

# Building Resilience for Uncertain Water Futures

Patricia Gober

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*To Howard, my partner in water science and in life*

# Preface

This book follows from a graduate seminar in water policy taught in the Schools of Sustainability at Arizona State University in Tempe, Arizona, and Public Policy at the University of Saskatchewan in Saskatoon, Canada. Over the course of ten years, the course attracted an interdisciplinary audience of students from geography, sustainability, civil engineering, public administration, policy studies, and environmental science. Some had considerable knowledge of a narrow field of water science but wanted a broader synthesis of water problems and their potential solutions. They were attracted to the social science and policy dimensions of the course and to the effort to integrate those perspectives with climatology, hydrology, and ecology.

The course evolved somewhat over the ten years to include the perspectives of the international students and more international issues, but the storyline remained constant. It begins with the woeful state of global water resource management, overuse, and increasing pressure on water systems from climate change. Emphasis is on the lack of human capacity to deal with climate change rather than on a warmer planet per se. The water sector's longstanding practices of optimization and prediction, efforts to control water systems for human use, separation of water decisions from public input, and emphasis on water engineering practice present particular problems in the face of today's rapid and uncertain environmental and societal change.

Students were aware of the many vulnerabilities in existing water systems for people, the economy, and environment. They were eager for a more structured way of thinking about vulnerability from a natural hazards perspective. The idea of “hidden vulnerabilities” that lie in water’s complex relationships with food, energy, and land and transcend scale particularly intrigued them. Also significant were competing values about water that are manifest in the way cities price water, difficult choices made during drought events, and efforts by Indigenous peoples to reassert their water rights.

At this point in the class, it was clear that today’s water issues are not solely the sort of technical and scientific problems seen in coursework in hydrology, policy, and geography. These are complex system problems with the capacity for surprise and problems of deep uncertainty where there are profound value-based disagreements about how to proceed. Considerable discussion centered on the recent climate attitudinal data because they reveal deep societal divides and competing worldviews about climate adaptation and, by implication, water management. Case studies at local and regional levels reveal the different ways that people see water as having value in their lives and the trade-offs they are willing to make to get what they want from the water sector.

The last part of the course shifts to ideas that improve long-term planning and adaptation. Resilience involves the capacity of a system to absorb recurrent natural and human shocks without slowly degrading or even unexpectedly flipping into a less desirable state. Decision Making Under Uncertainty (DMUU) provides a framework for addressing problems of deep uncertainty where parties do not agree on the problem definition itself, the probability distributions that convey risk, and who will be winners and losers in this scheme. Wicked problems are, by definition, complex, uncertain, and controversial. Managing water as a wicked problem requires greater emphasis on the social aspects that surround water problems. Socio-hydrology is a new trend in hydrology that includes the human dimensions in water science and the social processes that connect the science to decision-making and public values. The idea of social learning, in which people learn best in groups, has potential to unite scientists, decision-makers, and the public in efforts to solve local water problems.

Each year, members of the class collaborated to develop a framework for evaluating urban climate adaptation efforts worldwide. These adaptation efforts include water problems (sea level rise, storm surge, flooding, water quality, sanitation, and resources), but they are more broadly focused on adapting cities to climate change. Cities are logical places for policy action because they are at the level where most people experience water problems and understand the trade-offs in decision-making. In a structured evaluation of adaptation efforts at the city scale, students explored water's complicated relationship with land, food, energy, urban design, urban heat islands, and economy. They saw the ideas of resilience, DMUU, wicked water, socio-hydrology, and social learning put into action on the ground across the world. They came away with an appreciation that today's water problems are not simple technical and science problems but social and policy issues that reflect competing values, hidden vulnerabilities, deep uncertainties, and potential for surprise.

This book evolved from class reading lists, projects, guest speakers, discussion groups, movies, and students from across the world who shared their own very personal experiences with water and water problems. It provided me with a way to see my own research about water, climate, and adaptation issues in the Phoenix area and Western Canada as part of a large global story about water resource management in an era of rapid and uncertain environmental and societal change.

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# Acronyms

ADWR	Arizona Department of Water Resources
AMA	Active Management Area
BIA	Bureau of Indian Affairs
C	Centigrade
CAD	Canadian dollar
CAGR	Central Arizona Groundwater Replenishment District
CAP	Central Arizona Project
CBC	Canadian Broadcasting Corporation
CC&Rs	covenants, codes and restrictions
CO <sub>2</sub>	carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organization
DCDC	Decision Center for a Desert City
DMUU	Decision Making Under Uncertainty
EQCC	Quito Strategy for Climate Change
EQCC	Quito Strategy for Climate Change
ET	evapotranspiration
FIFA	Fédération Internationale de Football Association, International Federation of Association Football
FITFR	First-In-Time-First-In-Right water allocation system
GHG	Greenhouse Gas
GMA	Groundwater Management Act of 1980
GNP	Gross National Product

GRACE	Gravity Recovery and Climate Experiment
GRIC	Gila River Indian Community
HOA	homeowner association
IPCC AR5	Intergovernmental Panel on Climate Change Assessment Report 5
IPCC	Intergovernmental Panel on Climate Change
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MEC	Metropolitan East Coast
NAFTA	North American Free Trade Agreement
NASA	National Oceanic and Atmospheric Administration
NVCH	North Village Cumberland House
NWI	National Water Initiative
PDSI	Palmer Drought Severity Index
PUB	Public Utilities Board
RO	Reverse Osmosis reclaimed water
SNWA	Southern Nevada Water Authority
SWTP	South-North Water Transfer Project
TGD	Three Gorges Dam
UHI	urban heat island
UKCIP	United Kingdom Climate Impact Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNESCO-IHE	Delft Institute for Water Education
USCRP	United States Climate Research Program
USDA	United States Department of Agriculture
USGU	United States Geological Survey
WELF nexus	water-energy-land-food nexus
WRM	Water Resources Management

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