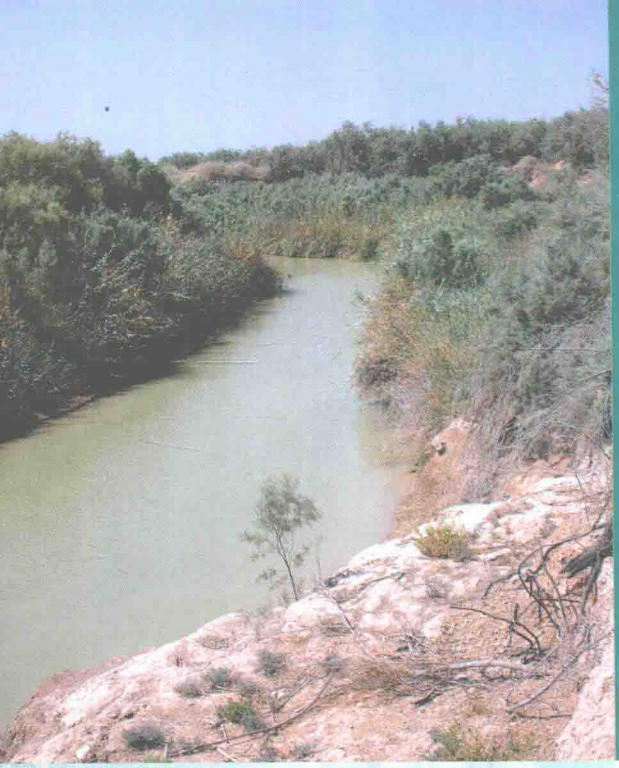
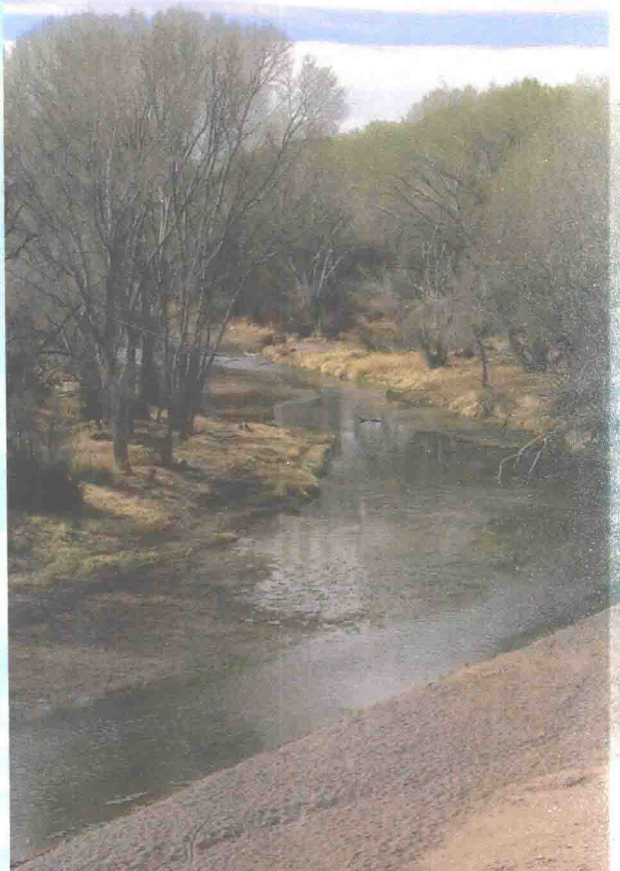


Shared Borders Shared Waters

Israeli-Palestinian and Colorado River Basin Water Challenges

EDITORS
Sharon B. Megdal
Robert G. Varady
Susanna Eden



CRC Press
Taylor & Francis Group
A BALKEMA BOOK

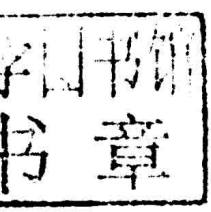
Shared Borders, Shared Waters

Israeli-Palestinian and Colorado River Basin Water Challenges

Editors

Sharon B. Megdal, Robert G. Varady & Susanna Eden

The University of Arizona, Tucson, Arizona, USA



CRC Press
Taylor & Francis Group
Boca Raton London New York Leiden

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

A BALKEMA BOOK

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

Typeset by V Publishing Solutions Pvt Ltd., Chennai, India
Printed and bound in The Netherlands by PrintSupport4U, Meppel

Published by: CRC Press/Balkema
P.O. Box 447, 2300 AK Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.com

Library of Congress Cataloging-in-Publication Data

Applied for

ISBN: 978-0-415-66263-5 (Hbk)
ISBN: 978-0-203-59768-2 (eBook)

Shared Borders, Shared Waters

Foreword

Fresh water is finite and universally sustains life as well as all aspects of human society. Its distribution, however, varies a great deal both in space and time, ignoring political boundaries and giving, therefore, rise to possible competition between uses and users. Increasingly felt global change phenomena, ranging from the impacts of population change to those of climate variability, exacerbate the stress on world's water resources. Increased industrialization, urbanization and agricultural needs, a growing world population and the need to adapt to climatic changes place high demands on the planet's water resources – and therefore on our vital capacity to manage, govern and share water wisely.

In a world with nearly 300 river basins shared by two or more countries, the management of water across political territories requires particular knowledge and skills to decrease the potential for conflicts and find mutually acceptable solutions through cooperation among the stakeholders of a limited but vital resource, water.

In 2009, the University of Arizona in Tucson hosted the *Arizona, Israeli, and Palestinian Water Management and Policy Workshop* (AzIP), with the support of UNESCO. The workshop was held in one of the driest regions of the planet. International experts coming from various disciplines, ranging from the fields of science, water management and governance, examined transboundary water management and cross-border cooperation in comparable environmental settings: naturally scarce water resources under high pressure from various sectors. The AzIP workshop gave the impulse for this book, *Shared Borders, Shared Waters*. It reflects the expertise of the participants of the workshop and of international water experts in developing and evaluating feasible water management solutions and demonstrates the value of a science-based policy dialogues in a highly sensitive context.

Through its M.Sc. course on Water Conflict Management, UNESCO-IHE trains water experts to manage shared water resources and resolve water conflicts, focusing on negotiation, mediation and decision-making processes. By co-publishing *Shared Borders, Shared Waters*, UNESCO-IHE is proud to further contribute to the expansion of the knowledge base for water cooperation and good governance and to help provide an innovative source for researchers and decision makers.

As global environmental and demographic changes heighten competition for limited water resources, we are thankful for efforts that attempt to harness science to achieve effective water-management policies. *Shared Borders, Shared Waters* is that rare book that seeks to promote this aim by drawing on the expertise of scientists and practitioners from sometimes-contentious border regions. In spite of its conflict

potential, water connects rather than divides, giving us hope for increased cooperation and conflict avoidance. For the arid areas that are the focus of this collection, the book offers the promise of the best of science diplomacy.

The Editors of this valuable volume, Sharon Megdal, Robert Varady and Susanna Eden, deserve a great deal of appreciation for their brave and bold act to bring together experts from various disciplines and areas of potential water conflicts to turn those, through open and intelligent dialogs, into areas of potential cooperation.

András Szöllösi-Nagy
Rector
UNESCO-IHE Institute for Water Education
Delft, The Netherlands

Preface

This book traces its origins to 2006. That summer, lead editor Sharon Megdal, the director of the University of Arizona (UA) Water Resources Research Center, traveled to Israel to explore what she saw as potential commonalities between that country's water-resources-management challenges and those faced by Arizona, in the arid southwestern United States. Megdal toured the region, meeting with officials, academics, and practitioners. She found that in spite of the dramatically different histories of the two regions, a number of palpable similarities emerged: the prevalence of drought, problems of salinity, the promise of seawater desalination and effluent reuse; and the significance of institutions, water pricing, and allocation policies across water-using sectors. The experience whetted Megdal's appetite for a deeper, more sustained examination of these issues.

At about the same time, co-editor Robert Varady, deputy director of the UA's Udall Center for Studies in Public Policy, was invited by UNESCO's International Hydrological Programme (IHP) to participate in an unusual event organized by the Israeli-Palestinian Science Organization (IPSO). IPSO was embarking on a multiyear effort to produce the first modern history of water management in Israel-Palestine. That December, Varady – at the time the secretary of the International Water History Association – attended a special meeting in Perugia, Italy, convened by IHP and hosted by the Government of Umbria. The other participants were the Israeli and Palestinian co-directors of IPSO, three distinguished Israelis and thee prominent Palestinians (including the present head of the Palestinian Water Authority), two UNESCO officials, and a few host-country dignitaries. The chief outcome of this two-day session was a commitment to pursue the history project and any related activities that might promote its achievement.

Soon after, in early 2007, Megdal and Varady met, compared experiences, and agreed to collaborate by holding a workshop designed to merge the two sets of interests, both concerning the topic of water. Megdal's aim was to effect a comparison of water-management and policy in the two regions, while Varady sought to introduce temporal context into the discussion. Discussions with Ed Wright, Director of the Arizona Center for Judaic Studies at the UA, and Anne Betteridge, Director of the UA Center for Middle Eastern Studies, confirmed their interest in joining this effort to share lessons learned and identify solutions to the myriad water challenges faced by the regions.

The result of these discussions was the September 2009 Arizona-Israeli-Palestinian Water Management and Policy Workshop hosted by the University of Arizona in

Tucson, Arizona. The program explored salient issues relating to water scarcity in the two regions, but its thrust was an attempt to understand the economic, environmental, and community implications of expanding reuse and desalination for sustaining future water supplies.

The workshop represented an intensive planning effort involving four University of Arizona centers whose missions reflect the span of topics included in the workshop. The Water Resources Research Center, the Udall Center for Studies in Public Policy, the Center for Middle Eastern Studies, and the Arizona Center for Judaic Studies worked together for 18 months to attract experienced and knowledgeable experts from the two regions.

At the workshop, invited presentations by expert scientists and practitioners formed the basis of the discussion. In addition to invited speakers, the workshop included young scholars as full participants. These emerging researchers contributed actively and participated throughout the workshop.

The workshop was motivated by the identified similarities of two transboundary, water-scarce areas whose populations and economies are growing. Arizona, a state in the southwestern United States, bordering Mexico, relies significantly on the over-allocated Colorado River as well as on non-renewable groundwater supplies. Across the globe, the Israeli-Palestinian region is supplementing its traditional water sources with desalinated seawater. Both regions are suffering from chronic water scarcity that is likely to be exacerbated by unfavorable climate conditions should climate change projections prove accurate. In addition, in each case, legal frameworks for surface water and groundwater rights and use remain subjects of debate. Sustainable and cost-effective solutions to the water challenges of the two regions clearly require innovative, multifaceted approaches.

A central goal of the program was to identify potential future collaborative activity. While the workshop acknowledged the various divides that exist in these regions, the participants – and in this volume, the authors – were guided by the principle of "science diplomacy." Across the world, the history of contentious water issues confirms that the resolution of such issues can engender collaboration rather than divisiveness. Experience has shown that researchers who are sensitive to sociopolitical conditions often can help avoid or resolve conflict by serving as neutral experts, offering assistance through reasoned, independent analysis.

The workshop, grounded on this premise, and the volume that it has spawned benefited from consultation with many colleagues on both sides of the Atlantic. The book, while based upon the event and relying on its key presentations, is substantially enhanced by newly-commissioned chapters with additional insights and analyses by authors who did not participate in the 2009 workshop. It includes perspectives on past and present water management challenges. It looks to current and future solutions for the two regions, where shared borders and shared waters are fundamental to water management dialogues.

The chapters confirm that much work remains to be done. Policy makers, water managers, experts such as university researchers and consultants, and citizens – the ultimate beneficiaries or losers of public policies – will all be involved in development and implementation of sustainable solutions to the many challenges.

Preparation of this volume drew from the insights and expertise of many across the globe, including many who are budding scholars. In a field that has been traditionally

dominated by males and by engineers, this collection benefits from significant gender diversity as well as disciplinary diversity among our authors. We are especially pleased to note that several of our female authors, in particular, are in the early stages of their careers. Whatever our individual role in developing water solutions, it is important that we encourage and support the development of future water leaders.

Of course we hope this book informs the reader; but perhaps more importantly, we hope it will stimulate consideration of how we can bridge the divides to cross borders and share the waters.

Sharon B. Megdal, Robert G. Varady and Susanna Eden

Acknowledgments

We begin by thanking the many authors who have contributed their research and observations to this collection. We have already noted their diversity, but we should also acknowledge their expertise, their commitment to improving water-management policy, and their patience through an extended publication period.

The workshop, and therefore the present volume, could not have been possible without grants from the U.S. National Science Foundation (NSF), the U.S.-Israel Binational Science Foundation (BSF), and the University of Arizona Foundation. We are grateful to program official, Geoffrey A. Prentice, and official contacts Martha Ione and Osman Shinaishin of NSF, and Yair Rotstein, the executive director of BSF. Other financial support was provided by UNESCO-IHP, then directed by András Szöllösi-Nagy; the UA Faculty Research Development Grant program; UA Water Sustainability Program and Technology Research Initiative Fund (TRIF); International Arid Lands Consortium; International Water History Association; Israeli-Palestinian Science Organization; Sol Resnick Water Resources Research Endowment; UNESCO International Hydrological Programme; United Nations Association of Southern Arizona; Tucson Water; Elaine Minow Resnick; Arizona Center for Judaic Studies; Center for Middle Eastern Studies; Udall Center for Studies in Public Policy; and Water Resources Research Center.

A number of individuals bear special recognition for their support and assistance throughout the process leading to the appearance of this volume. At the University of Arizona in Tucson, the president, Robert Shelton, addressed the public event held as part of the workshop and provided institutional support. J. Edward Wright, the director of the UA's Arizona Center for Judaic Studies; and Anne H. Betteridge, the director of the UA's Center for Middle Eastern Studies were stalwart supporters and cosponsors of the workshop. Also at the UA, staff members of the Water Resources Research Center offered invaluable assistance in organizing the workshop and in preparing the manuscript; we thank LaVonne Walton, Jane Cripps, Joe Gelt, Marissa Tamar Isaak, Kelly Mott-Lacroix, Chet Phillips, and Hunter Richards.

Meanwhile, in Europe, Alexander Otte at IHP in Paris, was instrumental in arranging for UNESCO support for and cosponsorship of the workshop, and for the publication of the volume. Léna Salamé, also at IHP, helped facilitate the publication process. In 2012 this process was taken on by UNESCO-IHE in Delft, The Netherlands, through the good offices of the rector, András Szöllösi-Nagy, Bart Schultz, chair of IHE's publications board. Thanks also are due to Janjaap Blom, Senior Publisher, and Lukas Goosen, Production Manager, Taylor & Francis Group/CRC Press

Balkema, and to Peter Stroo, graphic designer for IHE, for shepherding this book through publication.

The Tucson workshop was fortunate to have presentations by Uri Shani, at the time the head of the Israeli Water Authority, and (via video) by Shaddad Attili, the head of the Palestinian Water Authority. Their involvement facilitated participation by their Israeli and Palestinian colleagues. The program and this book have similarly benefited from collaboration with the Israeli-Palestinian Science Organization and their respective co-directors, Dan Bitan and Hassan Dweik. Jill Shaunfield of the U.S. Department of State attended the workshop and provided continuing encouragement.

The richness of this volume was informed by the presentations and discussions that took place during the Tucson workshop. We are grateful to all the workshop participants for their contributions.

After the workshop, in early 2010 two of the editors (Megdal and Varady) were able to discuss the subject of this book with a number of scientists, administrators, and NGO representatives in Israel and in the Palestinian territories, including Uri Shamir, Shaul Arlosoroff, David Katz, Paul Rohrlich, Fuad Bateh, Nader Al-Khateeb, Dan Bitan, and Hassan Dweik.

Finally, we would like to give special thanks to the anonymous reviewers who contributed their expertise to ensuring and enhancing the high quality of the individual chapters.

Acronyms

ACC: Arizona Corporation Commission
ADWR: Arizona Department of Water Resources
AE: Actual Evapotranspiration
AFY: Acre Feet per Year
AMA: Active Management Area
AOGCM: Atmosphere-Ocean General Circulation Model
AWS: Assured Water Supply
AWTF: Advanced Water Treatment Facility
BADCT: Best Available Demonstrated Control Technology
BCM: Billion Cubic Meters
BECC: Border Environment Cooperation Commission
BEIF: Border Environment Infrastructure Fund
BOD: Biochemical Oxygen Demand
BOO: Built, Owned & Operated
BOR: Bureau of Reclamation
BOT: Build, Operate & Transfer
CA: Chemical Addition
CAP: Central Arizona Project
CAPEX: Capital Expenditures
CCI: Control-Check-Isolate
CEA: Controlled Environment Agriculture
CEC: Commission for Environmental Cooperation
CEC (2): Contaminants of Emerging Concern
CF: Cartridge Membrane Filtration
CILA: Comisión Internacional de Límites y Aguas
CM: Cubic Meters
CONAGUA: Comisión Nacional del Agua
CRU: Climatic Research Unit
DFID: Department for International Development
DOP: Declaration of Principles
DWR: Deptartment of Water Resources
EDR: Electrodialysis Reversal
EMS: Environmental Management System
ENSO: El Niño-Southern Oscillation
EPA: Environmental Protection Agency

ET: Evapotranspiration
GAO: General Agricultural Ordinance
GCM: Global Climate Model
GDP: Gross Domestic Product
GFD: Gallons per square Foot per Day
GHG: Greenhouse Gas
GMA: Groundwater Management Act
GMF: Granular Media Filtration
GPCD: Gallons Per Capita per Day
GTZ: German Agency for Cooperation
IBC: International Boundary Commission
IBWC: International Boundary and Water Commission
ILA: International Law Association
ILC: International Law Commission
INA: Irrigation Nonexpansion Area
IOI: International Outfall Interceptor
IPCC: Intergovernmental Panel on Climate Change
ISARM: Internationally Shared Aquifer Resources Management
IWRM: Integrated Water Resource Management
JRV: Jordan Rift Valley
JSET: Joint Supervision and Enforcement Team
JWC: Joint Water Committee
L/C/D: Liters per Capita per Day
LCRB: Lower Colorado River Basin
LCRMSCP: Lower Colorado River Multi-Species Conservation Program
LPWTF: Lewis Prison Water Treatment Facility
MAF: Million Acre Feet
MC: Marginal Cost
MCL: Maximum Containment Level
MCM: Million Cubic Meters
MCMY: Million Cubic Meters per Year
MDPF: Marana Desalination Pilot Facility
MF: Membrane Microfiltration
MGD: Million Gallons per Day
MoU: Memorandum of Understanding
NADB/NADBank: North American Development Bank
NAFTA: North American Free Trade Agreement
NGO: Nongovernmental Organization
NIWTP: Nogales International Wastewater Treatment Plant
NWC: National Water Carrier
OPEX: Operation Expenditures
OPT: Occupied Palestinian Territory
PA: Palestinian Authority
PE: Population Equivalent
PE (2): Potential Evapotranspiration
PLS: Partial Lime Softening
PPP: Polluter Pays Principle

PS: Permeate Stabilization
PWA: Palestinian Water Authority
R&D: Research And Development
RCM: Regional Climate Model
RO: Reverse Osmosis
SAIC: Science Applications International Corporation
SAR: Sodium Adsorption Ratio
SAT: Soil Aquifer Treatment
SMX: Sulfamethoxazole
SRES: Special Report on Emissions Scenarios
SRP: Salt River Project
SUSMAQ: Sustainable Management of the West Bank and Gaza Aquifers
SWRO: Sea Water Reverse Osmosis
TAAP: Transboundary Aquifer Assessment Program
TDS: Total Dissolved Solids
TOR: Terms of Reference
TSS: Total Suspended Solids
UCRB: Upper Colorado River Basin
UN: United Nations
UNESCO: United Nations Educational, Scientific and Cultural Organization
USGS: U.S. Geological Survey
VMP: Value of The Marginal Product
VSEP: Vibratory Shear Enhanced Processing
WB: West Bank
WDA: Water Desalination Administration
WHO: World Health Organization
WIFA: Water Infrastructure Finance Authority
WMIDD: Wellton-Mohawk Irrigation and Drainage District
WRP: Water Reclamation Plant
WWTF: Wastewater Treatment Facility
WWTP: Wastewater Treatment Plant
YDP: Yuma Desalting Plant
YHWWTP: Yad Hanna Wastewater Treatment Plant

Key terms and definitions

Acre-foot: One acre of surface area to a depth of one foot (unit of volume)
Alluvial: Deposited by flowing water
Anti-scalant: Additive for water to delay impurity accumulation, to be used in preparation for reverse osmosis
Aqueduct: A device or channel constructed to convey water
Brackish: A type of water that is more saline than freshwater, but less than seawater
Brine: Saline water containing more than 100,000 mg/L TDS
Chloramine: A disinfectant for treating drinking water
Contaminants of emerging concern: Chemicals found in drinking water that may be more concentrated than previously known, which may be of danger to humans or the environment
Co-riparian states: States which share a boundary along a riparian zone due to a river or stream
Cryosphere: Earth's collective ice-covered regions
Desalination: Process used to remove salt or minerals from saline water to make it more suitable for certain purposes
Drip irrigation: A water- and fertilizer-saving irrigation method which gradually delivers small amounts of water and nutrients directly to a plant's roots
Effluent: Treated or untreated wastewater that flows out of a waste water treatment plant or other facility
Electrodialysis reversal: An electrochemical separation method that is used to remove charged particles from water
Enjoin: To legally prohibit or require a specific action
Epikarst: The surface of karst, along with its fissures and cavities that collect surface-water and transport it underground
Estuarine ecosystems: Ecosystems found in partly enclosed bodies of water, connected to the open sea, with nearby rivers or streams
Eutrophication: A water ecosystem's response to the addition of various substances found in waste, such as sewage or fertilizer
Evapotranspiration: A portion of the water cycle that involves both evaporation and the loss of a plant's water in the form of vapor through transpiration
Flocculation: In chemistry, the process by which colloids come out of suspension following the addition of a clarifying agent
Fodder: Feed for domesticated agricultural livestock

Fouling/Biofouling: The accumulation of undesirable material, organic or inorganic, onto the solid surface of a device that hinders its ability to function
Granular media filtration: An intermediate step in a water treatment or filtration process that generally takes place after gravity separation
Halophyte: A plant that grows in highly saline waters
Hectare: One thousand square meters of area, commonly used in measurement of land
Hydraulic slope: The slope of the bottom of a water channel
Influent: Anything that flows into a body of water
Karstic: Shaped by the dissolution of soluble layers of bedrock
Khamasin event: A hot, dry cyclone
Kibbutz: Communal village in Israel, traditionally based on agriculture
Moshav: Cooperative agriculture-based village in Israel
Multi-partite basins: River basins with more than two nearby riparian countries
Nanofiltration: Membrane filtration process, used mostly with low TDS water, for removing unwanted materials
Nitrification-denitrification: A microbial wastewater treatment process that involves converting ammonium ions to nitrogen gas
Oxidation ponds: Ponds used for secondary treatment of sewage effluents, in which bacteria break down organic matter
Paramaterization: Approximation by analysis of average effect and sensitivity to change
Parts per million: Measurement used to describe dilute concentrations in water or soil
Pervaporation: Process used to separate mixtures through partial vaporization through a membrane
Photovoltaic: Related to the conversion of solar radiation into electricity
Potentiometric surface: Hypothetical surface representing the height to which water trapped in an aquifer would rise if it were not confined
Reverse osmosis: Method of membrane filtration in which a saline liquid is pressurized on one side of a membrane, forcing out the solvent but leaving unwanted materials on the other side of the membrane
Riparian zone: An area characterized by the meeting of land with a river or stream
Safe-yield: Water management goal for achieving a long-term balance between annual amount of groundwater withdrawn in an active management area and annual recharge
Saline: Characteristic of water that contains a significant amount of dissolved salts
Silviculture: The practice of managing health, growth, and other characteristics of forests to meet specified needs
Sodium absorption ratio: Measurement of suitability of water for agricultural irrigation, as determined by the amount of dissolved solids in the water
Specific flux: Permeate flux divided by net transmembrane pressure difference
Vadose zone: Portion of Earth extending from the top of the ground surface to the water table
Wadi: Intermittent stream that remains dry except during the rainy season

Contents