massive Open Online Course (MOOC) titled 'Water Supply and Sanitation Policy in Developing Countries'.

**Min-Qiang (Kent) Zhao** is an Assistant Professor in the Wang Yanan Institute for Studies in Economics, the MOE Key Laboratory of Econometrics and Fujian Key Laboratory of Statistical Science at Xiamen University, China. His research focuses on environmental economics and labor economics, with an emphasis on nonmarket valuation of environmental resources, structural change and development, migration and labor market policies. Before joining Xiamen University, he was a Postdoctoral Research Associate at the Center for Environmental Economics and Sustainability Policy at Arizona State University (Tempe) during 2010–11. Zhao received his bachelor's degree from the University of Maine at Farmington, his master's degree from the University of New Hampshire (Durham), and his PhD from the Ohio State University (Columbus).

**David Zilberman** is a Professor and holds the Robinson Chair in the Department of Agricultural and Resource Economics at the University of California, Berkeley, USA. David's areas of expertise include agricultural and environmental policy, the economics of innovation, risk and marketing, water, pest control, biotechnology, biofuels and climate change. David is a Fellow of the American Agricultural Economics Association (AAEA) and the Association of Environmental and Resource Economics (AERE), and is the recipient of the 2000 Cannes Water and the Economy Award. He won the AAEA 2002 and 2007 Quality of Research Discovery Award, and the 2005 and 2009 AAEA Publication of Enduring Quality Award. He has edited 16 books and co-authored 240 papers in refereed journals. David received his BA in economics and statistics at Tel

Aviv University, Israel, and his PhD at UC Berkeley in 1979. He has served as a consultant to the World Bank, FAO, USDA, EPA and CDFA. He served as department chair from 1994 to 1999, and was on the boards of the AAEA and C-FARE and on three NRC panels.



To my grandson Issa, whose love of water and the environment is exemplary  
Ariel Dinar

To my wife, Citra, and kids, Petra and AJ  
Kurt Schwabe

---

# Contents

---

<i>List of contributors</i>	viii
1 Introduction <i>Ariel Dinar and Kurt Schwabe</i>	1
PART I CONCEPTS AND THEORETICAL FOUNDATIONS	
2 Institutions and water <i>William K. Jaeger</i>	13
3 Sustainability economics of groundwater usage and management <i>Keith C. Knapp and Bradley Franklin</i>	32
4 Concepts and methods for assessing economic impacts from climate change on water resources <i>Brian H. Hurd</i>	56
PART II SECTORAL FOCUS	
5 Agricultural water management <i>Sarah Ann Wheeler, Rosalind Bark, Adam Loch and Jeff Connor</i>	71
6 Economic analysis of industrial water use <i>Steven Renzetti</i>	87
7 Residential water management: an economic perspective on policy instruments <i>V. Kerry Smith and Min-Qiang (Kent) Zhao</i>	103
8 The use of the ecosystem services approach in guiding water valuation and management: inland and coastal waters <i>Phoebe Koundouri and Osiel González Dávila</i>	126
9 Incentivizing interdependent resource management: watersheds, groundwater and coastal ecology <i>Kimberly Burnett, Sittidaj Pongkijvorasin, James Roumasset and Christopher A. Wada</i>	150
10 Hydropower management: electricity versus other values <i>Per-Olov Johansson and Bengt Kriström</i>	162
11 Water, land use and environmental aspects of biofuel production <i>David Zilberman and Scott Kaplan</i>	181

- 12 The economic sustainability paradigm and freshwater and marine fisheries governance 199  
*R. Quentin Grafton and Dale Squires*

### PART III WATER SOURCES

- 13 Economics of surface water management: a review 221  
*Frank A. Ward*
- 14 Wastewater management and reuse 239  
*Francesc Hernández-Sancho and María Molinos-Senante*

### PART IV ALTERNATIVE APPROACHES TO VALUING WATER

- 15 Experimental economics and water resources 263  
*Hernán Bejarano and James Shortle*
- 16 Nonmarket valuation and water resource management 283  
*Richard T. Carson*

### PART V WATER QUALITY MANAGEMENT

- 17 Model-based regulation of nonpoint source emissions 313  
*Kenneth A. Baerenklau and Jingjing Wang*
- 18 Salinity and groundwater management: a hydro-economic analysis 328  
*Kurt Schwabe and Keith C. Knapp*

### PART VI ADDRESSING WATER SCARCITY

- 19 Water markets: from theory to practice (with focus on the USA) 355  
*Kristiana Hansen*
- 20 Water conservation: thinking beyond the tap 372  
*Diane Dupont*
- 21 Conjunctive management of water resources in agriculture 388  
*Yacov Tsur*

### PART VII TRANSBOUNDARY WATER MANAGEMENT

- 22 Joint management of international water bodies under scarcity and variability 409  
*Ariel Dinar*
- 23 The economics of transboundary water management 434  
*Erik Ansink and Harold Houba*