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Úrsula Oswald Spring
Editor

Water Resources in Mexico

Scarcity, Degradation, Stress, Conflicts, Management, and Policy

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Water Resources in Mexico

Scarcity, Degradation, Stress, Conflicts, Management, and Policy

With 196 Figures and 74 Tables

Springer

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The top photograph illustrates the impact of a flood in Tabasco; the lower-left photograph shows campesinos planting onions in El Pañuelo and the lower-right photograph a water ceremony in El Texcal, both in the state of Morelos in Mexico. All photographs were taken by Úrsula Oswald Spring, who also holds the copyright.

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Lastly, it is important to highlight that this is the first collective work that presents the state of the art of water research in Mexico to a global audience. It reflects the first steps towards a complex, interdisciplinary, inter-institutional and international understanding of water-related issues. It also includes many concrete proposals for improving water management policy globally. It is hoped that these positive suggestions and constructive critiques will help Mexico to move gradually towards a better environmental, social, political and culturally sustainable water management that will generate well-being, enhance the quality of life, reduce the number of water-related conflicts and thus contribute to water-peace for all inhabitants of this beautiful country.

Cuernavaca, Morelos, 10 April 2011 Úrsula Oswald Spring, editor

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- *Figure* 2.2: Spatial distribution of annual precipitation. *Source*: CONAGUA (2008b).
- *Figure* 2.4: Regional contrast in terms of development and water availability. *Source*: CONAGUA (2008).
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- *Figure* 2.15: Over-exploited aquifers by hydrological and administrative region. *Source*: CONAGUA (2008c).

Some figures are based on previous publications by *Felipe I. Arreguín Cortés* and co-authors, for which they hold the copyright:

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- *Figure* 2.10: Behaviour of maximum temperature in Mexico, 1961-2040. *Source*: Arreguín, Chávez, and Rosengaus (2008).
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- *Figure* 2.18: Soil moisture for May 2009 (in mm). *Source*: CPC and NOAA (2009); at: <http://www.cpc.ncep.noaa.gov/soilmst/leaky glb.htm>.

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- *Figure* 2.9: Sealevel variation (period 1883-2004). *Source***:** Modified and extended by the authors based on Douglas (1997).

In chapter 3 *Ignacio Sánchez Cohen, Úrsula Oswald Spring, Gabriel Díaz Padilla,* and *José Luís González Barrios* developed figures 3.1 to 3.4. Some figures are based on previous publications by *Ignacio Sánchez Cohen* and *Úrsula Oswald Spring* for which they hold the copyright:
- *Figure* 3.3: Conceptual model of the cascade effect stemming from precipitation problems in basin RH36. The grids portray gaps in knowledge. *Sources*: Sánchez (2005: 44); Sánchez et al. (2006: 2, 2007: 13).
- *Figure* 3.5: Structure of an integrated water management model in a basin: dynamic, self-regulated and dissipative system with four subsystems. *Source*: Oswald (2005: 68).
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- *Figure* 3.6: Decision-making chart at the basin level. *Source*: CONAGUA (2003: 3).

In chapter 4 *Gabriel Díaz Padilla, Ignacio Sánchez Cohen,* and *Rafael Alberto Guajardo Panes* relied in figures 4.3 to 4.7, 4.8 and 4.9 to 4.16 and in table 4.1 to 4.5 on the results of their research. They also used material from CONAGUA that is in the public domain:
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- *Figure* 4.1: Start-up panel of the R-ClimDex 1.0 program. *Source*: Zhang/Yang (2004).

In chapter 5 *Miguel Rangel Medina, Rogelio Monreal Saavedra,* and *Christopher Watts* developed figures 5.6, 5.7, and 5.11 based on their research. Some figures are based on previous publications by *Miguel Rangel Medina* for which he holds the copyright:
- *Figure* 5.3: Left: the location of aquifer zones in the Sonora River basin; shading represents different districts of rural development (DDR). Aquifers in the valley whose recharge is modern and the Coast of Hermosillo (CH) with millennial recharge are sh. Right: the administrative division of the aquifers showing DDR 141 (CH) with direction of regional flows. *Source*: Rangel Medina (2006).
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- *Figure* 5.2: Drought indexes in the Sonora River basin. *Source*: CONAGUA (2007).

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- *Table* 5.1: Classification of climate types by average annual precipitation. *Source*: Bull (1991).

In chapter 6 *Eugene Perry, Guadalupe Velazquez Oliman,* and *Niklas Wagner* designed figures 6.1 and 6.2 and compiled tables 6.1 based on their research as well as on photos taken by them (figures 6.4, 6.5). Some figures are based on previous publications by *Eugene Perry* for which he holds the copyright:

- *Figure* 6.3*:* Sulphate *vs*. chloride concentration. *Source:* Research data. Vertical axis is 1000[(Sr)/(Cl)]. Horizontal axis is 1/(Sr). Both axes are in units of millimoles/kg. On this plot, mixtures of two waters plot along a straight line. Labels as in figure 6.2. In addition, diamonds are samples from Yucatan state and northern Quintana Roo (taken from Perry et al., 2009).

In chapter 7 *Jaime Garatuza Payán, Julio Cesar Rodríguez,* and *Christopher J. Watts* compiled tables 7.1 and designed figures 7.2, 7.4, and 7.5 based on their research. The following documents do not require permission as they contain research results of the authors:

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In chapter 8 *Felipe Omar Tapia Silva* designed figure 8.4 based on his research. One figure is based on previous publications by *the author* for which he holds the copyright:

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He used the following material that is in the public domain:

- *Figure* 8.6: Principal screen of a geomatic artefact on the web (under development). *Source*: Mexican Geographic Information System of Water Basins; at: <http://xsei.centrogeo.org.mx/ine/>.
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- *Figure* 8.2: Left: Aquifer vulnerability to contamination in the Mexico Valley basin. Right: index of sources of contamination for the Mexico City urban sprawl zone. Source: Ramos Leal et al. (2010).

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In chapter 11 *Lyssette E. Muñoz Villers, Miguel Equihua, Conrado Tobón,* and *Francisco J. Gutiérrez Mendieta* compiled tables 11.1 to 11.3 based on their research. Three figures are based on previous publications by *Lyssette E. Muñoz Villers* for which she holds the copyright:
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One figure is based on a master thesis that was guided by the author:

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In chapter 16 written by *Francisco Javier Avelar González, Elsa Marcela Ramírez López, Ma. Consolación Martínez Saldaña, Alma Lilián Guerrero Barrera, Fernando Jaramillo Juárez,* and *José Luís Reyes Sánchez* table 16.1 is based on the authors' research.

In chapter 18 *Julia Pacheco Avila, Armando Cabrera Sansores, Manuel Barcelo Quintal, Ligia Alcocer Can,* and *Mercy Pacheco Perera* drafted figures 18.1 to 18.6 and compiled tables 18.1 to 18.5 based on their research.

In chapter 19 *Catherine Mathuriau, Norman Mercado-Silva, John Lyons,* and *Luis Manuel Martínez-Rivera* compiled figures 19.1, 19.2, and 19.3 and compiled table 19.1 based on their research.

In chapter 20, *Salvador Israel de la Garza González* and *Raúl Herrera Mendoza* compiled all figures 20.1 to 20.13 based on their research.

In chapter 21 *Ramiro Vallejo Rodríguez* and *Alberto López López* compiled table 21.1 based on their research. Three tables were adapted from the copyrighted material based on their research results:

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In chapter 23, *Úrsula Oswald Spring* drafted figure 23.1 based on her research and on previous publications for which she holds the copyright:

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The following four figures were done by former students of the author under her supervision:
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- *Figure* 25.7: Soil distribution. Source: Pérez Hernández (2006: 58).
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In chapter 26 *Claudia Rocío González Pérez* and *Antonina Galván Fernández* drafted figure 26.1 and compiled table 26.1 based on their research. For the following figure permission was granted by the copyright holder:
- *Figure* 26.2: Cycle of knowledge management. *Source*: Solis and López (2000).

In chapter 28 *Jorge A. Morales Novelo* and *Lilia Rodríguez Tapia* developed several figures and tables based on data from SEMARNAT that are in the public domain:

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In chapter 29 *Arsenio Ernesto González Reynoso* and *Itzkuauhtli Zamora Saenz* drafted figures 29.3 and 29.4 based on their research. The remaining two figures are based on an official government plan that is in the public domain:

- *Figure* 29.1: Location of the Magdalena River basin. *Source*: Master Plan of Integral Sustainable Management of the Magdalena River Basin in Mexico City (SMA-GDF, UNAM, 2008: 9).
- *Figure* 29.2: The planning area of the Magdalena River Master Plan. *Source*: Master Plan of an Integral Sustainable Management of the Magdalena River Basin in Mexico City (SMA-GDF, UNAM, 2008: 16).

In chapter 30 *Alejandra Martín Domínguez, Víctor Javier Bourguett Ortiz, Flor Virginia Cruz Gutiérrez, Miguel Ángel Mejía González, Víctor Hugo Alcocer Yamanaka, Juan Maldonado Silvestre, Gustavo Armando Ortíz Rendón, Petronilo Cortés Mejía, Arturo González Herrera, Martín Piña Soberanis, Ma. de Lourdes Rivera Huerta, Leticia Montellano Palacios, Carlos Eduardo Mariano Romero, and Velitchko Georguiev Tzatchkov* drafted figures 30.1, 30.3, and 30.4, contributed one photograph (figure 30.2), and compiled tables 30.1 to 30.3 based on their work.

In chapter 31 *Rosario Pérez Espejo* designed one figure (31.1) and compiled tables 31.1 to 31.4 based on official government publications that are in the public domain:

- *Figure* 31.1: Location of the state of Guanajuato, Mexico. *Source*: Developed by author, based on INEGI (2009), "Información geográfica".