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Úrsula Oswald Spring  
*Editor*



# Water Resources in Mexico

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

 Springer

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Editor

# Water Resources in Mexico

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

With 196 Figures and 74 Tables



*Editor*

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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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Cuernavaca, Morelos, 10 April 2011

Úrsula Oswald Spring, editor

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- *Table 15.4*: Proposed Environmental Matrixes for TPBS Monitoring. *Source*: Hansen et al., (2006).

One figure and one table rely on material by CONAGUA that is in the public domain:

- *Figure 15.1*: Delimitation of the Mexican hydrological basins. *Source*: CONAGUA (2009).
- *Table 15.1*: Distribution of RNM Monitoring Sites. *Source*: CONAGUA (2008b).

One figure is based on a source that is in the public domain:

- *Figure 15.2*: North America and MDN Sites. Blue symbols: active sites; white symbols: inactive sites. *Source*: NADP (2009).

One figure is based on a master thesis that was guided by the author:

- *Figure 15.4*: Arcediano Dam River Basin. *Source*: Corzo Juárez (2009).

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:

- *Table 21.2*: Methods of analysis used by various authors for the identification of EDCs and ECs. *Source*: Adapted from Yu Zirui (2007).
- *Table 21.3*: Comparison of rate constants of molecular ( $k_{O_3/M}$ ) and radical ( $k_{HO\cdot/M}$ ) oxidation of  $O_3$  on some EDCs and pharmaceuticals. *Source*: Adapted from Naghashkar and El-Din (2005a).
- *Table 21.4*: AOP- $O_3$  applied to different types of water and under different conditions. *Source*: Adapted from Esplugas et al. (2007).

In chapter 22 *Linda González* and *Eleazar Escamilla Silva* drafted figures 22.1 to 22.14 and compiled all tables 22.1 to 22.7 based on their research.

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

- *Figure 23.4*: Interrelationship between water supply, human demand, and potential conflicts. *Source*: Oswald Spring/Davis Mazlum, in: Davis Mazlum (2004: 17).

- *Figure 23.10*: Hydrodiplomacy. Source: Author's elaboration based on Oswald Spring/Davis Mazlum in Davis Mazlum (2004: 19).
- *Figure 23.11*: Sustainable Water Management. Efficiency and Equity with Natural Resources. Source: Developed by the author.

The following material is in the public domain:

- *Figure 23.2*: Green and Blue Water Global Flow. Source: UNEP (2007).
- *Figure 23.3*: Annual Rainfall in Mexico. Source: CONAGUA (2009).
- *Figure 23.5*: Causes of land degradation in Mexico, a) desertification, b) salinization, c) water erosion, d) wind erosion. Source: SEMARNAT, INE (2005) based on CONAZA (1994).
- *Figure 23.6*: Population growth in Mexico City. Source: INEGI (1960-1990).
- *Figure 23.7*: Population in Mexico City and in the states of Mexico and Hidalgo. Source: INEGI (1990).
- *Figure 23.8*: Illegal immigrants in the USA, 2000-2008. Source: PEW (2009).
- *Figure 23.9*: Loss of population in drylands. Source: Designed by F. Lozano based on INEGI (1990, 2000, 2005).
- *Table 23.1*: Water volume in Mexico (million m<sup>3</sup>). Source: Author's elaboration based on CONAGUA (2009).
- *Table 23.2*: Natural risk in Mexico: Volcanoes, floods, hurricanes, earthquakes, landslides. Source: Developed by the author, based on SEGOB/CENAPRED (2009).

In chapter 24 *Vicente Germán Soto* and *José Luis Escobedo Sagaz* compiled tables 24.1 and 24.2 based on their research, and elaborated figure 24.1 based on GIS information that is in the public domain:

- *Figure 24.1*: Location of the twelve water flow measuring points. Source: Authors' elaboration using Geographical Information System (GIS) data; at: <<http://gisdata.usgs.gov/website/ibwc/viewer.htm>>.

In chapter 25 *Antonina Galván Fernández* drafted figures 25.1 and 25.2 and compiled tables 25.1 to 25.3 and 25.6 based on her work. The following figures and tables are based on the author's previous publications for which she holds the copyright:

- *Figure 25.3*: Relations between the factors that constitute the universes. Source: Galván and Márquez (2006: 318).
- *Figure 25.4*: Loop that links the components of a basin. Source: Galván and Márquez (2006: 319).
- *Figure 25.9*: Distribution of vegetation. Source: Galván (2005: 27).
- *Figure 25.10*: Basin subsystems. Source: Galván (2003: 14).
- *Table 25.4*: Indicators of impact. Source: Galvan (2003).
- *Table 25.5*: Intervention matrix for each subsystem. Source: Galvan et al. (2006: 713-739).

The following four figures were done by former students of the author under her supervision:

- *Figure 25.5*: Topography. Source: Morón Vázquez (2004: 34).
- *Figure 25.6*: Fortnightly histograms. Rain distribution. Source: Ulloa Juárez (2005: 41).
- *Figure 25.7*: Soil distribution. Source: Pérez Hernández (2006: 58).
- *Figure 25.8*: Potential erosion. Source: Pérez Hernández (2006: 62).

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:

- *Figure 28.1:* Water stress in the Valley of Mexico (2004). *Source:* Prepared by the authors based on data from SEMARNAT (2005: 37).
- *Figure 28.2:* Hydrological cycle in the Valley of Mexico Basin. *Source:* Prepared by the authors based on data from SEMARNAT (2005: 36, 2004: 42-43).
- *Figure 28.4:* Water imports to the Valley of Mexico. *Source:* Prepared by the authors based on data from SEMARNAT (2004: 82).
- *Figure 28.5:* Water reuse in the Valley of Mexico by sector. *Source:* Prepared by the authors based on data from SEMARNAT (2004: 81).
- *Figure 28.6:* Gross total water withdrawal and mean natural availability in the Valley of Mexico: 2004-2030. *Source:* Prepared by the authors based on data from SEMARNAT (2005: 36).
- *Figure 28.7:* Total water stress on the hydrological resources in the Valley of Mexico subregion. *Source:* Prepared by the authors based on data from SEMARNAT (2004: 81).
- *Figure 28.8:* Projection for the over-exploitation of the aquifers in the Valley of Mexico Basin. *Source:* Prepared by the authors based on data from SEMARNAT (2004: 43).
- *Figure 28.9:* Total water stress on the hydrological resources in the Valley of Mexico subregion. *Source:* Prepared by the authors based on data from SEMARNAT (2005: 37).
- *Table 28.1:* Mean natural water availability in the Valley of Mexico Basin (2004). *Source:* Prepared by the authors based on data from SEMARNAT (2005: 36).
- *Table 28.2:* Average water withdrawal in the Valley of Mexico Basin (2004). *Source:* Prepared by the authors based on data from SEMARNAT (2004: 81).
- *Table 28.3:* Aquifer over-exploitation in the Valley of Mexico Basin (2004). *Source:* Prepared by the authors based on data from SEMARNAT (2004: 43).
- *Table 28.4:* Population growth rate in the Valley of Mexico and in the Metropolitan Zone. *Source:* Prepared by the authors based on data from SEMARNAT (2005: 36).

In chapter 29 *Arsenio Ernesto González Reynoso* and *Itzkuauhli 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 Ortiz Rendón*, *Petronilo Cortés Mejía*, *Arturo González Herrera*, *Martín Piña Soberanis*, *Ma. de Lourdes Rivera Huerta*, *Leticia Montelano 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”.