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The US–Mexico Border: Conflict and Co-operation in Water Management

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ABSTRACT *Water has become a topic of general concern to governments and society worldwide. Mexico and the United States are no exception, especially considering that the border between the two countries is located in an area not only characterized by drought and low rainfall, but also by the growth of the population living on both sides and the impacts of industrial development projects and increased pressure on water demand. The two countries share major surface water basins under an international treaty that was signed in 1944, but this treaty does not include the groundwater. Competition for water within each country has been growing, and also between the two countries, creating potential for possible conflicts, but has also resulted in close co-operation. This paper analyzes how the two countries work to reduce conflict and enhance co-operation in terms of managing water scarcity.*

Introduction

The paper analyzes and discusses some of the issues which have the potential to create conflict between Mexico and the United States in relation to the management of shared transboundary basins, and the prospect of bilateral cooperation to address the problems of water shortage in the face of growing demand for the resource in the region. It is assumed that the water available in the watersheds subject to the International Treaty of 1944 has been distributed in full, and that there are only limited alternatives in the ongoing search to improve water management by bi-national planning, conservation and protection of water sources. The active participation of local border communities is essential to meet the future challenges for managing water scarcity.

In recent years, water scarcity has become the centrepiece of concern of both international organizations and national governments, and also of academia and the media. The shortage has guided policy and water management practices so that availability of and access to this vital resource can be assured for present and future generations. A part of the discourse on scarcity in recent years had focused on managing water for the urban centres where market mechanisms exist and which could contribute to efficiency improvement.

There are numerous predictions of likely conflicts in different parts of the world, especially in terms of controlling the sources of the water and thus assuring access. Water shortages could compromise the future development of many countries (Biswas, 1992).

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An important part of the problem to solve is to do with climate change and the uncertainty generated in terms of the effects on the water availability over both the short- and the long-term. This will present great social and institutional challenges in terms of predicting, organizing, and taking appropriate and timely decisions that allow assured access to water. The focus has been on how best to manage scarce water resources, as well as floods and droughts (Sánchez, 2009).

Water has historically been a potential cause for conflict, given that the geographical distribution of available sources is not homogenous around the world. Even within countries there are regions with a greater supply than others. Furthermore, demand for water is not always linked to its availability. Sadly, with increases in population and economic activities water scarcity is seldom considered to be a possible constraint on future growth. Therefore, areas of water shortage imply a forecast of competition for access to and control and use of water. It also holds some potential for co-operation in order that it can be better managed and there could be agreements for distribution with a sense of fairness.

An important factor to consider is the distribution of water between countries. Water is very much one of the most symbolic natural resources at all levels. In relation to politics, it has been and continues to be an essential part of territoriality which is important to the States. Thus, the water control is often viewed as an integral component of sovereignty. In this context, both society as user of the water and government, which is responsible for national water policy of the countries, have very similar interests.

A considerable portion of available water is located in transboundary river basins. It is estimated that 300 watersheds around the world are shared between two or more countries (Levesque & Ingram, 2002, 161), and 245 rivers are found on the borders between separate countries (Wolf, Yoffe & Giordano, 2003), in some cases the courses of rivers being the recognized limits and agreed-upon boundaries between neighbouring countries, which means that the water located in those areas must be shared, requiring co-operation between countries and neighbouring communities to protect the sources, ensuring the quality of the resource, and preventing international conflicts. Thus, the appropriation of water requires institutional agreements and regulations between countries, and, internally, between communities and user organizations, as well as national, regional, and local institutions. This adds to the complexity of managing transboundary water resources.

One of the tangible results of discussion on the potential implications of climate change on water availability is the urgency shown by various governmental and social actors to undertake activities to meet the potential water shortages. There are many regions in the world which have been facing for a long time this type of complex situation, though not always with much success.

One of these regions with characteristics of relative water is located in the arid zone between Mexico and the United States. Both countries have been working together for over 100 years, attempting to resolve conflicts and improving bilateral co-operation for shared water management in the transboundary watersheds. One aspect which is most worth noting is that, in spite of the asymmetries which characterize relationships between the two countries, the institutional instruments that have been developed for processing conflicts and operating the water agreements have performed reasonably in solving problems that have arisen over time. It is expected that the spirit of co-operation will be maintained in the future to meet the challenges of scarcity and manage successfully the possible conflicts that could arise from this situation.

Mexico–United States Border: Water and Shared Problems

Mexico is a country characterized by arid and semi-arid areas, in two-thirds of its territory, which are located in the middle to the north, where the boundaries with the United States are demarcated. The border between both countries encompasses desert and semi-desert, with a limited water availability and low rainfall. The border demarcation between the two countries has a length of 3,150 km, with 66% of the international boundary being formed by river runoff channels (Vela, 2006).

The United States–Mexico border area records rainfall below the national Mexican average of 772 mm, but, nevertheless, between the Gulf of Mexico and the Pacific Ocean there is a great variation of climate and rainfall. While the San Juan River Basin in the state of Tamaulipas average annual precipitation is 600 mm, in the Tijuana–Ensenada region, in Baja California, rainfall averages 264 mm, and in some areas of Chihuahua and Sonora it only reaches 150 mm annually. The rainfall runoff that precipitation generates in the region represents 5% of the national total (Vela, 2006). At the same time, the Central-East region of the Mexican border, which encompasses the Rio Grande Basin (*Río Bravo* in Mexico) experiences recurrent prolonged droughts with impacts on both sides of the border, and has been a source of conflict between both countries with regard to the water management in that area. Mexico is behind in terms of compliance with annual deliveries of water that are stipulated under the International Treaty on Water Distribution.

Border Institutional Framework for Water Management

In 1848 the international boundary between Mexico and the United States was agreed by the signing of the Treaty of Guadalupe Hidalgo, beginning a complex relationship between the two countries. This has been the starting point in creating the institutional framework that has allowed the resolution of conflicting issues in the border that separates the two countries. This includes the domain, control, and use of natural resources located in the border areas. Water certainly tops the list, although the pressures of demand for this resource became greater from the beginning of the 20th century, once the population and economy of the border began to grow. There were also claims on the rights to water, contributing to a competition for higher volumes from both countries.

The boundary treaty of 1848 was, for the first 40 years, the normative instrument for settling disputes between the parties. Later, the two countries signed conventions in which they established agreements over distinct aspects related with the boundary, such as demarcation of the land and water boundaries, for which they created commissions with specific ends and limited durations. Such conventions were agreed to in 1882, 1884, 1889, 1905, 1906, and 1913. The Convention of 1889 set the stage for the final establishment of the Rio Grande and Colorado as international boundaries, giving rise to the International Boundary Commission (IBC) as the body responsible for enforcing the existing boundary treaties, including the 1884 changes in courses on international rivers (Brown, Castro, Lowery & Wright, 2003).

The first agreement reached between the two countries on the distribution of waters from the trans-border watersheds was the Convention of 1906. This stipulated that Mexico would receive 70 million m^3 of water annually from the Rio Grande Basin, above Juarez and El Paso, for agricultural use in the Valley of Juarez. It is important to underline that the 1944 Treaty does not consider the shared groundwater along the border area.

The Santa Fe Agreement, reached in 1922 between the seven basin states of the Colorado River in the United States, recognized Mexico as the eighth user, providing it an allocation of 1,233 million m^3 a year. This was amplified in the Treaty of 1944. After an intense and long struggle, Mexico received greater volumes of water.

In February 1944, the governments of both countries signed the Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, which resulted from long negotiations. It was only possible once the states along the Colorado River in the United States had reached an agreement over sharing the river water between them, so that the treaty would give Mexico the water which the upriver states agreed upon. The treaty also expanded the scope of the authority of the International Boundary Commission including operation and maintenance of the water infrastructure constructed to meet with the treaty obligations as well as the infrastructure built by agreements reached between the two governments over specific aspects of the basins covered by the Treaty. This was how the International Boundary and Water Commission (IBWC) or *Comisión Internacional de Límites y Aguas* (CILA in Mexico) emerged, which, to date, has been working together in the management of the border basins included in the Treaty of 1944. With respect to the water volumes agreed, the Treaty guarantees to Mexico a total of 1,850 million m^3 water annually from the Colorado River. From the Mexican tributaries into the Rio Grande/Bravo between Fort Quitman and the Gulf of Mexico, the United States is assigned a third of the flow which comes from the principal flow of this river, so that, on average in cycles of 5 consecutive years, it will be no less than 432 million m^3 per year. The Treaty also establishes that in cases of extraordinary drought that might impede compliance, the deficits shall be supplied in the following five-year period. On the Colorado River, Mexico shall receive 1,850.2 million m^3 annually, and in the case of excess it may receive up to 2,097 million m^3.

Since the signing of the Treaty in 1944, the two countries have established multiple negotiations with regard to various issues related with the border and they have reached important agreements around them, which may be seen in the extensive list of Minutes from the IBWC. An important part of these Minutes refers to problematic situations concerning international waters from the border basins. Minutes have been incorporated as part of the Treaty and they are references for the solution of similar situations that may occur in the border at any moment, or place, of the common border. Specially noteworthy are the agreements reached in relation to the problems of salinity in the agricultural areas of the Mexicali Valley in the 1960s and the solution reached in 1973, with the signing of Minutes 241 and 242.

Some of the agreements included in the Minutes signed later are related to situations arising from the lack of services infrastructure in the Mexican border cities that have maintained a rapid and unplanned growth by the local governments. As part of this urban and industrial growth on the Mexican border, sewage became a source of pollution in riverbeds and streams, creating risks to public health and ecosystems. This also violated the Article Three of the Treaty, which details the responsibility of both the countries for sanitation in the border areas. To strengthen the obligation of governments of both the countries regarding environmental protection of the border, the two governments signed in 1983 the De La Paz Peace Agreement. It was specifically designed to formulate policies and programmes related to water quality management and protection of natural resources along the border. In fact, these agreements laid the foundation for bilateral co-operation in environmental issues which were subsequently extended through the institutions that

emerged from the signing of the North American Free Trade Agreement (NAFTA) in 1994.

In this context, Minutes 264 and 288 were signed in which the agreement for developing programmes for border water quality management was established. This was an attempt to solve pollution problems caused by the discharge of untreated wastewater through the New River (*Rio Nuevo* in Spanish), which crosses into the United States from the Mexicali Valley.

Additionally, Minute 291 established a commitment to solve the problem of sediment deposition in the Colorado River bed, which affected the network for urban distribution of water and also the irrigation areas in the Mexicali Valley during the floods of 1993.

As an example of the evolution of the IBWC agenda related to the international commissions responsible for implementing the Treaty, the Minute Act 306 was signed in 2000. This refers to the commitment to develop studies over the environmental conditions of neighbouring tracts and the Colorado River Delta, with the objective that the commissions can put forward recommendations for the preservation of riverine ecology and the Colorado River Delta. This represents a novel development in the bi-national agenda of the commissions, and responds to pressures manifested in criticisms of the IBWC over its bureaucratic culture and lack of openness to respond to the concerns of border communities over the deterioration of the riverine and coastal habitats and the urgency for protecting natural resources. IBWC also did not respond adequately to the environment of co-operation which had been generated in border communities of both the countries, helped by institutions of environmental co-operation attached to NAFTA which became operational in 1994.

Minutes had been signed for the Rio Grande River Basin since 1945 recording the agreements for improving the conditions of the river channel. The first Minute on this aspect was the 129 and the last was the 313 in 2008. However, the Minutes after the 303, dealing with the reduction of the salinity of the lower Rio Grande have been the result of intense public discussions and polemics which exceed the scope of the commissions. This is indicative of the environment of tension generated by water scarcity in times of droughts, and the Mexican government's failure to comply with the delivery of water volumes to the United States under the Treaty.

Minutes 307 and 308 refer to the agreements reached to cover the deficit in deliveries of water from Mexico to the United States in the middle and lower watercourse of the Rio Grande/Bravo. Minute 307 is unusual in that it does not have a precedent since it was signed in Washington D.C. during a meeting of the Presidents of the two countries. This is probably indicative of the pressure on the Mexican Government by the accumulated debt of water during the previous five-year period. The fact that the Government of Mexico had accepted gauging water tributaries not included in the Treaty to make the deliveries to the United States and thus liquidate the accumulated debts of water was also a concern. This was an extraordinarily complex solution without any precedent, which established a principle which can be used under drought conditions, as is the case for the Colorado River during extraordinary drought situation. A provision for reducing the delivery in the same proportion as it reduces the deliveries for the users on the Mexican side was drawn up, although there is an alternative by which once the international dams located on the Rio Grande River reach their maximum water level, the debt of water from the previous cycle is considered to be paid. A special solution like this was permitted to liquidate the Mexican water debt which had incited such a controversy between the two countries.

On the other hand, Minute 309 refers to the modernization of the irrigation system located in the upper watershed of the Conchos River, the main tributary of the middle Rio Grande/Bravo Basin, with the financial assistance of institutions of bi-national co-operation. The improvement in efficiency of water management in the district will save enough water to ensure compliance with the water volumes agreed with the United States in terms of the International Treaty.

During the last period of drought in the Rio Grande/Bravo Basin, some tensions became evident between the various water users of the Basin, primarily because of increasing competition during a period of scarcity. In this context, the federal government promulgated the signing of the *Acuerdo para el uso Sustentable del Agua Superficial de la Cuenca del Río Bravo entre el Gobierno Federal y los Gobiernos de los Estados de Chihuahua, Nuevo León y Tamaulipas* (Agreement between the Federal Government and the Governments of the States of Chihuahua, Nuevo Leon and Tamaulipas for the Sustainable Use of Surface Water in the Rio Bravo Basin), which was signed on 5 June 2002. This agreement is very meaningful for the new role of the states in the management of water in the territory, and is also a very important precedent for the possibility of finding solutions from a more regional vision with regards to the provision of water from the Rio Grande Basin on the Mexican side. Following this agreement, the states of Chihuahua, Coahuila, Durango, Nuevo Leon, and Tamaulipas agreed with the *Comisión Nacional del Agua (Conagua)* in 2008, for the elaboration of a baseline study for applying rules to the distribution, use, and provision of water from the Rio Grande Basin (El Universal, 2008). It was an important step to improve watershed management and to develop rules for organizing the management of water among the users of those states. Conagua recognized that some of the principal problems in that Basin are the established over-assignment and illegal extraction of water (El Universal, 2008). Hopefully, these poor practices can be improved by the strengthening of institutions responsible for management and the active participation by the communities of users.

Water authorities on the Mexican side of the border seem to have assumed a realistic perspective that there will be no more water, and have even assigned more water than that exists. This is why the institutional interventions have to be more oriented toward creating agreements between the governments of states and among the users of the Basin, so that water can be used in an orderly and efficient manner.

During the signing of the agreement between the governments of the Mexican states, the Director General of Conagua remarked that:

> I believe that we can sustain the growth of population without detriment to the basin by increasing efficiency, seeking adequate financial plans, and looking toward the way of cultivating the same acreages with less water, by technical means. (El Universal, 2008).

The institutional framework for transboundary management of water in the border areas between Mexico and the United States is the result of complex relations, marked by power asymmetry between the countries and the fact that the nature has made Mexico a downstream country. This does not mean that solutions reached thus far are unfair or unjust to either of the two countries. They do, however, make the process to reach solutions that lead to efficient water management, difficult, complex and time-consuming. Naturally, the asymmetry is a fact of the structural conditions in terms of relations between

the two countries. This should not be an insurmountable problem, given that improvements in the efficiency of water management are feasible and could be the only additional resource since the available water is already distributed and used in full. This seems to be the direction that both Mexico and the United States seems to be heading towards. However, Mexico must make a greater effort to improve the functioning of its water-related institutions and also induce of a distinct cultural shift in its water users.

Of course, we are not dealing only with the surface waters provided by the three basins included in the Treaty but also groundwater aquifers located in the surrounding areas of the border, over which there is no treaty which establishes the principles of shared use. However, continuing water scarcity should also be an incentive for the governments to formulate joint policies in achieving an agreement to avoid over-exploitation of these aquifers. To date, the only precedent is Minute 242, signed as an agreement for solving the conflict caused by the flow of agricultural drainage water from the United States into Mexico which inflicted great damage to agriculture lands in the Mexicali Valley. To compensate for the loss of quality of the water that was received, Mexico began to pump more groundwater. This led to the governments agreeing in Minute 242 to limit the extraction of water along the border areas in their respective countries and to consult with the other country regarding developments of future projects related to groundwater.

For Mexico, 64% of the water available in the US border area comes from the mentioned basins, while the other 36% is extracted from aquifers located along the border. Some of these aquifers are over-exploited and require careful management. Information from the National Water Commission (Conagua) indicates that there is no additional groundwater available in the Mexican border area, except for one area located in the state of Sonora, between Nogales and Agua Prieta (Arreguin, 2009). There are cities like Juarez in Mexico and El Paso in Texas that are dependent on a common aquifer—the Hueco Bolson—for their water needs.

The institutional framework for the water management at the border is composed not only of the International Treaty and the agreements reached by the commissions, but also the laws in force in each country and state, especially for the United States. So the national and state laws are also part of the complex relationships that affect boundary waters. The institutional framework in Mexico has also experienced changes. For example, the National Water Commission was created in 1989 as the only federal authority for water in the country. This has improved coordination between different public and private actors regarding water management. Equally important are the various environmental standards have been established to protect the water quality, although in all cases there is need to generate greater institutional capacity to enforce the implementation of the existing regulatory frameworks.

The Growth Dynamics in the Mexico–United States Border and Water Demand

Water was a central issue during the early history of economic development in the US–Mexico border. The most important rivers of the region were controlled by large water infrastructure projects constructed during the early part of the last century with the governmental support in both countries. Large irrigation districts are located along both sides of the border because of these developments (Sánchez, 2005). Border towns linked to the agricultural development started to grow. Later, some of those same urban areas on the

Mexican side became part of the platform for the *maquiladora* industry based on foreign investment. This also constituted as an important component of policy of the Mexican federal government to generate employment in the country.

Other border cities grew by protecting the service economy encouraged by the politics of prohibiting gambling, alcohol, and track betting in the United States, and the proximity of military bases in times of war. This was the case with Tijuana and Ciudad Juarez, which have a history aligned with the demand for centres of entertainment, gambling, and alcohol consumption by foreign visitors. This are the cities that, after the 1960s, received significant investment from the *maquiladora* industry (see Table 1).

Over the long term, policies of industrialization of the border were an impetus to the growth of the urban centres located along the international borders which attracted people from other regions of the country in search of better employment opportunities. The counties and cities on the United States side of the border did also grow, their Mexican counterparts although not as much as they (Nitze, 2006). According to a recent estimate, the demographic dynamic on both sides of the border may lead to a population of 19.5 million inhabitants by 2020, around to 9 million in the United States and 10.5 million on the Mexican side (Peach & Williams, 2000) (Table 2).

However, those who planned the investment policies in the region did not consider the water supply and perhaps did not correctly estimate the growth rates that border cities were going to have, nor the pressure that industrial and demographic growth would have over water supply. To date, this is one of the biggest challenges that governments and communities in both countries have had to face in the vast region. There has been an increasing water demand for different types of urban consumption, as well as provision of acceptable wastewater management. Cities have grown very fast, without planning, and this has brought environmental impacts related to transboundary water management with regard to supply, distribution and water quality.

On the US side, the water demand has also increased. The quality of water service associated with wastewater management are not the problems. The US problems are more related to high water consumption per capita, especially in a region of growing populations where water is already scarce. Even then, management skills and long-term planning needs have to be improved to ensure adequate quantity and quality of water is available over the long-term. Fortunately, US has a better culture than Mexico for formulating and implementing long-term visions and ways of planning for the future. Accordingly, it is the border cities like San Diego or El Paso that have planned for their sources of water supply for 100 years and 40 years, respectively.

One of the factors of demand that exerted the greatest pressure on available water along the Mexican border has been the rapid growth of population and the economic dynamism shown by the principal cities like Ciudad Juarez, Tijuana, and Mexicali. Other cities in the lower part of the Rio Grande/Bravo Basin (Nuevo Laredo, Matamoros, Reynosa) have also

Table 1. The Maquiladora Industry in the Mexico–US Border, 1990–2008.

	1990	1995	2000	2006
Plants	1,462	1,692	2,063	2,081
Workers	389,019	531,123	936,559	929,682

Source: Nationa Council of Maquiladora Industry, 2009.

Table 2. The Mexico–United States border population 1980–2000 (US counties and Mexican municipios).

	1980	1990	2000	Growth rates 1980–2000
Total border	**6,976,694**	**9,103,319**	**11,797,954**	**69.1%**
United States subtotal	**4,009,151**	**5,213,774**	**6,286,169**	**56.8%**
California	1,953,956	2,607,319	2,956,194	51.3%
Arizona	728,142	914,919	1,159,828	59.3%
New Mexico	117,974	159,978	205,630	74.3%
Texas	1,209,079	1,531,958	1,964,517	62.5%
Mexico subtotal	**2,967,543**	**3,889,545**	**5,511,785**	**85.7%**
Baja California	1,002,459	1,400,873	2,053,217	104.8%
Sonora	312,079	394,712	515,979	65.3%
Chihuahua	635,490	869,951	1,294,214	103.7%
Coahuila	151,623	191,135	263,885	74.0%
Nuevo León	16,475	17,312	18,524	12.4%
Tamaulipas	849,417	1,015,562	1,365,966	60.8%

Source: Castro & Sánchez (2008, p. 175)

witnessed increasing water demands. Furthermore, the metropolitan area of Monterrey is also part of the increasing demand that affects the Rio Grande/Bravo Basin. It would be a mistake not to consider its influence in the region. Not only does it share the San Juan River waters and other tributaries with Tamaulipas State, but it has also has also been in disputes over water from these sources. This is a fact to be taken into account when considering the likelihood of regional conflicts in critical situations of increasing water demands and drought conditions.

This means that during the last 50 years not only has the population increased in those cities, but also that the demand have also gone up. Up until the 1960s, water demand was principally for agricultural uses and to a lesser extent for municipal uses. More recently, demand for industrial and commercial uses have expanded while the domestic demands have also increased with the growth of the population living along the border. This is a phenomenon which also appears on the US side of the border, but with a much slower pace of growth than on the Mexican side. Between 1980 and 2000, the United States border population grew at an annual average rate of 1.89%, while the border population on the Mexican side recorded an annual average growth of 3.55% (Castro & Sánchez, 2008). In addition, greater access to financial resources and better institutional capacities have enabled US to manage its demand growths better than Mexico. Consider that between 1980 and 2000, the total population of the border grew by 69.1%, with an increase of 56.8% in the border counties of the United States, and 85.7% in the border municipalities of Mexico (Table 1). This population was mainly concentrated in few cities on both sides of the border.

It has been observed that, after the signing of NAFTA and the upsurge in new institutions of bi-national co-operation in environmental matters, the coverage of piped water and sewerage services in the Mexican border cities has improved substantially, to reach 95% of coverage in water service, and between 85% and 88% in sewerage, in spite of the high rates in population growth. The changes have been dramatic, as in the 1980s the Mexican border cities registered a considerable lag in such services. By 2000 they had

managed to overcome these constraints and now have risen above the level of other regions of Mexico with regard to the coverages of such services.

It is very likely that growth factors for the demand for water at the border, such as population and the urban economic sectors, may continue along the same trend observed, although in both cases there are exogenous factors over which local authorities have no control. Due to the integration and strong dependence on international economic factors, and also migration, the border cities have faced accelerated growth. The future of population dynamics in the border areas will depend on economic conditions in other regions of the country, and will remain a variable that cannot be controlled by the border authorities.

It would be desirable if the Mexican federal government formulated policies for other regions of the country, especially further from the border with the United States, so that investment and employment could flow to such areas which would retain people and lower the demographic pressure on the border cities and help to moderate the demand for water in the border regions.

There is evidence that water management can be influenced through the reconfiguration of administrative organizations responsible for the planning and operation of services. For example, some of the policies geared towards such objectives, have led, in most cases, to the transformation of local water authorities on the Mexican side and have improved service coverages. The partial modernization of the water institutions, along with improvements in technical and management capacities, have been instrumental in service delivery improvements.

There are significant differences in the institutional capacities of local water management on both sides of the border which make more noticeable the asymmetries that characterize relations between the two countries. However, co-operation has become a regular practice between water authorities in the border area and has been an important factor that contributed to improve the water infrastructure in the Mexican side.

At least, in the twin largest cities along the border, El Paso–Juarez and San Diego–Tijuana, the cities have created bi-national working practices, with open participation of the communities of both the sides, to address water management problems that mostly affect the health and wellbeing of the population. In the case of El Paso, Las Cruces, and Ciudad Juarez, the Paso del Norte Water Task Force responsible for formulating long-term plans, which seeks alternatives for sustainable water management within the framework of a regional trans-border vision. The sources from which both cities depend to satisfy their needs for water are shared and require bi-national co-operation in order to ensure sustainable supply in the future. This would require the generation of reliable information on the volumes of water in the aquifers, as well as extraction and recharge rates. The work of this group is important, given the social profile of the organization, its bi-national character, and its ability to influence decision-making on water policy of the region and also water authorities in both countries.

Also, in the case of Tijuana and San Diego, the bi-national group "The Tijuana Watershed Task Force" has been working jointly through public meetings, where they present the problems that affect the bi-national watershed of the Tijuana River. Given the population growth on the international watershed, it is essential to address problems related to the quality of water draining into the estuary located in southern San Diego that has been declared natural reserve by the US Government. Water quality in the beaches of the two countries also is affected because of the risk to the health of the population due to discharge of untreated waters by the city of Tijuana.

The US–Mexico Transboundary Basins

The Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, signed in 1944, refers only to these rivers. The Field Co-ordination Committee (FCC), constituting the Mexican Ministry of the Environment and Natural Resources (Semarnat) and the US Geological Survey (USGS), are expected to co-ordinate institutional activities and responses of the two federal governments. This Committee has defined a border area that includes about 411,000 km^2, in which hydrological boundaries are considered at ranges from 2.5 km to 285.5 km from the international border (US Geological Survey, 2003). This Committee has identified eight regions, based on physiographic and hydrological criteria which extend on both sides of the border. However, the basins, categorized according the De La Paz Agreement cover an area of 31,520 km^2, of which 19,823 are in the United States and 11,697 are in Mexico.

The Colorado and Grande Rivers are the two major border rivers watersheds between Mexico and the United States. The Treaty also includes the Tijuana River watershed, which only carries water during heavy rainfall and most of the time has negligible water flows.

Río Grande /Bravo

The Rio Grande River (or Bravo) has a length of 3,034 km, between its headwaters in the mountains of Colorado in the United States and its mouth at the Gulf of Mexico, and drains an area of 607,965 km^2. The largest contributions which the Rio Grande River receives between Fort Quitman and the Gulf of Mexico are from the Conchos, Salado, Florido, and San Juan Rivers on the Mexican side. In the United States side, the Pecos River contributes the greatest volume of water.

The last prolonged drought that affected the region lasted for about 10 years (1992–2002) and lowered the Amistad and Falcon reservoirs on this river to levels of only 30% of their total capacity, reducing storage in the reservoirs to 16% and 18% respectively (CSIS-ITAM-UTA, 2003; Aguilar & Mathis, 2005). This was a very serious situation since these two reservoirs account for 81.6% of the water storage capacity along the northern border of Mexico (Conagua, 2006).

During the middle of the last decade it was noted that the total volume of water available in the Rio Grande was 12,059 million m^3, from which 10,142 million m^3 was extracted (Mumme & Pineda, 2005).

The extraction of groundwater has been growing in both countries. In the 25 border counties of the United States, the surface water covers 59.5% of the demand, and the remaining 40.5% is from groundwater sources. This dependence on groundwater has increased significantly, both in the Chihuahua State and in the Texas side, which has resulted in a trend that could have serious consequences over the long term. In fact, the city of El Paso has been operating for some years a desalinization plant for brackish groundwater which increases the supply of water available to the population of that city.

It has been estimated that the annual recharge of the four major aquifers in the region, the Alluvium and Bolson (which include from the Juarez/El Paso region to Presidio/Ojinaga), the Edwards-Trinity (Del Río/Ciudad Acuña), the Carrizo-Wilcox (Laredo/Nuevo Laredo), and Gula COSAT (McAllen/Reynosa to the Gulf), will reach an extraction rate equal to their recharge rate by the year 2030 (Eaton & Hurlbut, 1992).

For the United States Government, groundwater in its southwest border has become a priority. In 2006 the Law of Transboundary Aquifers for United States-Mexico aquifers was signed. This allocates funding for a wide-ranging investigation over the 16 shared aquifers on the border with Mexico. Priority work will be carried out in the Hueco Bolson Aquifer in the Juarez-El Paso area, and the river valleys of Santa Cruz and San Pedro Rivers in the Arizona and Sonora border region (Milenio, 2008).

The balance of groundwater on the Mexican side of the Rio Grande Basin indicates that of 96 aquifers identified in this region, 21 are already overexploited. The recharge has been estimated at 5,082 million m^3, whereas extraction has reached 4,145 million m^3 (Conagua, 2009).

The rate of water extraction to supply the demand of Ciudad Juarez has drawn attention because it could be in a situation of over-exploitation. This would risk the sustainability of the aquifer in the long term. In addition, Juarez does not have access to other alternative or complementary sources. The closest groundwater is located more than 100 km away, which means higher costs. Thus, the real alternatives are improving the efficiency of water management, and its sustainable extraction.

In February 2009, the dams storing water in Mexico for delivery to the United States reached their maximum storage volume, by which time the cycle of five years, referred to the International Treaty, was closed. This heralded the beginning of a new cycle of accounting for water deliveries from Mexico to the United States in the Rio Grande/Bravo Basin. As in other cases, nature helped to smooth over tensions created by drought and the non-delivery of water. This is an opportunity for the different stakeholders to improve basin management, and generate agreements before the next drought occurs.

The two countries also worked to finalize a project for lining the canals in the upper Conchos River Basin in the state of Chihuahua, which contribute the largest volumes of water into the Rio Grande in the stretch between Fort Quitman and the Gulf of Mexico. The project allows for the saving of water and its storage for Mexico to comply with the agreement for deliveries to the US, as set out by the International Treaty. There is an open dispute between water users of the Conchos in Chihuahua State and downstream users in the lower Rio Grande in Tamaulipas, who feel affected by the lowering of the volumes of water available for productive activities. The complexity of the relations between distinct users of different countries and states in the Basin requires an ongoing dialogue and timely care by institutions to prevent an upsurge in conflicts. This requires improvements in management practices, with greater involvement of users, and also presence of strong institutions and high-quality information for decision-making.

Colorado River Basin

The Colorado River Basin is formed by the runoff from the Rocky Mountains in the United States, and flows into the Sea of Cortez in Mexico, after running 2,300 km. The Basin has a total area of 655,000 km^2, which represents the most important hydrologic system in southwestern United States. It serves a population of 20 million people in seven states, and in Mexico it is the principal source of surface water for the state of Baja California and the municipality of San Luis Río Colorado in Sonora, which represent a very small portion of the total area of the watershed, less than 1% (5,923.16 km^2).

The Colorado is a river entirely controlled by a system of dams along its length, and its average annual runoff is 22,400 million m^3. This is distributed between the seven states on

the American side and Mexico. California is the principal user of the Colorado watershed. The water of the River is distributed between seven states, and Mexico, in accordance with documents and laws known collectively as "The Law of the River" (US Geological Survey, 2003; Cortez Lara, 2005).

California receives the greatest share of water among the riparian states. The state receives 5,427.3 million m^3 of water, representing 48.6% of the available supply of the lower Colorado Basin estimated at 9,189.4 million m^3. The state of Arizona has a share of 3,515.4 million m^3, Nevada has a share of 358.9 million m^3, and Mexico receives 1,850 million m^3.

Agriculture has been the main user of water in the lower Colorado Basin. The growth of urban population has increased the demand for different uses in the region. This has led some states to reach the limit of their allocated share of water. California had used water allocations for Arizona and Nevada, but once Arizona developed the infrastructure for its share of water, California had to stop using them and had to seek alternatives to replace them because it had to recognize the rights of Arizona and Nevada. The Department of the Interior ordered California to limit its dependence on the Colorado water to its allocation under the Compact by which the distribution of water from the lower Colorado watershed was agreed to.

In recent years, the Colorado Basin has been affected by a prolonged and severe drought, which led the Bureau of Reclamation of the United States (2007) to point out:

> The watershed of the Colorado River is in the eighth year of drought, the worst eight years in a period of over a century of continuous record keeping. This is the first great drought in the modern history of the Colorado River.

The border area in which the Colorado River crosses into Mexico is the most arid in this country. The average rainfall is 264 mm, a third of the national rainfall average, so the aquifers depend on the flow of the Colorado and return water. 1,417 million m^3 are extracted each year from these sources, but their over-exploitation has carried them to a negative balance of 467 million m^3 per year. By the middle of the last decade it was estimated that the excessive extraction of water from the aquifers in the Peninsula of Baja California had reached 3,994 million m^3, which is 4% over the capacity for recharge (Mumme & Pineda, 2005).

Mexico has received, on time and every year, the volumes of water according the International Treaty. However, demands have grown rapidly because the border area of Baja California has the highest population growth registered in recent decades, especially in the Tijuana–Rosarito–Ensenada corridor. This is located on the Pacific coast, outside of the Colorado River Basin, at a distance of 185 km. The city of Mexicali and the population in its valley have also experienced considerable growth.

The two situations, inefficient use of available water by the agricultural users who have led the aquifers of the Valley of Mexicali/San Luis Rio Colorado area to over-exploitation, and rapid growth of population in the border area are joined with pollution of surface streams by the lack of infrastructure in urban wastewater management. Cross-border interaction is absolutely essential to solve such problems, including institutions and user communities on both sides of the border.

As noted earlier, the main aquifers in this area have been over-exploited, including that of the Mexicali Valley. In view of this situation, the water authorities are considering desalinization plants to supply the future demand of water for the coastal population of

Baja California. This could include building plants of bi-national character for sharing the investment and water with San Diego.

There are also conflicting situations between Mexico and the United States in the Colorado Basin. One of those is the construction of a lined canal to replace the old All-American Canal that allowed water infiltration to the Mexicali Aquifer. The US Government decision to line the canal was seen as a unilateral measure by the Mexican Government and water users from the Mexicali Valley. Their reaction was late and they did not have any strategy to litigate or negotiate the issue (Sanchez, 2004). The other is the Interim Agreement to allocate the Colorado River surplus for a period of 15 years, which was also made unilaterally, affecting Mexican users and the environment of the river delta. Concurrently, however, there is bi-national co-operation in projects, such as the construction of wastewater treatment plants in the Mexican cities, where the interests of United States lie in improving wastewater management since outflows of agricultural and urban sewage seriously contaminate water bodies. The situation is worsened by the fact that the water from the Colorado is facing high demand, competition between different users is increasing, and groundwater is not properly managed.

Because of population growth in Baja California, the Colorado River has become almost the only source of surface water available to this state and represents a high dependence on this source in meeting the demands. Indeed, article three of the International Treaty of 1944 establishes the priority in allocations by type of water use. The municipal domestic consumption is first priority, which means that, in critical conditions, it is the last one that can be constrained. However, it is a rarely discussed issue in the official negotiations, may be not to generate tensions between different water users.

Tijuana River

The Tijuana River is the third basin included in the International Treaty, and is very limited in terms of water availability. Until the 1970s it was the main source of water for the city of Tijuana because of the Abelardo L. Rodriguez Dam on the River. The dam and the aquifer of the same river, were the main water sources in the past. By the 1970s, Tijuana was already experiencing noticeable scarcities of water. Such scarcities contributed to a protest movement demanding better water services. For this reason, the federal and state governments agreed to build an aqueduct to carry water to the city from the Colorado River, and this way started the dependence of Tijuana upon this source. The aqueduct pipeline is undergoing a phase of enlargement in order to double the volume of imported water to Tijuana and the coastal area of Baja California.

The Tijuana River is located in Mexico's most northwestern area and runs a course from south to north, draining parts of the runoffs of the Sierra de Juarez towards the Pacific Ocean in the United States side of the border. The river watershed covers a surface area of 4,450 km^2, two thirds of the Basin being found in the Mexican side, and the remaining third in San Diego County, California. It is a semi-arid zone which receives rainfall ranging from 150–500 mm per year (Ojeda, 2007). At the same time, it is a basin that has been subjected to an intense urbanization process, leaving the mark of pollution and environmental degradation because of absence of land-use planning, and lack of infrastructure to properly treat wastewater and poor solid waste disposal practices.

Joint co-operation and work by the Tijuana and San Diego communities have been important in this watershed. Researchers from San Diego State University (SDSU)

analyzed the urban watershed flows from Tijuana that cross the border, and found heavy metals such as chromium, lead, mercury, copper, cadmium, and zinc, hydrocarbons such as oils, grease, oil-derived products, polycyclic aromatic hydrocarbons, and nutrients such as nitrates and phosphates (Michel, 2002).

The Tijuana River watershed is not significant in regard to the volume of water since it carries little water, except in some winter seasons when rainfall is higher and more concentrated. It has also become relevant from an environmental viewpoint during the bi-national discussions since rapid urbanization has increased seriously the levels of water pollution.

The population living in the watershed depends significantly on the waters from the Colorado River, because the Colorado and Tijuana Basins are related through this link, and therefore the Tijuana watershed has become a receptor of the water from the Colorado River. Wastewater outflows have become a source of pollution to the Tijuana groundwater sources. One laboratory analysis in 1998 found that more than 100 wells of the Tijuana Aquifer had high levels of total dissolved solids, nitrates, and varying amounts of coliforms (Guzman, 1998). That is the main reason as to why the wells have been closed.

On the Californian side, dependence upon water from the Colorado River is also very high. However, they have developed alternatives for rainwater harvesting water treatment, reuse, and management, with long-term plans and policies for efficient use of the waters. Such alternatives have not yet been developed on the Mexican side.

Conclusions

The current conditions are very different from those prevailing at the time of the signing of the International Treaty of 1944 by Mexico and the United States, which allocated the waters from the Grande, Colorado and Tijuana Rivers. The asymmetric character in the relations between Mexico and the United States cannot be obviated. The latter not only exercises a much greater power than exercised by Mexico. It is also upstream country for the two main transborder river basins which provides it a natural advantage regardless of international law.

The Treaty deals with elements within a landscape of recurrent water shortages, limited options for increasing supplies and expanding demands. It is important that both the countries should consider options in which bilateral relationship and water management can be optimized. There can be no long-term sustainability on the availability of water resources. We should be clear that there is no sustainability in the border areas without bi-national co-operation, and without the domestic agreements between different social and institutional actors in each country.

Recent experiences have shown that competition and shortages have been factors of bi-national tension and conflict. They are also an opportunity for agreements and co-operation to improve water management which is far from optimal on both sides of the border. The different border basins are working in projects aimed at improving efficiency in water use, and also improving water quality management by constructing appropriate infrastructure. Specialized bi-national groups have been formed to consider proposals for solving the most important problems, and strengthening water institutions, especially in Mexico which still lack the professional capacities and maturities. The Mexican water institutions need to gain the strength with community participation, along with openness, transparency, and accountability by water authorities.

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