Edited by Jacques Ganoulis, Alice Aureli and Jean Fried

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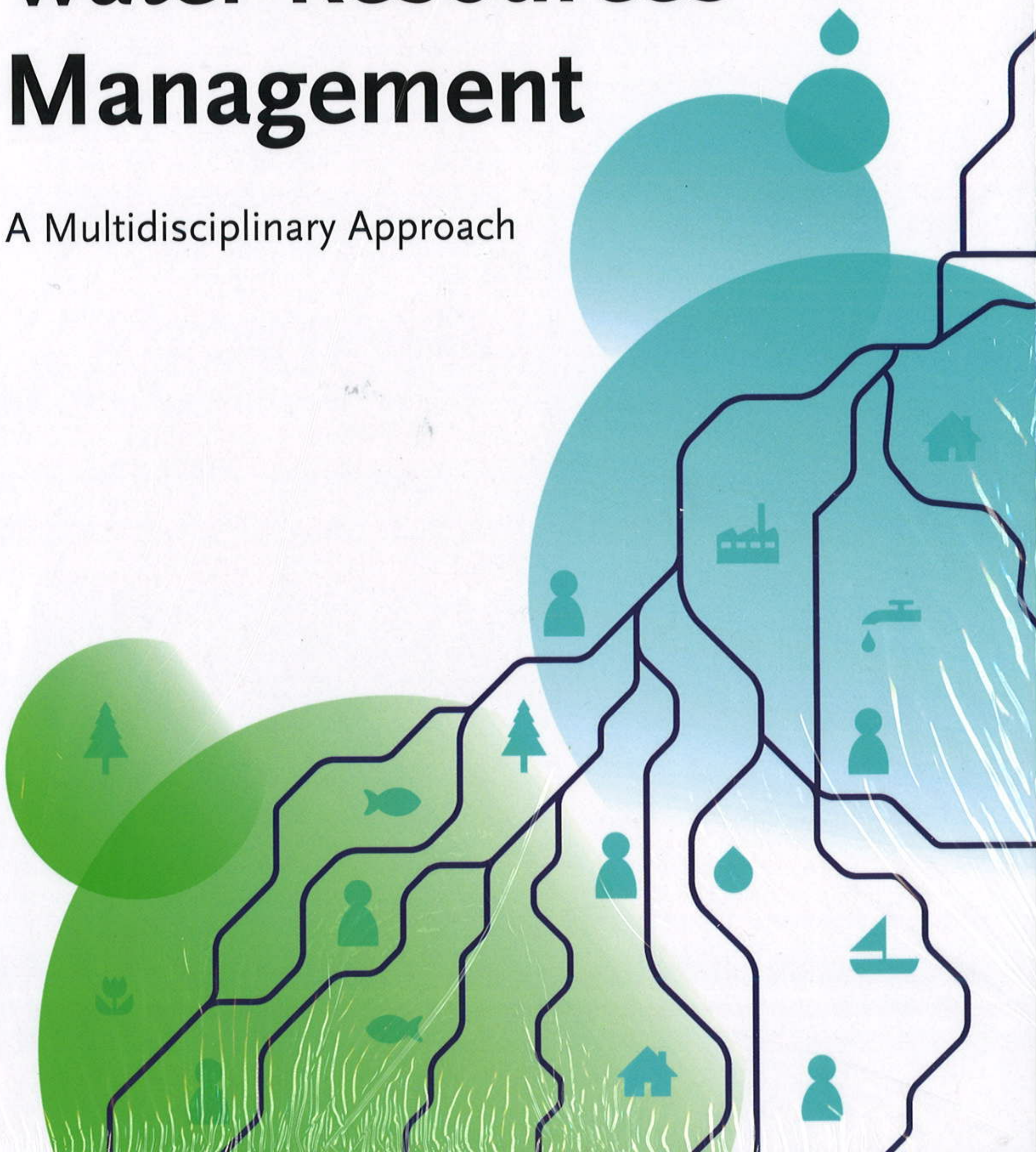
Transboundary Water Resources Management

A Multidisciplinary Approach



This book aims to serve as a practical guide for collaborative actions in Transboundary Water Resources Management (TWRM), and includes the latest developments in methodological tools, illustrated by practical case studies from around the world. On a national basis, water resources management is a complex issue mainly of water sharing and conflict resolution between different national administrations and various stakeholders. When waters cross international borders, this becomes even more challenging.

International guidelines and programmes are analysed, such as the UNESCO Internationally Shared Aquifer Resources Management (UNESCO-ISARM) initiative, the UNESCO Potential Conflict to Cooperation Potential (PCCP) programme, and the EU Water Framework Directive (EU-WFD) 2000/60. Practical tools, state-of-the-art methodologies and models for TWRM from different parts of the world are also provided, showing how to deal with data sharing, water scarcity, climate change, water related conflicts, enhance stakeholder participation and incorporate socio-economic issues. This will be very useful not only to engineers, hydrologists, and hydrogeologists but also to lawyers, social and political scientists, decision-makers, graduate students and researchers interested in TWRM.

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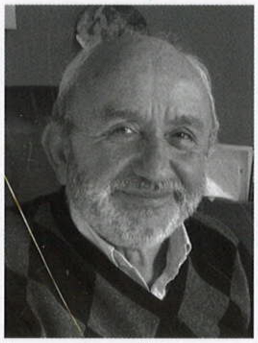

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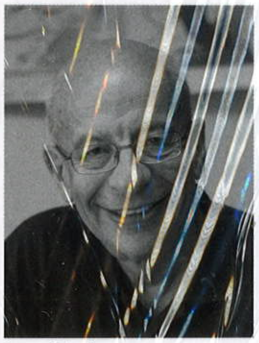

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6.2 Water Management Policies to Reduce over Allocation of Water Rights in the Rio Grande/Bravo Basin

Samuel Sandoval-Solis, Daene C. McKinney and Rebecca L. Teasley

6.2.1 Introduction

The Rio Grande/Bravo basin has a severe problem of over allocation of water rights, especially in the Rio Conchos tributary of Mexico, due to a misunderstanding of the basin's hydrology and incorrect water rights allocation policies in the 1970s and 1980s. Historically, the hydrology of the basin has shown periods of 25 years with plenty of water followed by extended drought periods of about ten years. During the 1970s and 1980s, which was a wet period, there was an increase in the allocation of water rights in the basin, mostly in the irrigation districts. Later, from 1992 to 2002, an extended drought period occurred, threatening not only the water users, but also the international obligations of water delivery in the Treaty of 1944 between Mexico and the USA. In fact, during the drought period of 1992 to 2002, there was a deficit of water delivery for the treaty obligations from Mexico to the USA. In 2007, this deficit of water was completely paid back, but now there is a consciousness about the over allocation of water [1] and the necessity to solve this problem before another drought period. Nowadays, there is not enough water in the basin to meet the institutional and international obligations that the Rio Grande/Bravo basin is subject to.

6.2.2 Buying Back of Water Rights

In 2003, the Mexican Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA from its acronym in Spanish) announced the PADUA programme [2]. The objective of this programme is to preserve the productivity and competitiveness of irrigation districts through the permanent buy-back of water rights conferred to irrigation districts that under drought conditions would be impossible or hard to supply, for either economic or hydrological reasons. The PADUA programme reduces the water rights in the basin, trying to match the demand with the availability of water under different hydrologic conditions. In 2008, according to NAFTA (North America Free Trade Agreement) regulations, free commercial tariffs exist between Mexico and the USA for agricultural products. Because of this, productivity and competitiveness are key objectives in the PADUA programme. Table 6.2.1 shows the volume of water bought back [3, 4]. Surface and groundwater rights were bought at $148 and $185 US dollars per 1000 m^3, respectively. Figure 6.2.1 shows the location of these irrigation districts.

6.2.3 Scenarios

Two scenarios are analysed in this chapter, a baseline and a PADUA programme scenario. The baseline scenario represents the actual water management in the basin considering the water demand before the PADUA programme; this scenario can also be considered a no-action scenario. In the PADUA scenario, the water demands after the PADUA programme are used to evaluate the efficiency of the PADUA programme. A basin simulation model has been developed to perform the evaluation of this policy.

6.2.4 Simulation Model

A simulation model of the Rio Grande/Bravo basin has been developed using the Water Evaluation and Planning System software (WEAP) [5]. The model was constructed jointly with the collaboration of the Natural Heritage Institute (NHI), the Stockholm Environment Institute (SEI), the Centre for Research in Water Resources (CRWR), the Texas Commission on Environmental Quality (TCEQ), the International Boundary and Water Commission (IBWC), the National Water

Table 6.2.1 Buying back of water in the PADUA programme.

Irrigation district	Water source	Water demand per year		Water bought back (million m^3)	Investment ($million USD)[a)]
		Before PADUA (million m^3)	After PADUA (million m^3)		
005 Delicias	Surface	941.6	850.3	91.3	13.53
	Groundwater	189.0	170.7	18.3	3.39
090 Bajo Rio Conchos	Surface	85.0	63.7	21.3	3.16
	Groundwater	—	—	—	—
			Total	130.9	20.07

a) Monetary exchange 13.5 Mexican pesos per US dollar.

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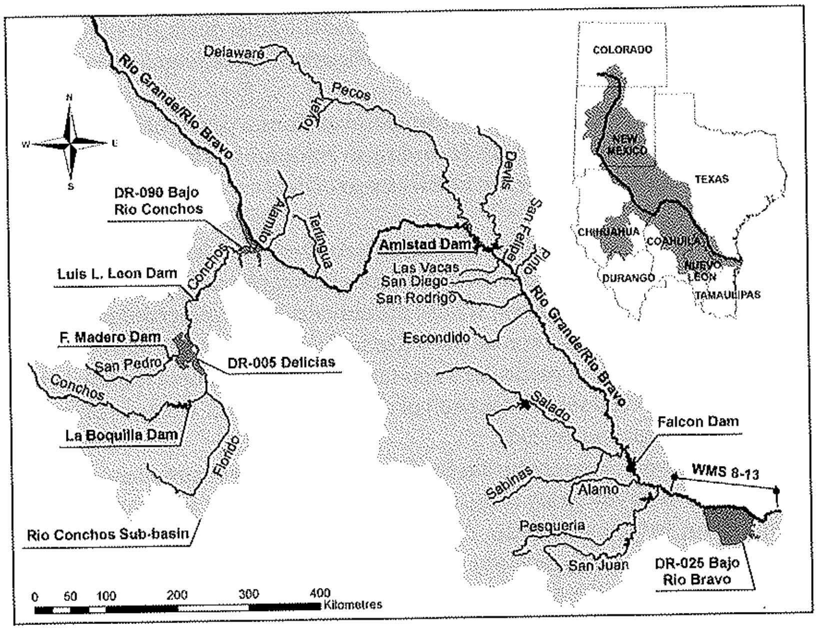

Figure 6.2.1 Rio Grande/Bravo Basin.

Commission of Mexico (CONAGUA) and the Mexican Institute of Water Technology (IMTA). The model contains the logic to separate the water between the USA and Mexico as required in the Convention of 1906 [6] and the treaty of 1944 [7]. An international reservoir accounting system was created in the model for tracking the inflows, outflows and storage of both countries in the international dams, Amistad and Falcon, in accordance to the 1944 treaty. For the water users in the USA, water is allocated according to the Texas Watermaster logic [8] implemented for the USA storage in the international reservoirs. For water users in Mexico, water is allocated according to the National Water Regulation [9] implemented for storage in the international reservoirs and reservoirs located on Mexican territory. A 60 year period of hydrologic analysis is considered, from October 1941 to September 2000. Further information on construction, calibration and validation of the model can be found in Danner *et al.* [5].

6.2.5
Performance Criteria

Four performance criteria are used to evaluate water management in the Rio Grande/Bravo over the simulation period: reliability, resilience vulnerability and maximum deficit [10]. These performance criteria are selected because they express the period of time the system is working properly (reliability), the severity of the system's failures (vulnerability), the worst failure (maximum deficit) and how fast the system recovers from a failure (resilience).

Reliability is the frequency that water demand was fully met during the simulation period, or in other words, the probability of no-deficit in the water demand during the hydrologic period of analysis [11, 12].

Resilience is the probability that the system recovers from a period of failure, which in this case is a deficit in water supply. According to Hashimoto *et al.* [11], resilience is the probability that a year of no-deficit follows a year of deficit in the water supply for a particular water user.

Vulnerability is the expected value of the deficits, in other words, it is the average of the water supply deficits experienced over the simulation period [11]. Vulnerability expresses the severity of the failures. We use the dimensionless vulnerability, dividing the average annual deficit by the annual water demand for any particular water user [12].

The maximum deficit is of particular importance as a performance criterion in this basin. This parameter allows a comparison of changes during the worst water supply period over the simulation period.

There are 6989 water users in the Rio Grande/Bravo basin. For simplicity we focus our attention on the 1944 treaty obligations and the five largest water users in the basin, which are irrigation districts 004 Delicias (DR-005 Mexico), 025 Bajo Rio Bravo (DR-025 Mexico), 090 Bajo Rio Conchos (DR-090 Mexico) and Watermaster Section 8-13 (WMS 8-13 USA);

The treaty of 1944 between the USA and Mexico specifies the obligations for water delivery from Mexico to the USA. In summary, Mexico has to deliver $^1/_3$ of the flow reaching the Rio Grande/Bravo from six Mexican tributaries (Conchos, Arroyo Las Vacas, San Diego, San Rodrigo, Escondido and Salado), provided that this third shall not be less than 431.721 million m^3 per year, as an average amount in cycles of five consecutive years. Treaty cycles can expire earlier than five years if the conservation capacity assigned to the United States in both international dams, Amistad and Falcon, is filled with water belonging to the United States, in which case all the previous deficits are considered fully paid. Deficits can occur only when a cycle lasts the full five years and the $^1/_3$ of the flow reaching the Rio Grande/Bravo from the six Mexican tributaries is less than 2158.605 million m^3 per cycle (5×431.721 million m^3 per year). Any deficit must be made up in the following treaty cycle. The performance criteria are evaluated according to the previous description of treaty obligations.

6.2.6
Results

Table 6.2.2 shows the results of the performance criteria for the selected water users for both the baseline and the PADUA scenarios. For irrigation district DR-005 Delicias, there is an increase in reliability from 62% to 70%; the recovery from deficit periods (resilience) is also faster from 30% to 33%; the expected deficit (vulnerability) decreased from 50% to 47% and the maximum deficit does not change.

For irrigation district DR-025 Bajo Rio Bravo, there is a slight decrease in reliability from 88% to 87%; recovery from deficit (resilience) is faster from 14% to 25%; the expected deficit (vulnerability) decreased from 37% to 33% and the maximum deficit also decreased, from 56% to 55%.

Table 6.2.2 Summary of results.

Water user	Scenario	Demand (million m^3 per year)	Reliability (%)	Resilience (%)	Vulnerability (% demand)	Max. deficit (% demand)
DR-005	Baseline	1130.5	62	30	50	97
	PADUA	1021.0	70	33	47	97
DR-025	Baseline	860.5	88	14	37	56
	PADUA	860.5	87	25	33	55
DR-090	Baseline	85.0	98	100	0.2	0.2
	PADUA	63.7	100	100	0	0
WMS 8-13	Baseline	1116.9	95	40	18	29
	PADUA	1116.9	95	40	20	29
Treaty obligations	Baseline	2158.6[a)]	67	75	28	42
	PADUA	2158.6[a)]	83	75	31	55

a) Demand per cycle.

For irrigation district DR-090 Bajo Rio Conchos, there is an increase in reliability from 98% to 100%; recovery from deficit periods (resilience) is the same (100%); the expected deficit (vulnerability) decreased from 0.2% to 0% and the maximum deficit also decreased from 0.2 to 0%. These are all positive results for DR-090.

For irrigation district Watermaster Section 8-13, reliability, recovery from deficit periods (resilience) and the maximum deficit are all the same; the expected deficit (vulnerability) increased from 18% to 20%.

For the treaty obligations, there is an increase in reliability from 67% to 83%; recovery from deficit periods (resilience) is the same; the expected deficit (vulnerability) increased from 28% to 31% and the maximum deficit increased from 42% to 55%.

6.2.7 Conclusions

The PADUA programme improved the water supply not only for the water users located where the programme was applied, but also for water users downstream. Benefits for the water users (DR-005 and DR-090) where the PADUA programme was applied include more water over time, fewer expected and smaller maximum deficits and faster recovery from deficit periods. As a result of the PADUA programme, water users downstream were subject to changes in their water supply. Benefits for water users downstream (DR-025 and WMS 8-13) include smaller deficits and faster recovery from deficit periods. For treaty obligations there will be fewer periods of deficit, but the expected and maximum deficits will be more frequent and bigger.

Furthermore, this analysis showed that policies should not be analysed locally where the policies are applied. In this case, local actions such as the buying back of water rights resulted in both benefits and detriments for other water users. In complex systems, such as the Rio Grande/Bravo basin, analysis must be done on the basin level due to the close interaction and dependence between all water users.

Acknowledgements

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6.3
Interstate Collaboration in the Aral Sea Basin – Successes and Problems

Viktor A. Dukhovny and Galina Stulina

6.3.1
Introduction

The region of Central Asia is a typical example of an arid and semi-arid region with a serious water deficit, where for thousands of years the well-being and survival of the population has been based on irrigated agriculture and complicated water systems.

In the twentieth century the trend was to utilize natural resources including water as fully as possible and huge engineering and social infrastructures for the growth of irrigated lands, hydropower production and common water use were developed. All these system existed in a single state, namely the USSR, which was administrated in a