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Cover photo: A view of the Milky Way over Phoinix Ranch in Jim Wells and Live Oak counties.

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Water Management in the Rio Conchos Basin: Impacts on Water Deliveries Under the 1944 Treaty

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Abstract: The unusual drought that struck the Rio Grande Basin between Mexico and Texas in 1993 marked a new order in the relationship and commitments to water deliveries from both countries in the 1944 Treaty Between the United States of America and Mexico for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande. As a result, Mexico did not comply with the volume of deliveries required in the 1992–1997 cycle. Since then, Mexican deliveries have shared a climate of tension with the United States, blamed partly on Mexico's unpredictability of its obligations. This tendency is gaining academic interest from the perspective of the treaty and the binational relationship. However, the evidence on Mexico's inability to meet its binational commitments is still scarce. Hence, this article explores the management of the Rio Conchos, Mexico's most significant tributary, to meet its obligations under the 1944 treaty; the role of stakeholders involved; the competition among water uses and possible conflict scenarios and potential solutions; and the impacts on water deliveries from Mexico to the United States. This paper uses the multi-level governance and sub-national hydropolitics concepts and the partial results of an investigation on the internal factors in the basin that affect water deliveries to the United States.

Keywords: water management, multi-level governance, sub-national hydropolitics, 1944 water treaty, Rio Conchos Watershed

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Terms used in paper

Acronym/Initialism	Descriptive Name
af	Acre-Feet
AURECH	Irrigation Users Association of the State of Chihuahua
CC	Consejo de Cuenca (Basin Council)
CCRB	Consejo de Cuenca Rio Bravo (Rio Bravo Basin Council)
CILA	Comisión Internacional de Límites y Aguas entre México y Estados Unidos (International Boundary and Water Commission [Mexico])
CONAGUA	Comisión Nacional del Agua (National Water Commission [Mexico])
GECH	Government of the State of Chihuahua
GIT	Grupo Interinstitucional de Trabajo
GM	Government of Mexico
ha	Hectare
HAR	Hydrological-Administrative Region
IBWC	International Boundary and Water Commission (U.S.)
ID	Irrigation District
INEGI	National Institute of Geography and Statistics (Mexico)
IWT	1944 Treaty Between the United States of America and Mexico for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande
km^2	Square Kilometer
LAN	Law of National Waters (Mexico)
MAF	Million Acre-Feet
MCM	Million Cubic Meters
mi^2	Square Mile
MLG	Multi-level Governance
JCAS	Central Board of Water and Sanitation of the State of Chihuahua
JMAS	Municipal Water and Sanitation Boards in the municipalities of Chihuahua
NADB	North American Development Bank
OCRB	Rio Bravo Basin Organization (Mexico)
OECD	Organisation for Economic Cooperation and Development
PNH	National Water Program (Mexico)
PO	Participant Observation
SADER	Secretariat of Agriculture and Rural Development (Mexico)
SNH	Sub-national Hydropolitics
t	Ton

Table 1. Mexican tributaries of the Rio Grande under the 1944 water treaty.

Tributary	Confluence with Rio Grande	Proportion of total delivery
Rio Conchos	Ojinaga, Chihuahua	49%
San Diego River	Jimenez, Coahuila	51%
San Rodrigo River	Piedras Negras, Coahuila	
Escondido River	Piedras Negras, Coahuila	
Salado River	Falcon Dam, Tamaulipas	
Las Vacas Creek	Ciudad Acuña, Coahuila	

Source: González-Velázquez 2020

INTRODUCTION

Since the signing of the Treaty of Guadalupe Hidalgo in 1848, the large surface water systems shared by Mexico and the United States have been an essential part of their historical relationship. The 1944 Treaty Between the United States of America and Mexico for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande (IWT) signed by both countries in 1944 continues to be considered an extraordinary achievement for multiple reasons. First, despite pressure from the U.S. border states, its ratification allowed both countries to settle their differences in using these resources. Second, it displayed a complexity beyond most treaties through its differential multi-basin application –Colorado, Grande, and Tijuana basins. Third, IWT is recognized as one of the few international agreements with negotiation from equal power between the signatory countries (Mumme 2019).

The Rio Conchos is Mexico's most important water source to fulfill its obligations to deliver water to the Rio Grande under the IWT. At present, this river by itself contributes almost 49% of the volumes corresponding to Mexico (CILA 2019; Table 1). It also has a central role within the Mexican national context. It is one of the most important systems in its northern states and is the primary water source for Chihuahua to support its urban and economic development. The unusual drought that affected the Mexico/Texas section of the Rio Grande Basin in the 1990s, and its effects on Mexico's water deliveries in the corresponding cycle, led to two significant changes. First, it broke the balance and existing order regarding delivery commitments under the IWT. Though Mexico continued to fulfill its obligations, the difficulties in delivering the accorded volume of 1.75 million acre-feet (MAF; 2,158.6 million cubic meters [MCM]) in subsequent 5-year cycles began to become evident, calling for more attention to the terms of the IWT and generating tensions between the two governments (Mumme 1999; Ingram 2004; Carter et al. 2017). Secondly, said event renewed the academic and other sectors' attention in the Rio Conchos, its international and regional relevance, the problems related to its economic and urban development, and the impacts of climate change (Kelly 2001; Kim et al. 2002; Vargas 2007; Barrios et al. 2009; CONAGUA 2011; GIT 2013; Stewart et al. 2014; Martínez-Austria 2017; Montero-Martínez et al. 2018).

This paper contributes to the previous knowledge on the Rio Conchos and its basin, in the context of its national importance and the impacts that its conditions and water management trends have on water deliveries by Mexico to the international Rio Grande/Rio Bravo Basin. We examine the current features of the watershed, the water management forms and actors involved, the competition for water and potential scenarios of internal conflict, the ways in which conflicts were resolved, and the impacts on deliveries from Mexico. This paper utilizes the multi-level governance (MLG) approach through the typology created by Hooghe and Marks (2002, 2003) and the recently developed concept of sub-national hydropolitics (SNH; Moore 2018).

METHODS

The methodology followed in the analysis combined the participant observation (PO) approach with documentary research and unstructured interviews. PO was done during a stay at the headquarters of the Comisión Internacional de Límites y Aguas entre México y Estados Unidos (CILA), the Mexican section of the International Boundary and Water Commission (IBWC) in Ciudad Juárez, Mexico. The unstructured interviews were done with key actors in the Rio Conchos Basin—CILA-IBWC, Comisión Nacional del Agua (CONAGUA) officials, irrigation district stakeholders, and state and local water agencies—and focused on their views on different issues and ways to improve cooperation and coordination.

Participant Observation

PO makes it easy to collect valuable information, in a more direct way (face to face). Furthermore, the aim is to avoid any distortion when applying experimental and measurement

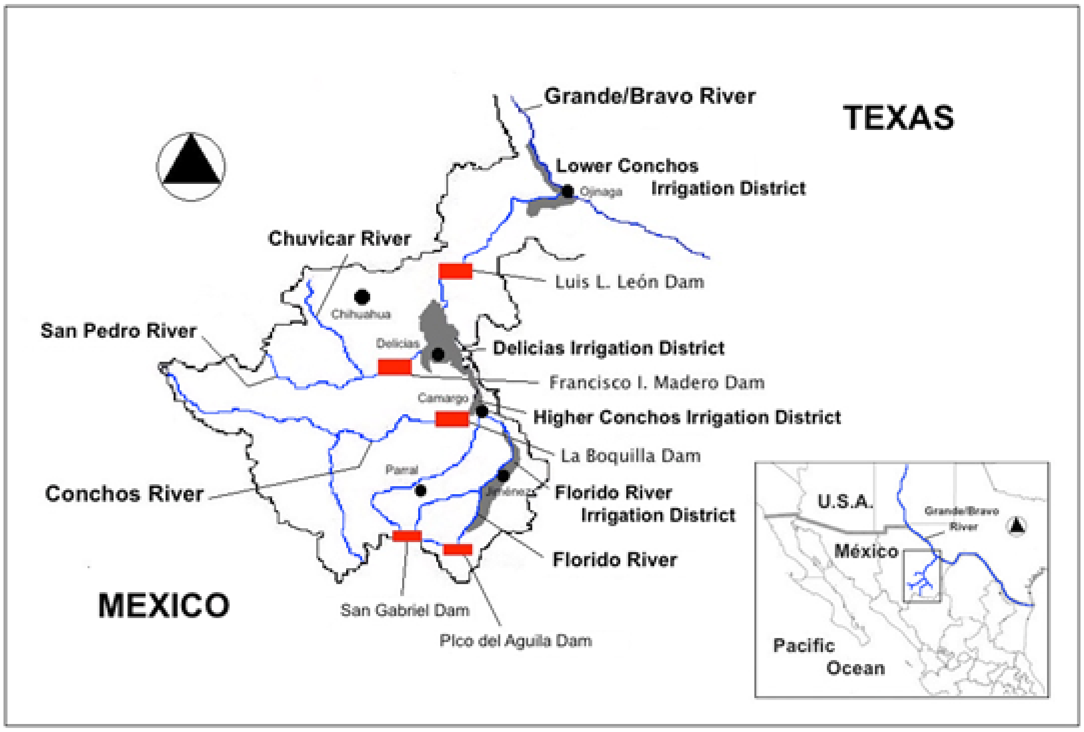

Figure 1. Rio Conchos Basin. Authors' depiction based on SIG-Bravo n.d.

instruments that do not collect data beyond their design. We therefore observed, recorded, processed, and systematically interpreted the data (Sánchez Serrano 2001). The data collection took place during a stay at CILA's headquarters in Ciudad Juárez. In addition, PO was also carried out in the assemblies and meetings of the Rio Bravo Basin Council (CCRB) users to document how cooperation, interactions, conflict, allocation, and decision-making occur in and between the different levels of government.

Documentary Research

This stage dealt with identifying, gathering, and consulting related references and other materials to extract and collect the relevant and necessary information to frame the research problem (Hernández Sampieri et al. 2010). The analysis sought to pinpoint the actions, decisions, and events that generated cooperation, conflict, and water allocation at the different levels of government participating in the basin in the study period.

Unstructured Interview

Interviews are a specific form of social interaction to collect data for an investigation. Their design includes questions directed at actors capable of providing data of interest for the research. The unstructured interview offers a relatively large margin of freedom to formulate questions and answers with a certain degree of spontaneity (Nel Quezada 2010). We addressed these questions to key actors such as officials of CILA, the Rio Bravo Basin Organization (OCRB), CCRB, members of the irrigation districts in the Rio Conchos Basin, and officials of operating agencies in the state of Chihuahua. In total, we conducted 18 interviews. Interviewees were selected using the snowball methodology by interviewing an actor with a recommendation from a previous actor. This methodology allowed us to find the key actors most involved in the problem analyzed.

The objective of the interviews was to have the specialized opinion of key actors regarding the necessary measures to improve cooperation and coordination between the actors at different participating levels and thereby make effective deliveries of water to the United States. Another objective was to identify the possible factors that hinder deliveries and generate conflict.

THE RIO CONCHOS WATERSHED

The Rio Conchos is one of the most important systems of Hydrological Region 024 (RH-024) Rio Bravo-Conchos, comprising the northern states of Chihuahua, Tamaulipas, Durango, Coahuila, and Nuevo León[3]. The Rio Conchos Basin is located in the southwestern part of Chihuahua. It has an area

[3] Thirty-seven hydrological regions represent the natural boundaries of the main river basins in Mexico. The Bravo-Conchos region is the largest, comprising about 12 % of the national territory (CONAGUA 2020a).

Table 2. Water concessions by user in Chihuahua, 2020.

User	Surface Water (acre-feet [AF])	%	Underground Water (AF)	%	Total water conceded (AF)
Agriculture	1,576,719	40.5	2,311,854	59.5	3,888,573
Public Supply	42,900	10.8	355,574	89.2	398,474
Industry and Thermoelectric Generation	5,204	11.3	63,029	88.7	68,233
All Users Total	1,624,823	37.3	2,730,457	62.7	4,355,280

Source: CONAGUA 2020b

Table 3. Rio Conchos Watershed irrigation districts in agricultural year 2018-2019.

Irrigation district	Total surface (hectares)	Total water volume (acre-feet)	Surface water (%)	Underground water (%)	Related dam	Related river
Bajo Rio Conchos	8,080	66,151	100	-	Luis L. Leon	Rio Conchos
Delicias	73,002	788,686	94.5	5.5	Francisco I. Madero	San Pedro River
Alto Rio Conchos	11,184	64,018	100	-	La Boquilla	Rio Conchos
Rio Florido	8,192	80,160	100	-	Pico de Aguila	Florido River
All Irrigation Districts	100,458	999,015	95.6	4.4		

Source: CONAGUA 2019

of 28,707 mi^2 (74,351 km^2), representing 13.6% of the Rio Grande Basin and around 30% of the state's surface (Figure 1). Its area includes 41 municipalities in Chihuahua and two in Durango. Surface hydrology includes several tributaries that feed the Rio Conchos along its route, from its source in the western Sierra Madre to the point of confluence with the Rio Grande. The main tributaries are the Florido, San Pedro, and Chuvicar rivers (Figure 1). Their contribution allows the Rio Conchos to maintain a perennial runoff during most of the year. As for groundwater, 17 aquifers supply the basin, 14 of which belong to Chihuahua, contributing around 20% of the groundwater extracted in the state (CONAGUA 2021c). Of this volume, the Chihuahua-Sacramento, Meoqui-Delicias, Jiménez-Camargo, and Aldama-San Diego aquifers stand out, which alone account for just over 70% of the total groundwater extraction (CONAGUA 2021c). The water infrastructure includes 10 dams that serve the different uses of the basin, with three of them—La Boquilla, Luis L. León/El Granero, and Francisco I. Madero/Las Vírgenes—concentrating 90% of the total capacity. They provide water to the irrigation districts (IDs) of the basin and the Pico del Aguila dam.

The water available to the different users in the basin is assigned annually by CONAGUA, the Mexican federal agency in charge of water management in the national territory through concessions[4]. Water availability accounts from a combination of surface and underground sources. In 2020, the total water assigned to the state of Chihuahua was 4.35 MAF (5,411 MCM). The agricultural sector was the largest consumer of water, receiving just over 89% of the total allocated volumes. In comparison, public supply to cities and urban localities accounted for 9% of federal allocations (Table 2). An important feature noted is the higher proportion of water coming from underground sources. This situation is even more acute in the case of cities with groundwater assigned for consumption reaching 89%.

There are four IDs in the basin, which stretches 100,458 hectares (ha), which alone account for 60% of the total surface water assigned for agricultural use in the state (Table 3). Among these, ID 005 Delicias stands out in the middle part of the basin, the largest and most important in the state, representing 90% of the south-central economy, with an approximate production according to farmers and federal legislators in the area of 7 billion pesos annually (González-Velázquez 2020). In addition, this ID also receives groundwater from the Meoqui-Delicias Aquifer.

In 2020, the basin had just over 1.6 million inhabitants, corresponding to just under half of the state's population. This amount includes seven of the most important cities of the entity—Camargo, Chihuahua, Delicias, Hidalgo del Parral, Jiménez, Pedro Meoqui, and Ojinaga—which alone concentrated 91.4% of the urban population in that year (INEGI 2020).

[4] Given the public nature of water resources in Mexico, CONAGUA manages their extraction and use through concessions or franchising to public and private entities (CONAGUA 2021a, 2021b).

Table 4. Rio Conchos Basin urban population in largest municipalities (2020).

Municipality	Total population	Urban population	Percent urban	Change in urban population 1990–2020 (%)
Camargo	49,499	42,019	84.9	13.7
Chihuahua	937,674	925,762	98.7	79.4
Cuauhtémoc	180,638	145,782	80.7	81.0
Delicias	150,506	140,157	93.1	55.7
Hidalgo del Parral	116,662	113,843	97.6	29.1
Jiménez	40,859	35,087	85.9	29.1
Meoqui	44,853	32,979	73.5	43.7
Totals	1,570,871	1,453,039	92.5	68.2
State of Chihuahua	3,741,869	3,274,046	87.5	99.5
Percent of Chihuahua population overall	42.0	44.4		

Sources: INEGI, Population Censuses 1990–2020

WATER STRESSORS

The World Resources Institute classifies Mexico as a country with high water stress due to its climatic variability and competition for water in different regions throughout its territory (Gassert et al. 2013). In particular, the Rio Conchos Basin is classified as a region with high pressure on its water resources due to an increased allocation of available renewable water (75%; CONAGUA 2018)[5]. There are currently three significant factors that affect water availability in the basin: the growth of cities and economic activities, the intense use of water in the agricultural sector, and the effects of recurrent droughts in the region (González-Velázquez 2020).

Urban Growth

The population of Chihuahua presents two particular characteristics in its distribution: a high dispersion of small towns throughout its territory and a growing urban concentration in some municipalities. More than 12,000 rural communities in the state account for more than half a million inhabitants. On the other hand, 19 urban localities concentrate 83% of the state population (INEGI 2020). Among these are the most significant urban centers in the Rio Conchos Basin, which alone account for 44% of the urban population of Chihuahua (Table 4). In 2040, the state is projected to reach a population of 4.45 million inhabitants (GECH 2019a), which will continue fueling the urbanization process of the basin. Although the volume of water assigned for urban public use represents only 9% of the total allocated to the state by CONAGUA, 89% comes from underground sources (CONAGUA 2020b), increasingly pressing the availability of the resource for this sector due to the overexploitation of the aquifers that feed it and the deterioration of water quality. Searching for solutions to this problem, the government of Chihuahua is considering exchanging groundwater for surface water through negotiations with the users of the IDs, which implies infrastructure works and operating costs for the extraction of the necessary volumes of water (GECH 2019a).

Agricultural Consumption

The agricultural sector's intensive use of available water is another factor contributing to the water-stressed conditions in the Rio Conchos Basin. In Mexico, 12% of agricultural production units have irrigation systems. Most of the rest (around 78%) is seasonal agriculture, where water use is more intensive, inefficient, and vulnerable to climate change (Earthgonomic 2017)[6]. These conditions are present in the Rio Conchos Basin, where 57% of the harvested area is rain-fed. Chihuahua has the highest national production and economic value of 12 crops, including walnuts and green alfalfa, for which water consumption is comparatively high (GECH 2019b)[7]. These are the fastest-growing crops in the last 10 years, representing 60% of state production in 2020 (Table 5). The Rio Conchos Basin

[5] CONAGUA defines the degree of high pressure as a percentage of water allocation between 40-100% of the total renewable water available (CONAGUA 2018).

[6] According to CONAGUA, the agricultural sector in Mexico wastes 57% of water due to obsolete and inefficient irrigation structures (Maguey 2018).

[7] The water footprint for vegetables and fruits is 322 and 962 liters/kg, respectively (Mekonnen and Hoestra 2010). The values are 9,000 and 1,000 liters/kg for nuts and alfalfa.

Table 5. Chihuahua main agricultural products, 2010–2020.

Crop	2010		2020		Change 2010–2020 (%)	
	Harvested area (hectares [ha])	Yield (tons [t])	Harvested area (ha)	Yield (t)	Harvested area (ha)	Yield (t)
Alfalfa	74,020.37	4,934,021.70	90,181.50	8,146,513.05	21.8	65.1
Cotton	63,696.43	254,114.02	99,510.44	501,663.14	56.2	97.4
Oat	272,273.00	3,139,480.10	156,892.50	1,487,609.90	-42.4	-52.6
Green chile	25,347.07	545,828.10	30,092.00	722,936.90	18.7	32.4
Bean	152,546.78	126,479.35	37,607.00	32,803.49	-75.3	-74.1
Corn	293,689.83	1,981,620.93	183,107.50	1,997,966.23	-37.7	0.8
Apple	23,079.00	398,155.26	31,785.37	594,710.82	37.7	49.4
Nut	39,420.64	39,764.97	64,993.23	102,061.00	64.9	156.7
Sorgo	36,989.37	388,787.31	6,355.00	110,132.36	-82.8	-71.7
Wheat	53,479.10	261,490.04	12,360.00	63,656.95	-76.9	-75.7
Totals	1,034,541.59	12,069,741.78	712,884.54	13,760,053.84	-31.1	14.0
Alfalfa + nut	113,441.01	4,973,786.67	155,174.73	8,248,574.05	36.8	65.8
Alfalfa + nut as % of totals	11.0	41.2	21.8	59.9		

Sources: GM n.d.

municipalities are the leading producers of these crops, representing 74% (walnuts) and 68% (green alfalfa) of the harvested area, respectively, and participating with 77% and 70% of the total output in 2020.

The above conditions have a significant impact on the available water resources in the basin. Six aquifers are currently over-exploited, including the four most important due to competition and over-concession from the agricultural and urban sectors: Chihuahua-Sacramento, Meoqui-Delicias, Jiménez-Camargo, and Parral-Valle del Verano (González-Velázquez 2020). The dependence of most irrigation units on rainwater places additional pressure on the water available in the basin dams. Federal allocations to the agricultural sector in dry seasons are therefore affected to ensure the volumes committed under the IWT. The overexploitation of aquifers also deteriorates the quality of water available to urban centers, forcing the water utilities to seek the possibility of exchanging surface water for groundwater (Montero-Martinez and Ibanez-Hernandez 2017).

Drought Conditions

Chihuahua is one of the Mexican states historically affected by recurrent droughts due to its geographic location in one of the most important desert strips in the world (GECH 2019a). The effects of drought conditions are more pronounced for the Rio Conchos Basin due to the dependence of large extensions of rain-fed agriculture on the available dams, the management of which must consider the volumes committed by the Rio Conchos as part of the IWT. Since the middle of the last century, some records of these conditions show a continuity of drought events in the three large basin sections, defined based on their duration and the accumulated deficit volumes (Ortega-Gaucin 2013). The period of exceptional drought that struck the entire basin during the 1990s stands out in these analyses. Its effects lasted for 14 years, from 1992 to 2005, reducing to 64% the availability of irrigation water for the IDs of the Rio Conchos Basin and forcing agricultural users to decrease the annual cultivated area by 61% (Ortega-Gaucin 2013). Its impacts also affected Mexico's water deliveries to the Rio Grande, when cycle 25 (1992–1997) finished with a deficit of 58% of the commitment of 1.75 MAF (2,158.6 MCM) established in the IWT, taking two cycles more before it was settled (Table 6). In the last 10 years, another critical drought was registered again in the basin, particularly affecting the area of ID 005 (Delicias). As a result, Mexico ended up with deficits in its deliveries in the two corresponding cycles (34 and 35). Finally, it paid the remaining debt at the end of cycle 35 through the signing of Minute 325 (IBWC 2020a), by which Mexico transferred 0.10 MAF (139 MCM) from its ownership at Amistad and Falcon International Reservoirs on the Rio Grande (Minute 234)[8].

[8] Minute 234 determines that any deficiency in a five-year cycle shall be made up by Mexico in the following cycle, including, among other options, the transfer of water in storage in the international reservoirs (IBWC 1969).

Table 6. Water delivery cycles to the United States in the Rio Grande.

Cycle	Period	Duration (years)	Debt (million acre-feet [MAF])	Delivered (MAF)			Difference (MAF)
				1/3 Mexican tributaries	Minute 234	Total	
1-3	10/1/53–9/30/68	15	Provisions of Article 4 of the IWT were considered satisfied to September 30, 1968 (Minute 234)				
4-15	10/1/68–6/1/82	13.7	The conservation capacities assigned to the United States were filled before the end of the cycle (IWT, Article 4)				
16	6/2/82–6/1/87	5	1.75	1.52	0	1.52	- 0.23
17	6/2/87–6/23/87	0.06	0.021	0.075	0	0.075	0.054
18-24	6/24/87–9/26/92	5.3	The conservation capacities assigned to the United States were filled before the end of the cycle (IWT, Article 4)				
25	10/1/92–9/30/97	5	1.75	0.73	0	0.73	-1.02
26	10/1/97–9/30/02	5	1.75	0.58	0.87	1.45	-0.3
27	1/10/02–9/30/07	5	1.75	1.25	1.83	3.08	1.33
28-33	10/1/07–10/24/10	3.1	The conservation capacities assigned to the United States were filled before the end of the cycle (IWT, Article 4)				
34	10/25/10–10/24/15	5	1.75	1.49	0	1.49	-0.26
35	10/25/15–10/24/20	5	1.75	1.65*	0.10	1.75	-

Color description: blue - the terms of the 1944 water treaty were met before or at the end of the cycles; orange - cycles with a deficit at the end; green - previous cycle debt was paid off; red - two successive cycles with deficit.

*Included 0.06 MAF through Minute 325

Sources: CILA 2019; IBWC 2020b.

WATER MANAGEMENT IN THE BASIN

Water management in a basin such as the Rio Conchos Basin has local, regional, national, and international characteristics. Human processes that influence decision-making add to the physical, geographical, and environmental contexts. Additionally, a diversity of actors participates in the operational management of water, from public authorities and institutions to private groups, communities, and individuals, giving rise to rules and conflicting interests that interact at all levels (Finger et al. 2005). In this section, we examine the water management structure in the Rio Conchos Basin using the MLG approach. The origin of this approach goes back to the emergence of the European Union in the 1990s and the analysis of the decentralized decision-making processes (Hooge and Marks 2002, 2003; Saito-Jensen 2015). An expanded version of MLG has gained the attention of academics and decision-makers worldwide, referring to governance systems with a vertical and horizontal dispersion of authority in different directions between the various levels of government involved and across other realms, including states, markets, and civil society (Daniell and Kay 2017). The Organisation for Economic Cooperation and Development (OECD) identifies central government ministries or agencies at the horizontal top-level in conceptualizing MLG. It analyzes the relationships between local, regional, state, national, and supranational levels in the vertical dimension and sub-national actors in the lower plane sphere (OECD 2011). Hooghe and Marks (2002, 2003) analyze the intellectual views sharing the idea that dispersion of governance across multiple jurisdictions is more efficient and flexible than concentration in a single jurisdiction. They identify two coherent governance structures that coexist, designated as Type I and Type II. Type I jurisdictions comprise a limited number of levels (international, national, regional, meso, local); have general purposes (involve multiple roles and responsibilities); have boundaries that do not intersect; are stable for periods of several decades or more; and have flexible jurisdiction across different jurisdictional levels. Type II jurisdictions are different in that they are specialized and fragmented; their functions are specific (particular services, monitoring) and include territories that intersect; their number is potentially vast; they are thin and flexible; and they come and go as a function of changes in governance. More recent research emphasized the role of Type II actors as key in resolving trans-jurisdictional problems and building bridges to improve social cooperation and conflict resolution (Mumme et al. 2012). In our case, we

Table 7. Rio Conchos Watershed type I actors.

Name	Authority/age	Jurisdiction/ boundaries	Functions	Planning/reporting
National Water Commission (CONAGUA)	Federal government (31 years)	National through 13 basin organizations and 26 basin councils; regional through OCRB* and CCRB**	• Grant permits for water extraction and waist waters discharge • Formulate the National Water Program • Collect and audit water-related contributions • Issue standards in hydraulic matters • Monitor compliance and application of the law (Law of National Waters [LAN])	• National Water Program (PNH) 2019–2024 • Indicators and targets of the PNH • Annual reports on accomplishments • Annual report on water statistics in Mexico • Regional and sectorial reports
Secretariat of Agriculture and Rural Development (SADER)	Federal government (103 years)	National, with state representatives	• Formulate, conduct, and evaluate the general rural development policy • Organize and promote agricultural, livestock, poultry, beekeeping, and forestry research • Prepare, update, and disseminate a bank of projects and investment opportunities in the rural sector	• Rural Development Program • Agriculture Promotion Program • Wellbeing Program
Central Board of Water and Sanitation of the State of Chihuahua (JCAS)	State government (77 years)	State	• Water planning in the state, with its proper coordination at the federal level • Coordination, between the state and the municipalities, of actions related to the exploitation of water and treatment and reuse of wastewater.	State of Chihuahua Water Plan 2040
Irrigation Users Association of the State of Chihuahua (AURECH)	Civil society/users (founded in the 1990s)	State	• Administration of the volumes granted by CONAGUA • Coordination of irrigation associations' activities • Administration of resources for infrastructure development and maintenance	The self-management carried out by the associations has allowed them to improve the efficiency of their irrigation district and thereby generate volume savings There are restoration projects in the upper area of the basin and pollution control in the main channels of the Rio Conchos
Municipal Water and Sanitation Boards in the municipalities of Chihuahua (JMAS)	Municipal government	Municipal (local)	• Responsible for the drinking water, sewerage, and wastewater sanitation services in the different municipalities • In charge of public works related to these services	Planning actions and programs are primarily short-term and usually depend on resources from CONAGUA, JCAS, or binational support through NADB's infrastructure programs

Source: González-Velázquez 2020

*OCRB: Organismo de Cuenca del Rio Bravo

**Consejo de Cuenca del Rio Bravo

adapt the Hooge and Marks (2002, 2003) typology to facilitate the analysis (Castro-Ruiz and Cortez-Lara 2020) by including type of authority (multi-functional or specialized); nature/level (national, state, local); trajectory/temporary durability; functions; and definition of jurisdictional territories (Table 7).

Water Governance Structure

Table 7 depicts a governance structure very similar to other regions in the Mexican territory, with jurisdictions belonging to Type I, well-defined boundaries, multi-functional features, and stable temporal trajectories. CONAGUA is the core actor within Mexico's centralized water management model (Sánchez Meza 2006). It has a long historical role beyond its creation in 1989 as the sole federal agency to manage Mexico's water and coordinate investment programs with other federal, state, and local agencies. Its characteristics are similar to other North American Type I jurisdictions in terms of its stability over time, geographic coverage, and multi-functionality. However, CONAGUA concentrates more responsibilities due to its authority in Mexico's water policy, including the formulation and implementation of the government's National Water Program. It carries out its duties through 13 basin organizations all over the Mexican territory, assisted by 26 basin councils[9]. Another actor at the federal level is the Ministry of Agriculture and Rural Development. It deals with the planning of agricultural production in the IDs of the state. At the state level, the Central Board of Water and Sanitation of Chihuahua (JCAS), created in 1942, has multiple functions, basically related to its role as a liaison body with the federal government in planning activities and coordination between the state government and the municipalities. In this capacity, JCAS was responsible for formulating and implementing the Water Plan of the State of Chihuahua 2040. Next are the local water and sanitation boards, which act as operating agencies and providers of services at the local level, with service areas clearly defined by the municipal divisions. Finally, the Association of Irrigation Users of the State of Chihuahua is a civil society but multi-functional organization, with well-defined state coverage and history going back to the 1990s when the federal government initiated the transfer of the operation and maintenance of IDs to the agricultural users in the country[10].

In theory, despite the absence of Type II actors, the structure described in Table 7 presumes the existence of a systemic and cooperative relationship between the actors regarding water management in the basin. However, in practice, CONAGUA maintains *de facto* central authority in decision-making related to the administration and planning of water resources, notwithstanding the changes undergone in the Law of National Waters (LAN) of 1992 and its modifications in 2004 towards decentralizing its functions in search of better governance conditions. CONAGUA is the sole agency to allocate water to the different user sectors, based on the concessions in each case and the provision and enforcement of the guidelines concerning water quality and quantity. It also leads the development of water availability studies and is responsible for the Public Registry of Water Rights (Collado 2008). The state and local authorities that participate depend mostly on CONAGUA's financial and regulatory support to operate, with little room for their participation in the decision-making process. Civil society involvement in water management occurs in the Irrigation Users Association of the State of Chihuahua (AURECH), which has operational autonomy but depends on CONAGUA for its annual water concessions and monitoring of its activities and projects. All sector users rely on CCRB, the regional consultation body, to participate in the decision-making process concerning the basin. In theory, all those sector users interact with authorities and CONAGUA's representatives, bringing their daily problems and proposals to try to solve them. CCRB is one of the Consejos de Cuenca (CCs), or basin councils, with more improvements in its functionality despite the size of its jurisdiction. Still, CCRB faces different challenges that hinder its governance objectives. Among them are a low capability at the local levels to interpret and observe the legal framework that sustains the existence of the CCs; the absence of coordination with other governmental actors; financial limitations; a lack of incentives to support the water users' involvement; and in general, limited operative autonomy (Sosa-Rodriguez and Castro-Ruiz 2020)[11]. In addition, both CONAGUA and its local and state counterparts have to deal with the discontinuity of programs and policy actions resulting from constant political-administrative changes.

Water Competition and Conflicts

The study of conflict and cooperation in shared international rivers has gained interest in recent decades, given urban growth and the effects of climate change. This research focused on the conflict conditions experienced by riparian nations and the search for cooperation and agreements to manage the resource (Wolf 1998; Elhance 1999). Some authors also recognized the existence of internal water management problems as the cause

[9] The basin councils are advising bodies instituted by the LAN of 1992 to promote user involvement in each basin organizations' regions (Collado 2008).

[10] With the transfer process, CONAGUA's responsibilities were to ensure the self-sufficiency of the transferred districts and the completion of the planned investments. Other functions were to provide guidance and technical support to user organizations and supervise and monitor the proper use of the water granted (Trava-Manzanilla 1995).

[11] Some authors noted a decentralization trend in the federal water institutions during the 1980s toward other instances at different levels. For example, the transfer of responsibilities on the urban water services to the municipal governments in 1983 was part of this course (Collado 2008).

Table 8. Rio Conchos Watershed conflict situations and actions of cooperation at the sub-national and binational levels.

Level	Current and potential situations of conflict	Identified actions for cooperation and conflict reduction
Sub-national	There is competition for surface water between Municipal Water and Sanitation Boards in the municipalities of Chihuahua (JMAS) and irrigation districts (IDs) in Chihuahua. The former is highly dependent on groundwater, which is on the verge of depletion and cannot consider surface water in their development plans because the IDs use it.	Just as there is competition, cooperation is also present. For example, ID* 005 Delicias reached an agreement with the municipality of Camargo, yielding 12,161 acre-feet (15 million cubic meters) per year for the JMAS to use.
	The frequent drought occurrences manifest themselves in complex conditions, requiring adjustable solutions not even per 5-year period but yearly. These changes are sources of conflict.	Farmers in the upper basin have no mechanisms to obtain water from another source under drought conditions, as farmers in the lower basin do. They want no special deals, so a flexible plan can be established, such as annual irrigation plans, where all agricultural users share the same conditions.
	Farmers identify the existence of clandestine water intakes in the basin and report several of them. However, they point out their displeasure because the authority does nothing, affecting other people's interests.	Technology can help solve this, but strategies are needed to enforce the water authority so that legal users trust it.
	National Water Commission (CONAGUA) had made decisions in situations with no consensus, such as the opening of the La Boquilla dam on several occasions in 2020, even when negotiations continued, which caused large demonstrations by farmers and great distrust towards the authority.	CONAGUA is under pressure to guarantee the volumes of water delivered to the United States. Despite this, it is essential to establish a dialogue with more time to forge a closer relationship with the farmers, so they feel their comments and requests take part in the process.
	There is an over-concession of water in the basin, which exacerbates the conflicts over competition for water. The commitment of all resources gives no room to provide a solution.	Improving the efficiency in managing the resource for all users should be a strategy to follow. It is necessary to enhance the distribution of available water without generating any conflict between uses.
	Agricultural users in the basin indicate that their peers from the Lower Rio Grande (Coahuila, Tamaulipas) let water drain for them. Still, they do nothing about the problems faced by the upper basin of the Rio Conchos, which they identify as their water factory. There is also the opinion that these farmers demand more water they use with very low efficiency. In comparison, the ID* 005 Delicias is presented as an example.	The Payment for Environmental Services Program has worked in several parts of Mexico. In this direction, the Lower Rio Bravo/Rio Grande and Rio Conchos basins may create mechanisms for cooperation to take care of the upper basins. Considering that the farmers of the Rio Conchos contributed partially with resources to improve the efficiency in the use of water, their peers of the lower Rio Grande could also begin doing the same.
Binational	The frequent occurrence of drought in the basin causes conflict in deliveries. There are reductions for all water users and no mechanisms to inform the percentage of decrease in deliveries on the assumption that there will be no excess water in the end.	The minutes are the principal means of cooperation and conflict resolution. In this case, the International Boundary and Water Commission (IBWC) should continue promoting the financial support in difficult times through organizations such as the North American Development Bank (NADB) to provide further certainty to constant deliveries to the United States (i.e., Minutes 307–309).
	The definition and classification of an extraordinary drought are still not entirely clear in both countries. When it has occurred, it complicated the process of agreements between both governments.	It is essential to have contingency plans during drought episodes to help clarify these pending aspects and thus cooperatively standardize the measures to be followed.
	The most critical issue is that users in general assume that there will be plenty of water to pay for the 1944 water treaty despite the current over-granting of water in the Rio Grande Basin.	Mexican users are willing to comply with the treaty. However, they are against the overexploitation of any of the current six tributaries and believe that Mexico should take more integral measures beyond these sources.

Source: González-Velázquez 2020

of those conflict situations (Uitto and Duda 2002; Giordano et al. 2002; Wolf 2005). A recent approach that deals with this context are SNH, a contemporary variant of the traditional concept of hydropolitics, which addresses a more common but little-studied problem: the conflict and cooperation in basins within countries, shared by multiple sub-national units (Moore 2018). One of the postulates of this approach establishes that the difference between international hydropolitics and SNH is one of scale rather than kind. However, the problems in searching for agreements leading to inter-jurisdictional collective action can be equally complex. The evidence around the dynamics of this trend defines three factors that intervene: (1) decentralizing processes (federalism, jurisdictions); (2) the sectoral identity (social, cultural, political, economic, ideological characteristics of the actors at the sub-national level); and (3) the structure of political opportunities, which opens the opportunity for actors and groups outside the governmental sphere to participate in political processes. These elements define greater participation of actors at the local and regional levels with significant weights in decision-making. The influence of ideological and institutional factors can modify the differences and conflicts between groups at those levels. A possible way in the opposite direction could be an institutional structure capable of building bridges between water users through third parties to allow collective action (Moore 2018).

The Rio Conchos Basin is prone to conflict due to the water stressors and the governance structure described in Table 7. Table 8 shows the main points of conflict and cooperation—existing or possible—perceived by the governmental actors and stakeholders over water management and its binational implications (González-Velázquez 2020).

Domestic Issues and Centralization in Mexico

The Rio Conchos Basin presents a *de facto* governance arrangement that contradicts the trends expected in a federalized model such as Mexico (Moore 2018). The omnipresence of CONAGUA in all orders related to water management inhibits the participation of other government entities and the possible influence of their sectoral identity. Also, the political opportunity structure is quite limited, and the involvement of actors outside the governmental sphere is almost nonexistent. Table 8 depicts a general view of CONAGUA's operational role problems resulting from its functions' weight and coverage. Among these is the absence of coordination, resources, and competence at the local level to interact with other government entities and users to solve problems, a condition common to other regions in the country (Sosa-Rodríguez and Castro-Ruiz 2020). As a result, stakeholders report their low influence in the CCRB, which significantly restricts the possibility of having their complaints and ideas considered and implemented by the central government. The result is the lack of application of the law on the issues of clandestine intakes, the over-concession of water in some sectors and the coordination and follow-up actions to avoid this, which provokes questions from users towards the authority of CONAGUA. Some stakeholders opinions also indicate the absence of provisions for the occurrence of droughts. Another concern is the high dependence of the urban sector on groundwater; the high population growth rates of some cities and the overexploitation of the main aquifers are common knowledge among the actors in the basin and public officials. There is also the impossibility of having greater volumes of surface water because only 11% of the water assigned by CONAGUA to this sector comes from this type of water (CONAGUA 2020b). Chihuahua's government has considered the feasibility of exchanging treated wastewater for potable water from the IDs, as the city of Delicias and ID 005 Delicias are doing (GECH 2019a). Still, these processes involve additional infrastructure costs, including improvements in the levels of treatment.

Water Delivery Obligations in the IWT

Table 8 also displays the views of the watershed stakeholders on Mexico's water delivery commitments within the IWT. They are aware of the IWT terms and the Rio Conchos' central role in these obligations. However, they experienced authoritarian actions from CONAGUA, such as opening the gates of La Boquilla dam in 2020 without the knowledge of the affected users. This lack of communication with CONAGUA prevents the participation of water users in decision-making about water delivery at the end of each five-year cycle. The watershed stakeholders feel that both users and authorities should seek agreements and develop contingency plans to improve water management efficiency and generate savings allocated to paying the debt, restoring ecosystems, and recharging aquifers. Because compliance with the IWT is a national commitment, the respondents deem it necessary that all the neighbor states downstream should ensure equitable deliveries. Also, they believe that both governments should continue their cooperative actions through binational financing programs like the North American Development Bank's (NADB) to improve the agricultural sector's efficiency in the basin. Finally, the absence of direct communication with CILA is also a concern affecting stakeholders' knowledge about the government's activities on Rio Grande deliveries. It is then that the actors in the basin are aware of these difficulties within the Mexican government structure and therefore propose a more flexible role of CONAGUA as a bridge with CILA to channel their viewpoints and ideas[12].

[12] This lack of flexibility shown by CILA is shared within the centralized Mexican model. It contrasts with the operative openness of its counterpart in the United States towards other governmental actors and the border communities (Castro-Ruiz et al. 2018).

CONCLUSIONS

Our analysis in the previous sections depicts a picture of the Rio Conchos Basin that calls for attention beyond the bare volumes of water required by Mexico at the end of the 5-year cycles established in the IWT. In this sense, we conclude that the problems related to water management in the Rio Conchos Basin have not been fully understood or addressed within the lines of water policy in Mexico. The main factor behind these problems is the persistent presence of the centralized political-administrative model in the basin and its effects at the operational levels, which hinders the possibility to reach an ideal governance. In addition, the autonomy of other government jurisdictions is considerably limited in decision-making, also inhibiting the participation of non-governmental organizations, as AURECH's characteristics show (Moore 2018). As the perceptions of stakeholders and government actors at lower levels consistently point out, CONAGUA, the central agency in charge of enforcing the LAN, exercises a significant weight in all active orders, despite its apparent territorial decentralization for decision-making. This presence forces other government entities and civil society to play a merely functional role, dependent on the regulations and funding of the agency.

On the other hand, CONAGUA's lack of resources and capabilities at the local level led to a series of operational gaps that do not allow the agency to fulfill its functions completely or enforce legal frameworks, promoting situations such as illegal access to water and the contempt by part of the farmers towards the entity for not solving the problem of the excess of concessions. A recurring theme related to these demands is the operation of CCRB, CONAGUA's consultative body for this region, whose relationship with users is a source of criticism for not fulfilling the support functions that justify its creation. The geographic jurisdiction of the CCRB is the largest of all CCs in Mexico, with almost 20% of the national territory (CONAGUA 2018). The lack of resources restricts continued support for users' participation or the representatives of the auxiliary entities in the sessions of the council.

The impacts of internal water management on deliveries to the United States within the IWT is another aspect that deserves some reflection. From our analysis in this regard, it is evident in the case of Mexico that it is necessary to implement programs that seek efficiency, save water, and involve users of the basin, allowing better planning of water deliveries to the Rio Grande during each 5-year cycle. This process should improve users' communication channels not only with CONAGUA but with CILA, enhancing the flow of information and allowing better cooperative work between them. On the other hand, cooperation around the IWT has not been constant in infrastructure investment to increase efficiency in water use in the basin; this would help to give certainty to delivery commitments to the United States. These programs are well known and expressed by water users in the Rio Conchos Basin from the projects signed in Minutes 307–309 of CILA. Therefore, investment opportunities in water infrastructure allow for more significant water savings in the basin.

Our work also highlights the proactive and committed attitudes of the stakeholders in the basin, despite the reduced options available to channel their views, complaints, and problems with CONAGUA. Their input and active participation align with other efforts from non-government actors and stakeholders along the U.S.-Mexico border (Mumme et al. 2014; Castro-Ruiz et al. 2018; Brown and Mumme 2021). Stakeholders provide strong support in seeking agreements on the role of the Rio Conchos in Mexico's water delivery obligations in future cycles. Moreover, their views are straightforward: timely provisions will lower the likelihood of deficit problems such as those experienced at the end of each 5-year process in the past.

The problem of the Rio Conchos should not be interpreted simply as the non-availability of water at the end of each cycle and take action based on short-term actions. Instead, the evolving characteristics of the Rio Conchos Basin and the feedback provided by its stakeholders and water users about the basin's problems and possible solutions should be an integral part of longer-range plans devised by CONAGUA and CILA. Minute 325, recently signed to solve Mexico's debt in the last cycle, demonstrated the willingness of the Mexican and U.S. governments to jointly solve the problems that arise from compliance with the IWT. This Minute can be the starting point for future actions that are not limited to short-term horizons and are sensitive to the sustainable future of the Rio Grande Basin and its tributaries. As demonstrated in this study, continuous and close coordination between the two countries is essential. On one hand, this coordination integrates the social dimension through better governance conditions between the actors of the Rio Conchos Basin and other regions downstream of the Rio Grande. On the other hand, it is opportune to consider the financial support that arose from cooperation programs through organizations such as NADB that foster long-term planning actions to assure greater water availability at the end of each cycle.

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