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The International Journal of Water Governance (IJWG) aims to become an important source of knowledge on governance of complex water systems, and an inspiration for all professionals in the water domain to improve the governance capacity in the domain in which they operate. In order to achieve this two-sided ambition we want to focus on actual and urgent theoretical issues and bring them further by application and elaboration in the domains of water. This will be the primary aim in the special issues. At the same time we will take care of the actual topics practitioners in the water domain are dealing with. From a variety of disciplines we will gather new insights on what constitutes the governance capacity with regard to specific topics, like water quality, flooding or scarcity.

The scientific domains we cover in IJWG, all related to the governance question, are: Public management, law, sociology, economics, planning, environmental sciences, risk management and innovation studies.

Furthermore we aim to develop a strategy in which the disciplinary contributions are confronted and combined in order to achieve a more interdisciplinary approach of water governance. We expect that professionals in the field can play an important role in these processes of transforming high quality, but also partially disciplinary knowledge sources into more integrated knowledge leading to innovations and improvements in the water governance systems all over the world.

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Multi-tiered Governance of the Rio Grande/Bravo Basin: The Fragmented Water Resources Management Model of the United States and Mexico

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The Rio Grande/Bravo (RGB) Basin governing structure is characterized by the absence of a governmental entity providing an entire basin vision. This research argues there is a fragmentation in the basins water resources management (WRM) due to the allocation and distribution regime of surface water between and within both countries. This has caused a hydrological disconnection of the river and the proliferation of stakeholders and institutions that only have partial competence of the WRM. We provide a descriptive analysis of the current WRM, as well as the institutional and organizational framework which clearly exhibits governance fragmentation. A qualitative assessment of interviews conducted with experts in the RGB Basin supports these findings. WRM in the RGB Basin consists of a collection of regional governments that handle only the water resources issues affecting their regional political territory. This multi-tiered, mosaic governance structure reinforces the hydrologic disconnection within the river, and the fragmentation of the stakeholders.

Keywords: Governance, Rio Grande, Rio Bravo, Fragmented Water Resources Management, Sustainability, Stakeholders Perspectives.

1. Introduction

This paper focuses on the surface water resources of the Rio Grande/Bravo (RGB); thus, the term *water* refers to surface water resources if not otherwise specified. A single governing framework does not exist to provide a shared and unified vision for the integrated water resources management (IWRM) in the RGB basin. The authors hypothesize that fragmentation occurs in the water resources management of the transboundary RGB basin due to: (a) the quantitative sharing and distribution of water of the river; (b) the hydrological disconnection of the basin due to regional hydraulic infrastructure; and (c) the heterogeneity of stakeholder organizations and institutions who only have competence on

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portions of the water management, either water quality, water quantity or the environment. The RGB basin translates into a mesh of independent regional governments bordered by hydrological engineering regions. As a consequence, each of these regions constitutes a semi-autonomous, self-organized and institutionalized sub-basin within the entire basin, but still riparian dependent. The main questions addressed in this paper are: (1) Which mechanisms and agreements, some enacted more than a century ago, have defined the institutional and organizational framework of the basin that consequently resulted in the fragmentation of the water resources management?, and (2) How does the current fragmentation of the RGB management challenge its sustainable development? Posing these questions helps conceptualize "a multi-tiered governing structure", which is a type of water governance characterized by fragmentation and heterogeneity among management communities and micro-regional sustainability practices.

In the RGB basin, the IWRM approach has not been implemented at the whole-basin scale. Paradoxically, each sub-basin has adopted a water governing system encouraging the management of quality and quantity issues, showing signs of regional IWRM. In the United States (U.S.), the IWRM approach has been widely promoted by the Environmental Protection Agency (EPA). However, this EPA-IWRM approach primarily advocates for the development, implementation and management of watershed-based plans, as a means to resolve and prevent water quality problems resulting from both point source and nonpoint source pollution. At all organizational levels, agencies and institutions can develop watershed guidelines to deal with quality uncertainties. Despite the principles of watershed management promoted by the EPA (2008), this approach is only introduced and perceived as a technical procedure to deal strictly with water quality issues and is not instituted by all watershed regions. In fact, it has been put into practice only in certain regions of the RGB within U.S. territory (RGB-US) to tackle and manage water quality concerns.

Similarly in Mexico, the IWRM approach has been promoted by the National Water Commission (CONAGUA by its acronym in Spanish), which encourages its implementation at the basin scale (CONAGUA, 2008). The notion of a *basin* in IWRM refers to the unique geographical space used to manage water resources. Water quality issues are considered at the basin scale level. Despite efforts to promote IWRM for the RGB in Mexican territory (RGB-MX), the integration of its management has failed due to a lack of hydrologic functioning knowledge and ineffective assimilation of governmental structures.

In summary, the governance of the entire RGB basin is characterized by segregated water governing structures that have disregarded IWRM and assumed suitable micro-regional governments and sustainability practices. This paper is not focused on discussing these key concepts, but rather in explaining how this process happened. The authors provide a brief explanation of why there is some collaboration among institutions even though the institutional and organizational framework is not designed to fully encourage collaboration. Thus, the status quo can be described as multi-tiered governance.

The methodology used in this article is divided in four steps: [*i*] a general overview of the RGB basin and its challenges is presented (Section 1); [*ii*] then the current water management of the basin is described, including its institutional and organizational framework (Section 2) and the hydraulic engineering of the basin (Section 3); [*iii*] based on the

previous description, the authors argue that the basin has a fragmented water resources management (Section 4), this discussion is further extended to notions of governance and sustainable development for the basin (Section 5); and [*iv*] the authors present key findings and perspectives of RGB stakeholders and experts (Section 6) obtained through interviews that align with the findings of the previous section. Valuable insights of the water management challenges and the current crisis over sustainable development and water governance are derived from the interviews. An argument is made for the need to promote more comprehensive and collaborative efforts to preserve the natural environment within the cluttered basin's current system of governance.

2. Rio Grande/Bravo Basin (RGB)

The RGB is the second largest river in the U.S., the fifth in North America and the 24th in the world. Stretching 2,892 km, its headwaters are sourced in the Southern

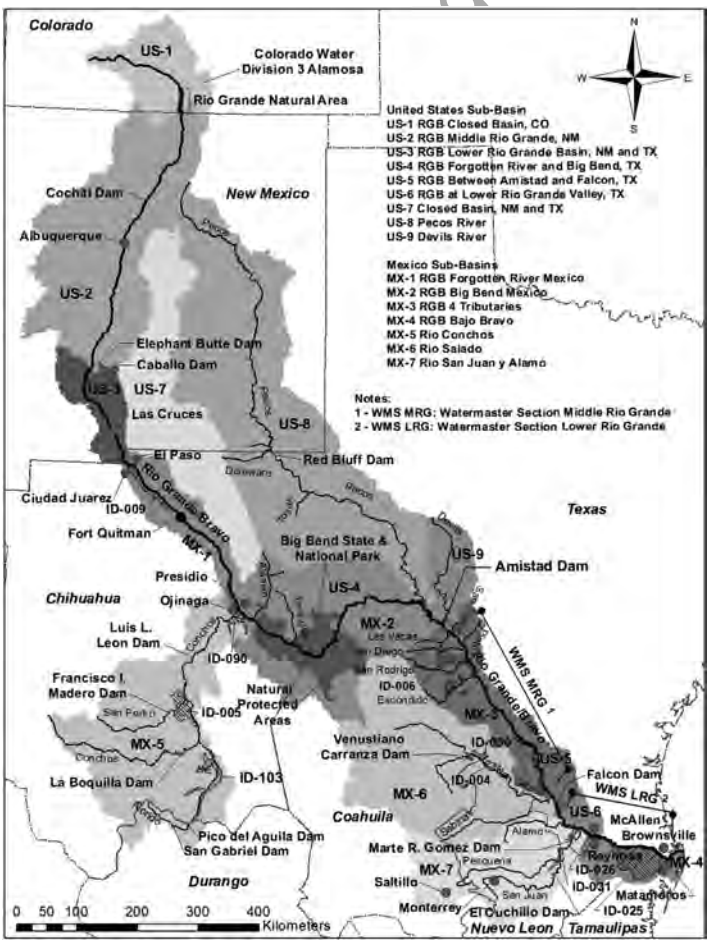

Figure 1. Rio Grande/Bravo (RGB) Basin

Colorado Rocky Mountain Range, continues through New Mexico via the Rio Grande Rift, divides the U.S. and Mexico for 2,034 km before finally emptying into the Gulf of the Mexico (Figure 1). The RGB basin drains a total area of 468,374 km^2, with 242,994 Km^2 (52%) in the U.S and 225,380 Km^2 (48%) in Mexico (Patiño-Gomez, McKinney, & Maidment, 2007).

2.1. Problematic

Since 1993, the RGB has been considered a threatened river. In 2003, American Rivers (McClain et al., 2003) declared it an endangered river, and in 2007, the RGB was described as "one of the most endangered rivers globally" by the World Wildlife Fund (WWF, 2007). Factors inhibiting the RGB basin's environment and sustainability are: (1) Development resulting in over allocation of water available water resources; (2) The large basin is – geographically divided into politically defined sub-basins, the Upper, Middle and Lower basins, — each with a large number of institutions, organizations and stakeholders; (3) Each sub-basin is highly complex, unique in terms of their goals and priorities. Sub-basins are independently operated and governed to their respective political territories which have a large spatial distribution; (4) The normative framework for the sharing and distribution of the basin's waters do not consider the environment as an integral part of water management (Enriquez-Coyro, 1976), hence environmental degradation is prolific.

3. Institutional and Organizational Framework of Water Resources

This section describes the institutional and organizational framework of the current water management in the basin. This framework has two main components: (1) the institutional framework, or the enacted agreements, treaties and compacts; and (2) the organizational framework that provides information about the diversity of the stakeholder priorities.

Institutions are a set of rules, formal and informal, that regulate stakeholder behavior by facilitating cooperation (Haas, Keohane, & Levy, 1993) while reducing the harmful effects of a "tragedy of the commons" (Hardin, 1968). Institutions regulate the system and provide a platform to manage the problems that result from the interdependencies between actors (Keohane & Nye, 1989). Institutions attempt to enhance security and stability within the system. The institutional frameworks in the RGB include: two interstate compacts (the Rio Grande and Rio Pecos compacts) and two binational agreements (Convention of 1906 and the Treaty of 1944) which allocate water between the U.S. and Mexico.

3.1. Water Sharing Regime

The RGB basin is characterized by a complex water distribution and allocation regime. A regime (Young, 1998) is a set of rules, organizations, responsibilities and

decision-making procedures that define social practices and provide the means for structuring systems of governance. A governing system manages the institutional arrangements as understood by the resource users. In this case, the resource users are the RGB stakeholders, the majority of whose interests and involvement lie in water allocation. Organizations are groups of individuals, or stakeholders, that are associated based on joint goals to materialize projects to create shared benefits.

Four rules institutional define the water distribution regime and provide guidance for water allocation in the RGB. The Rio Grande Compact (TCEQ, 1938) allocates the waters of the Rio Grande between Colorado, New Mexico and Texas upstream of Fort Quitman, Texas. It establishes water delivery obligations and depletion entitlements for Colorado and New Mexico to Texas, and, given the variable climate, provides for debts and credits to be carried over from year to year until relinquished under the provisions of the compact. Water of the Pecos River, the largest U.S. tributary of the RGB, is allocated between New Mexico and Texas through the Pecos River Compact (TCEQ, 1948). The Convention of 1906 (IBWC, 1906) allocates water between the U.S. and Mexico, within the international segment of the river located between the El Paso-Ciudad Juárez and Fort Quitman, Texas (McCaffrey, 1996). In total, the U.S. must deliver a total of 60,000 acre-feet/year (74×10^6 m^3/year) to Mexico at the diversion point called Acequia Madre, located close to Ciudad Juárez, Mexico. The Water Treaty of 1944 (IBWC, 1944) allocates water within the international segment of the Rio Grande downstream of Fort Quitman, Texas to the Gulf of Mexico. This treaty authorized the construction and operation of two reservoirs, Amistad and Falcon, along the mainstem of the RGB. It allocates one-third of the water reaching the RGB mainstem from 6 tributaries originating in Mexico to the U.S. and two-thirds to Mexico. The third shall not be less than 350,000 acre-feet/year (432×10^6 m^3/year), calculated as an average over a treaty cycle of five consecutive years. A treaty cycle can expire in less than five years if the U.S. storage account in both reservoirs is full with water. The International Boundary and Water Commission (IBWC) monitors the Mexican delivery of water to the U.S. and determines if the treaty commitments have been met. If there is a deficit in delivery, it must be paid in the following cycle. Furthermore, the two governments entrusted the IBWC to give preferential attention to all border sanitation problems.

The main organizations of the RGB are listed in Table 1, and acronyms for this table and all the organizations described in this paper are provided in Appendix A. These organizations have different roles in the water management of the basin, including water supply agencies, institutions (governmental, financial and science-based), non-governmental organizations (NGOs) and water users. In the context of this paper, governmental institutions can affect water management but they are not responsible for operational infrastructure; only water supply agencies and water users operate the distribution system. Governmental institutions can: (1) set the water allocation for water users; and/or (2) impose restrictions on water use and water quality through regulations; and/or (3) develop water plans. Financial institutions provide resources to build infrastructure and develop technical studies. Often, financial and governmental institutions provide science-based and technical knowledge. NGOs are important for communicating scientific

research and information to the society and stakeholders; they also act as non-partisan organizations during conflict resolution. Most of the water consumption in the RGB is for irrigation, about 85% (Sandoval-Solis, 2011), so the main irrigation districts, which are water users that divert water to irrigate agriculture land, are also listed in Table 1.

Table 1
Organizations in the Rio Grande/Bravo Basin, Their Roles and Responsibilities

		Location		Roles						Responsibilities						
		Upstream Fort Quitman	Downstream Fort Quitman	Water Supply Agency	Governmental Institution	Finantial Institution	Science-based Institution	Non-Governmental Organizations	Water Users	Water Allocation	Water Operation	Water Planning	Regulators	Finance	Irrigation	Communication of Scientific Knowledge
United States	BOR	X		X						X	X	X				
	USACE	X	X				X					X	X			
	EPA	X	X		X								X			
	USGS	X					X									X
	FWS	X			X		X						X			X
	RGCC	X			X					X		X	X			
	NMTXWC	X					X					X	X			
	CO-DWR	X			X					X		X	X			
	CWD3A	X		X						X	X	X				
	CWCB	X			X							X	X			
	CRGCC	X			X					X		X	X			
	SLVID	X							X		X				X	
	OSE	X			X							X	X			
	ISC	X			X							X	X			
	NMED	X			X							X	X			
	EBID	X							X		X				X	
	MRGCD	X		X						X	X	X				
	MRGBI	X			X							X				X
	PDNWC	X						X				X				X
	TCEQ		X		X					X		X	X			
	RGWMP		X	X						X	X	X				
	RGWMS13		X						X		X				X	
	EPCWID	X							X		X				X	
	TWDB		X		X					X		X	X			
	TCRP		X		X							X	X			
	TPWD		X		X							X				X
	TBBNP		X		X							X				X
International	IBWC	X	X		X		X			X		X	X			
	NADBank	X	X			X								X		
	BECC	X	X			X	X							X		
	CEC	X	X				X									X
Mexico	CONAGUA	X	X	X						X	X	X	X			
	SEMARNAT		X		X							X	X			
	INE		X				X					X				X
	PROFEPA		X		X								X			
	SAGARPA		X		X							X		X		
	SEDESOL		X		X									X		
	SEDATU		X		X									X		
	CONANP		X		X		X					X				X
	CCRB		X		X		X			X		X	X			
	IDs-RB	X	X						X		X				X	
	WWF	X	X				X									X

This Table has been elaborated based on a census of institutions related with surface water management done by the authors. Appendix A provides a complete list of abbreviations used.

Nine organizations have responsibility over all the regions upstream and downstream of Fort Quitman. They focus on water quality (EPA), water quantity (IBWC, CONAGUA), financing (NADBank, BECC, CEC), development of operational procedures (USACE), water consumption (IDs-RB) and environmental awareness (WWF); however, none have developed a mandate to develop an IWRM policy for the basin. In summary, the basin water resources allocation and distribution regime is a design of fragmented authorities, organizations and responsibilities. Across the spectrum of institutions and organizations, communication and trust building has been a challenge in successful collaboration and attempts to work towards respective priorities and goals.

4. Hydraulic Engineering Organization of Water Resources

Water is managed and distributed through an engineered system of dams, reservoirs, acequias and drains. The water distribution regime defines the hydraulic engineering organization of the basin. At the basin scale, the RGB has been divided into two large subsystems based on binational agreements to allocate water for each country: upstream of Fort Quitman, Texas, and downstream, where the river dries up and a hydraulic disconnection occurs.

4.1. Upstream of Fort Quitman

Water upstream of Fort Quitman is separated into three politically defined sub-basins: the upper basin, also known as the *Closed Basin,* from the headwaters to Cochiti reservoir in New Mexico, the *Middle Rio Grande Basin* from Cochiti Reservoir to Elephant Butte Dam, and the *Lower Rio Grande Basin,* from Elephant Butte to Fort Quitman, Texas (Nava-Jiménez, 2012). This separation is characterized by the presence of different institutions and organizations responsible for each sub-basins water management. Water resources throughout the sub-basins have been exhausted; all the water has been allocated to water users, very little water flows downstream of Fort Quitman. Average annual flows (1955–2009) are recoded at 4.2 m^3/s, compared to 24.8 m^3/s from the Rio Conchos for the same period.

The *Closed Basin* has a watershed of 7,416 km^2. DWR and, specifically, CWD3A are the agencies responsible for managing this sub-basin. DWR's mission is to ensure proper distribution of water and conformance to the laws and decrees enacted by Colorado. CWD3A is responsible for managing the allocation of waters (DWR, 2013). The goal of CWD3A , which is managed by the U.S. Department of the Interior and the Colorado BOR, is the preservation and conservation of tributary streamflow; water that would otherwise be lost to evapotranspiration during its use in agricultural production. The infrastructure is designed to capture all of the runoff and transfer it via the Franklin Eddy Canal, assisting Colorado's mandatory allocation to New Mexico and Texas according to the Rio Grande Compact. The mainstem of the RGB basin in Colorado is protected under the Rio Grande Natural Area, headed by the Committee on Energy and Natural

Resources (CENR, 2005), with the goal of promoting the protection and restoration of the river zone of the RGB between Colorado and New Mexico.

The organization and management of the Closed Basin are essential to the allocation and distribution of Rio Grande waters between Colorado, New Mexico, Texas and Mexico. In the *Middle Rio Grande Basin* (70,044 Km^2) water is primarily diverted for agriculture by the Middle Rio Grande Conservancy District, as well as for environmental restoration, municipal water use by the City of Albuquerque and recreational resources. In the *Lower Rio Grande Basin,* water is mainly allocated between the EBID, EPCWID and Mexico, and eventually distributed to Irrigation District 009 - Valle de Juárez. The water distribution and allocation in this region is complex because of the individual state laws, sub-basins, inter-state compacts and international agreement that must be met simultaneously while fulfilling environmental and water quality requirements.

4.2. Downstream of Fort Quitman

In this region, water is allocated in three steps. First, water in the RGB tributaries is allocated among water users. For stakeholders located along the Pecos River in Texas, water is allocated according to prior appropriation, which is based on beneficial use and "first in time, first in right" (TCEQ, 2005). In the five states of Mexico (Durango, Chihuahua, Coahuila, Nuevo León and Tamaulipas), water is allocated based on federal water law (CONAGUA, 2008). Second, water reaching the RGB mainstem from tributary and instream flows is allocated between the U.S. and Mexico according to the Treaty of 1944 (IBWC, 1944). Water along the RGB is stored in two international reservoirs, Amistad and Falcon. IBWC is responsible for the accounting and storage of water for each country. Third, based on IBWC's water accounting, water is distributed among water users along the RGB mainstem in each country. In Texas, water is distributed according to the Texas Administrative Code 303 (TCEQ, 2006) while, in Mexico, water is distributed according to the federal water law (CONAGUA, 2008).

In Texas, there are initiatives in place to improve the water quality of rivers. The Texas Clean Rivers Program has the goal of coordinating water quality monitoring at the local and regional scales. It also promotes community awareness and conservation in order to support water quality standards (TCEQ, 2013). Currently, both countries have failed to coordinate how to address quality and quantity problems of the shared basin, despite their interdependency on the resource. The RGB basin suffers the consequences of heavy anthropogenic development (Enriquez-Coyro, 1976). Dams, reservoirs, hydroelectricity generation, agricultural and municipal water use, as well as territorial planning, all contribute to water quality degradation and the alteration of the natural streamflow regime (Small, Bonner, & Baccus, 2009).

5. Fragmented Water Resources Management

Two concepts are discussed and differentiated in this section; basin management approach and IWRM. A basin is defined as the geographical drainage area of a river, or the region irrigated by a shared water system (Brun, 2006). The basin management approach,

or watershed approach, is a technical mechanism to facilitate the implementation of programs connected to a specific basin issue. This model recognizes the basin as a technical and administrative unit, used to improve the management of water resources. "Although it led to the creation of the IWRM, the basin management model is not necessarily comprehensive, but in fact, more technical" (Lasserre, 2012).

IWRM is a process that promotes coordination, development and integrated management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Loucks et al., 2005). The IWRM model allows all of the individuals and institutions to be organized and integrated within a single management structure. It accounts for all of the elements that make up the basin, including social, political and environmental aspects that are linked to the water resources; it also includes stakeholders in the decision-making process and project implementation (Lasserre, 2012, p.46). IWRM is often presented as an effective approach, and considered to be the best solution for transboundary basins. However, it is not widely applied in transboundary basins, even in the case of disputes over water sharing and distribution (Brun, 2006; Lasserre, 2012). In fact, its origins are more "science-based planning processes" been related to principles of international water and environmental management (McIntyre, 2009, p.1) having a normative content "often referring to the Dublin Principles and emphasizing such values as economic benefit, equity, sustainability and public participation" (Svendsen, Wester, & Molle, 2005, p. 2). However, the basic notion of basin leads to the fragmented water resources management approaches: first, focused on regional fragmentation (RGB-U.S.) and, second based on a unified governmental system (RGB-MX).

The current U.S. watershed management approach facilitates the identification of stakeholders and organizations involved in the water management; however, it maintains a highly fragmented basin structure. The U.S. governing system of the RGB is a prime example of fragmented and un-integrated management. This is attributable to three key factors: the unilateral appropriation of water resources; the structure of inter-state management; and the emergence of numerous institutions and organizations with competing interests for water. The U.S. governing system is based on a quantitative basin model. In the Mexican portion of the RGB, federal authorities have been required to follow the IWRM model, but without success. CONAGUA operates each reservoir as if it were an isolated infrastructure component disconnected from the rest of the system. Basin management in the Mexican RGB is not comprehensive; individuals and institutions are fragmented across the basin. The aforementioned systemic fragmentation in both countries persists despite the binational and long-lasting efforts of the IBWC to apply IWRM along the RGB mainstem. Unfortunately, the IBWC does not have the legal support to effectively implement IWRM in the basin.

6. Governance and Sustainable Development

The study of the RGB Basin is a case of governance where all stakeholders are supposed to play an important role in the regional management and sustainability of water resources. A large variety of stakeholders are involved; however, the political and

engineering fragmentation of the Basin encourages the emergence of different stakeholders, institutions and organizations. Water management efforts are therefore fragmented and driven mostly by water quantity, which in turn implies that water quality efforts are generally the result of very isolated and regional issues.

Governance is the definition and implementation of a set of rules that outline practices, assign roles and guide interactions between stakeholders, institutions and organizations. The goal is to treat the problems linked to "common goods" (Benedict, 2001; Haas, Keohane, & Levy, 1993; Kanie & Haas, 2004) by establishing and operating "[a] set of rules that define practices, assign roles and guide interactions to treat the collective problems" (Young, 1997, p. 28). International environmental governance analyzes the impact and roles of stakeholders at different levels in the environmental domain, as well as risk management linked to pressure exerted on natural resources (Haas, 2008). It encourages an understanding of international relationships where the environment is at the core of the problem (Buzan, Wæver, & de Wilde, 1988). Governance allows us to study the propagation of institutions that have an interest in the environment and there emergence in the complex and heterogeneous system where States play a crucial role (Haas, 2008). Institutions reflect the interests and worries of the system; they promote change in the environmental domain on the basis of understanding between States and the cooperation that they supply (Benedict, 2001; Haas, Keohane, & Levy, 1993; Kanie & Haas, 2004; Young, 2001). As a result, the system becomes complex and disorganized, and the State is no longer the only actor, but one of several and its decisions are not definitive but complementary to the overall participatory process.

6.1. Sustainable Issues and Practices

Defined in 1987, sustainable development (also referred in this paper as *sustainability*) is "[the] development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainable water systems are "those systems designed and managed to contribute fully to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity" (Loucks, 1997). Sustainability implies a rational use of natural resources and the reconciliation of economic and environmental objectives with the goal of harmoniously satisfying the needs of society (Sadoff et al., 2008; Voinov & Costanza, 1999). Sustainability is at the center of natural resources management, economic development, land use management and environmental impact (Da Cunha, 2005). It represents the capacity to maintain or promote development within the limits of environmental conservation (Allen, Tainter, & Hoekstra, 2003). Sustainability lies in the capacity for adaptation (Holling, Gunderson, & Ludwig, 2002); it requires institutional capacities and interdisciplinary knowledge that allow for responses to environmental variations provoked by anthropogenic activities. Sustainability exists intrinsically in coordination and prevision and as the system become more

complex, it is more difficult to coordinate and predict changes; consequently, complex systems are more difficult to sustain.

Sustainability in the RGB Basin requires a better understanding of the interrelated dynamics of the river system. There is no sustainable development plan for the RGB basin for three major reasons: (1) the sharing and distribution framework of water promotes fragmented water resources management; (2) the regionalization and hydrologic disconnection of the basin as a result of the river engineering; and (3) the proliferation of stakeholder organizations within the system. These factors have transformed the Basin into a multi-tiered governance system, where each level of water management independently develops its own mechanisms to deal with the sustainability of their respective jurisdiction. In fact, this is a common framework in almost all river basins. In the RGB, this is a well-accepted and institutionalized framework because: (a) it seems to be the best way to manage water in such large geographical space, (b) it defines water ownership and management jurisdictions, and (c) it favors understanding among all stakeholders within its territory. Moreover, in the RGB the notion of basin responds to "established administrative structures that are not commensurate with the entire watershed scale" (Norman and Bakker, 2013:50) but with the allocation of surface water resources.

Consequently, sustainability in the RGB basin is approached from a regional perspective. For instance, sustainable practices at the headwaters of the RGB in Southern Colorado, which is a snowmelt driven reach, are not necessarily applicable in the Forgotten Reach of the RGB mainstem (from Fort Quitman to Presidio, Texas), which is a desert region driven by the monsoon season. Similarly, there are different sustainability challenges even within the same region, e.g., environmental and sustainability challenges in New Mexico are quite different within the state. In the MRGB, a plan for the long-term protection of the riparian forest, or *bosque,* is an essential component for maintaining and improving the health and management of the riparian ecosystem (Robert, 2005). In the Lower Rio Grande basin, sustainability is threatened by the hydraulic engineering of the basin. The Elephant Butte Dam (EBD) is the main engineering structure in the area, used for hydropower and water supply for cities and agriculture. However, EBD has significantly altered the hydrology of the river, threatening the sustainability of the sub-basin in terms of environmental problems related to water quality and quantity (E-coli, salinity, sedimentation), ecosystem degradation and diminishment of quality of life. PDNWC (2010) is implementing a restoration plan whose objective is to improve the water quality in this sub-basin and favor the sustainability of the region through water monitoring programs, scientific studies and community outreach program.

7. Key Findings and Perspectives from Stakeholders

This section presents key findings and perspectives from 23 stakeholders and experts of the RGB in the field of water management and water quality. This analysis is based on

semi-structured interviews conducted from October 2011 to February 2012. The interviewees were selected to reflect the perspectives and knowledge from different sectors: academic, research, water management, irrigation, hydraulic infrastructure, policy and administration, citizen empowerment and natural resources conservation. For ethical reasons, results have been codified to ensure the confidentiality of the interviewees (Table 2). This section shares interviewee perspectives and discuss findings on the existing water management framework and its governance systems, the large mosaic of stakeholders and water governing bodies, sustainability and major issues in the basin, and citizen participation. Thus, the perspectives summarised in this document focus on four themes representing some of the root causes and challenges of governance fragmentation and sustainability practices heterogeneity.

Table 2
Codes of interviews

Affiliation	Specialiation - Profession - Fonction	CODE	LEGENDE-Code
Former New Mexico State University Professor, Chair of the Paso del Norte Watershed Council	Enseignant-chercheur, EWRI-ASCE founder	CAEU1	Academic Community at Las Cruces, New Mexico
The University of Texas at Austin	Professor/researcher at the Lyndon Baines Johnson School of Public Affairs	CAEU10	Academic Community at Austin, Texas, US.
New Mexico State University	Retired - Professeur et ex-director of the New Mexico Water Resources Research Institute	CAEU2	Academic Community at Las Cruces, New Mexico.
The University of Texas at Austin	Professor at the Lyndon Baines Johnson School of Public Affairs et Distinguished Fellow of the Houston Advanced Research Center (HARC)	CAEU3	Academic Community at Austin, Texas.
University of Texas at El Paso (UTEP)	Associate Professor of Political Science	CAEU4	Academic Community at El Paso, Texas
University of Texas at El Paso (UTEP)	Associate Professor of Political Science	CAEU5	Academic Community at El Paso, Texas.
New Mexico State University	Professor and Department Head of the Geography Department	CAEU6	Academic Community at Las Cruces, New Mexico.
New Mexico State University	Professor and Associate Department Head Department of Civil Engineering	CAEU7	Academic Community at Las Cruces, New Mexico.
University of Texas at El Paso (UTEP)	Professor, Center for Environmental Resource Management, University of Texas at El Paso	CAEU8	Academic Community at El Paso, Texas.
Middle Rio Grande Bosque Initiative	Middle Rio Grande Bosque Coordinator (MRGBI)	FNM	Middle Rio Grande Coordinator/Federal/FWS
Rio Grande Advisory Council (RAC)	Chair	GEBi	Environmental Group, Binational
Water-Culture Institute	Director	GENM	Environmental Group , New Mexico
Rio Grande International Study Center	Executive Director	GETx	Environmental Group, Laredo, Texas
Colorado Division of Water Resources Division 3	Responsable	SCo	State of Colorado
Texas Commission on Environmental Quality	Texas Commission on Environmental Quality (TCEQ)	STx1	TCEQ, State of Texas
Bureau of Reclamation (U.S. Bureau of Reclamation)	Manager of the El Paso Field Division of the Bureau of Reclamation in El Paso, Texas. & Planning Engineer, BOR in El Paso, Texas.	USBOR	Division of the Bureau of Reclamation in El Paso, Texas.
Conagua	Coordinator of Advisers of the General manager	FMx1	Federal government employee, MX
Conagua	Rio Bravo Basin Organization, CONAGUA	FMx2	Federal government employee, MX
Conagua	Irrigation Districts and Units for the Rural Development, State Commission of Tamaulipas's Water (CEAT)	EMx1	Tamaulipas State Government, MX
Service of the Environment and Climate Change, Nuevo Laredo	Director	AELMx	Environmental Organization-Group, Nuevo Laredo, MX
Centro Internacional de Estudios del Rio Bravo (Cier, Rio Bravo International Study Center)	Founder - member	GEMx	Environmental Organization-Group, Nuevo Laredo, MX
Instituto Mexicano de Tecnologia del Agua (IMTA, Mexican Institute of Water Technology)	International Relations Department	CAMx4	Academic Community, Mexico City, MX.
Instituto Mexicano de Tecnologia del Agua (IMTA, Mexican Institute of Water Technology)	Subcoordinator of Integrated Water Management, Hydrology Coordination	CAMx5	Academic Community, Mexico City, MX.

This Table has been elaborated based on Doctoral field research done by the first author from October 2011 to February 2012.

7.1. Theme 1: Water Resources Management Framework and Governance System

In the opinion of basin experts, the institutional framework of water sharing and distribution enhances the fragmentation of the basin in several administrative regions. In fact, the RGB-US basin is composed of a jigsaw puzzle of sections and organizations, all of which converge into one single system. This structure transforms the RGB-US into a labyrinth of governing entities, each one playing a role within the governing and water management system. Interviewees noted that there is no single agency overlooking the entire river basin, and that multiple governing agencies participate in most water management. Communications and collaborations between them, though generally effective, are quite often conflictive.

Interviewees argued that the water management regime does not consider water quality. Water management efforts are fragmented and driven to meet water quantity agreements. On one hand, there is no motivation to update the water quantity agreements because water is over allocated. At the same time, quality issues are managed separately; water quality in each region is governed differently. The fact that water quantity and quality are not integrated is strong evidence of the regional fragmentation of the RGB-US basin. Experts mentioned that institutions see the basin as an upstream-downstream riparian system instead of envisioning the basin as an IWRM system. For instance, in the context of water pollution control, a downstream region is expected to pay an upstream region to clean up the pollution source. Only then would the upstream region take care of the pollution source in order to ensure adequate water quality to the downstream riparian.

An example of the fragmentation and misconception of the basin is the importance given to one of the Mexican tributaries. When the waters of the Rio Conchos merge with the RGB at Ojinaga, Chihuahua, the RGB comes back to life; upstream of Ojinaga, there is almost no water flowing in the RGB. An interviewee noted that "the river that flows out into the Gulf of Mexico should really be called Rio Conchos, not RGB. From Ojinaga, the Rio Conchos is not a tributary of the RGB, but rather, the RGB is an intermittent tributary of the Rio Conchos. The 1944 Treaty refers to the sharing and distribution of water coming down from the RGB, which, in fact, is the Rio Conchos, all the way down to the Gulf of Mexico. Therefore, the river within the boundary region should be called the Rio Conchos." This perspective shows the fragmentation of system into two distinct basins: upstream and downstream of Fort Quitman. In truth, the Rio Grande Compact and the Convention of 1906 effectively allocated all of the water upstream of Fort Quitman, making the RGB a terminal river at that point; most of the time, the RGB does not connect to the basin downstream Fort Quitman, Texas.

A profound problem concerning water management, shaped by cultural and social patters, exists in Mexico, The IWRM framework was imposed by decree (CONAGUA, 2008) to the existing political and social reality. Experts highlighted that one of the most difficult processes for a society is the imposition of a framework when reality has not been analyzed and the socio-political context was not taken into account. Mexico is going through this process. The IWRM framework in the RGB-MX is not functioning properly

because of the imposition and mismatch with the reality. In reality, there is a lack of communication between stakeholders and governmental agencies and a lack of confidence in governmental institutions.

7.2. Theme 2: Stakeholders and the Mosaic of Water Governing Bodies

There is a high level of decentralization regarding water management and decision-making in the RGB-US. The coordination of the multiple water management agencies and stakeholders is a huge challenge given the size of the basin and its history of fragmentation. The experts mentioned that stakeholder relations are excellent when there is plenty of water, but during drought, the dynamics get tense and unproductive. The main challenge among RGB-US stakeholders is their ability to collaborate under all water conditions. Communication is another challenge; experts indicated that communication between water agencies, particularly in New Mexico, is often poor, and when it does happen, it is often instigated by a major water issue. In addition, one of the greatest challenges for water agencies is the successful implementation of the decision-making process. According to the experts, the decentralized system promotes participation in the regional decision-making process; in reality, no stakeholder group has a person with full decision-making power and the emergence of new stakeholders hinders the decision-making process.

The multiplicity of efforts and the consequent cost increase are two major challenges. Interviewees stressed the diversity of initiatives and organizations related to water management. Coordination and collaboration between institutions is not easy because their processes and standards may not be compatible. Each organization, at the state or federal level, has its own method of assessing water quality and quantity; designing water plans, implementing them, and monitoring progress. This generates a mosaic of largely disorganized water governing structures that relies heavily on cooperation between the institutions to achieve successful project outcomes.

7.3. Theme 3: Sustainability and the Major Issues in Terms of Water Resources

The sustainability issues in the RGB-US are very different from those in Mexico. Main concerns include the structures in place to promote sustainability and the cooperation between the water agencies and stakeholders. Experts pointed out two good examples of vision sharing on a problem and cooperation among agencies and stakeholders. The biological management plan for the cottonwood *bosque* (Robert, 2005) provides tools for land and water agencies, scientists, conservationists and those concerned with managing, maintaining and improving the health of this ecosystem. The Texas Clean Rivers Program is a collaborative program between the TCEQ (2013) and regional water authorities to conduct water quality monitoring and promote stakeholder participation for improving the water quality within each river basin in Texas.

Experts highlighted that water management agencies were created before the concept of sustainability was even conceived; this is why it is not included in their mission

statements. Experts pointed out that, even today, these agencies have very traditionally missions based on: flood control, water supply, hydropower, and the design and maintenance of hydraulic infrastructure. For instance, for the Rio Grande Compact, some experts affirmed that the concept of sustainability is not considered by the institutions in charge of the water distribution because, when the compact was signed, the notion of sustainability did not mean anything. In fact, this could be the reason why the RGB-US water regime only considers the likelihood of droughts and wet periods based on historic climate conditions. The RGB-US water sharing regime was built under the assumption of abundant water resources. Furthermore, most of the experts mentioned that the institutional framework does not consider climate change or its consequences on agriculture, water supply and land resources. They affirm that the term *extraordinary drought* depends on personal interpretation because it was not defined in the Treaty of 1944 (IBWC, 1944).

Environmental groups experience difficulty in matching interests with other basin players. In general, there is a lack of environmental awareness among stakeholders, government agencies and citizens. With respect to the farming sector, some experts had a hard time envisioning the notion of sustainability because farming is private activity. The cultivation of pecans, alfalfa and tomatoes in New Mexico and southern Texas is possible during full water allocation years; however, during less-than-full water supply years, the production collapses. Alfalfa is a strongly criticized crop because it is a high water use crop; however, it is one of the most important forage crops for the cattle industry. Experts believe that implementing more efficient irrigation practices and improving water resources conservation are key sustainable strategies for the future.

One challenge for the RGB-US, in terms of sustainability, is improving the water quantity management. Water management is currently characterized by a huge difference between the amount of water promised under compacts, treaties and water rights and the amount of water naturally available in the basin. Moreover, river engineering and infrastructure have altered the flows and river morphology such that many native ecosystems are currently in a very poor state or nonexistent. Occasionally, during the irrigation season, the RGB literally dries up. Hence, the restoration and protection of the river system are major concerns in terms of sustainability.

In the case of the RGB-MX, experts mentioned that Sustainable Development must be understood with respect to the local water management problems. For experts at the federal level, sustainability is a broad concept that needs to be defined according to a specific problem. Some, experts mentioned that sustainability could be achieved by the implementation of the IWRM approach, using ad-hoc strategies for semi-arid regions. Acknowledging that a large portion of the RGB-MX is in semi-arid region, droughts are one of the most recurring problems, with major sustainability implications. Another sustainability challenge is the integration of the environment into water management.

For a group of experts, the notion of sustainability was complex and ambiguous. Experts mentioned that the success of water management depends on abandoning the utopic concept of sustainable development; instead, they gave major weight to the implementation of specific actions to solve already identified problems such as excessive

irrigation and deforestation. A whole-basin sustainability vision is needed to identify specific actions for the RGB-MX, a river that is facing extinction. This sustainability vision must consider the social, economic and environmental aspects of water management.

7.4. Theme 4: Citizen Participation

Experts from the RGB-US acknowledged that success of river projects depend on citizen participation. Unfortunately, few citizens attend public hearings, although federal, state, municipal and local organizations encourage citizen participation. The Rio Grande Citizens' Forum (RGCF) is a public platform that brings together environmental organizations in favor of changing the water management activities in the U.S. section of the IBWC. This organization upholds the principle that citizens have the largest stake in terms of water use and management in the RGB-US Basin. But even if citizen participation could be increased, some experts believed that the most difficult problem to solve is building broad citizen awareness and promoting education in water and environmental issues. For Instance, some border human societies have an important impact in the environmental degradation of the RGB. The "*colonias*" are communities or neighborhoods along the Texas-Mexico border that may lack some of the most basic living necessities, such as potable water and sewer systems, electricity and paved roads (SOS, 2014). From one of the expert's point of view, these areas are referred as "an economically distressed area" characterized by precarious living conditions. Due to the lack of proper sewer system, or failing this, they have discharged untreated water into the RGB mainstem. The *colonias* translate in a border urban poverty issue impacting water quality.

In this context, experts underlined how difficult is to make people think about their water problems and change their water use patterns to help preserve the river system. One of the biggest challenges for environmental organizations is the change of perceptions, mind sets and behaviors regarding environmental topics. Therefore, it is critical that citizens have access to the river, meaning they should be able to see it, touch it, feel it and test it; so they can start thinking about it. Enhancing citizen participation in environmental and water issues is an important tool to promote water conservation and environmental awareness. According to the experts, the visibility of the river to citizens is very important. Citizens need to have river experiences to appreciate and preserve it. In the city of Nuevo Laredo, Tamaulipas, there is a strong sense among citizens of appertaining to the river; they participate in conservation activities promoted by the government as well as environmental groups. Experts mentioned that this is the result of citizen awareness of the existence of the river; citizens live near the river and identify with it. They carry out recreation activities, enjoy it and are conscious of its integrity. This phenomenon, not observed elsewhere in the basin, is the result of sensitization and activities carried out by environmental groups and organisms promoting the conservation of the river.

Upstream, the situation is completely opposite. In Ciudad Juarez, the river has water only during the irrigation season. According to some experts, if the river is invisible, the sense of appertaining will not be present. According to CONAGUA (2012), it is important

that the society recognizes and values its water resources. However, federal experts stated that "in reality, there is a lack of participation culture by the society and the current institutional framework does not encourage citizen representation […]." The experts highlighted the importance of building the IWRM approach from the bottom up, to reduce the lack of knowledge in the basin's organization and hydrologic functioning. This approach will favour the preservation of the river system.

8. Closing remarks and outlook

The current governing structure of the RGB is the result of a water sharing regime determined by numerous institutional regional bodies, basin-wide hydrologic fragmentation and stakeholder emergence. This translates into a multi-leveled system of governance, which explains the mosaic of institutions and organizations; directives, agreements, rules and regulations; and the interests of a wide variety of stakeholders. Water is shared as a common right and benefit; but its management is governed separately and differently within each sub-basin. The regionalization of stakeholders institutionalizes the sub-basin framework, giving rise to a plethora of governing entities. The sustainable development of the basin is fragmented and incongruous, since it is defined according to the water needs and problems of each individual sub-basin. At the local level, it is necessary to increase the visibility of the RGB, so citizens can appreciate and preserve it.

Governance in the RGB-US is based on a collection of regional governments that share water quantity and attempt to manage quality, and it is conducted according to regional sustainability challenges that each hydrologic region faces. Conversely, governance in the RGB-MX has a unicentric governmental agency (CONAGUA) and approach (IWRM through Basin Councils) to water management. In practice, the IWRM has not been successfully implemented because the system was imposed on and not well communicated to the society. Water management is fragmented due to the continuation of old practices of managing the system by sub-basin.

Similarly to the U.S., sustainability in the RGB-MX is mainly considered in the local context. In summary, the current system of governance for both countries promotes the fragmentation of water quantity and quality management. The emerging reality, as evidenced by the research, suggests that implementing IWRM is problematic in the RGB-MX where it has been practiced trying to involve all stakeholders meaningfully has proved to be an elusive goal. This prescription proves that its implementation is characterized by fragmentation and not to be very suitable for the entire basin.The governance of the Basin requires the reconciliation of micro-regional governments and localized sustainable strategies. The current water management mechanisms and policies do not consider: (a) the potential benefits that could be obtained through an IWRM, (b) the RGB's fragility and its contribution to human well-being, (c) the economic activities and sustainable functioning of the riparian ecosystems. Prospectively, a Whole Basin Sustainability Plan could be the method to integrate the multi-tiered governance structure and to unify the regional sustainable strategies. This will only be possible if the organizational and institutional structures

adopt a conciliatory and comprehensive vision within the current system of governance. Institutions and organizations must embrace the benefits derived from a whole-basin notion of sustainability. Comprehensive and collaborative efforts are needed to preserve the basin's ecosystems.

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10. Appendix A. Organizations in the RGB

10.1. International

10.1.1 Trinational (United States, Mexico and Canada)

CEC - Commission for Environmental Cooperation

10.1.2 Binational (United States and Mexico)

IBWC - International Boundary and Water Commission
NADBank - North American Development Bank
BECC - Border Environment Cooperation Commission

10.2. United States

10.2.1 Federal

BOR - U.S. Bureau of Reclamation
USACE - U.S. Army Corps of Engineers
EPA - Environmental Protection Agency
USGS - U.S. Geological Survey
FWS - Fish and Wildlife Service

10.2.2 Multi-State Institutions

RGCC - Rio Grande Compact Commission
NMTXWC - New Mexico – Texas Water Commission (NMTXWC)

10.2.3 Colorado

DWR - Colorado Division of Water Resources
CWD3A - Colorado Water Division 3 Alamosa
CWCB - Colorado Water Conservation Board
CRGCC - Colorado Rio Grande Compact Commission
SLVID - San Luis Valley Irrigation District

10.2.4 New Mexico

OSE - Office of the State Engineer
ISC - Interstate Stream Commission
NMED - New Mexico Environment Department
EBID - Elephant Butte Irrigation District
MRGCD - Middle Rio Grande Conservancy District
MRGBI - Middle Rio Grande Bosque Initiative (MRGBI)
PDNWC - Paso del Norte Watershed Council

10.2.5 Texas

TCEQ - Texas Commission on Environmental Quality
RGWMP - Rio Grande Watermaster Program
RGWMS13 - the 13 sections of the Rio Grande Watermaster Program
EPCWID - El Paso County Water Improvement District
TWDB - Texas Water Development Board
TCRP - Texas Clean Rivers Program
TPWD - Texas Parks and Wildlife Department
BBNP - Big Bend National Park (BBNP)

10.3. Mexico

10.3.1 Federal (by its acronym in Spanish)

CONAGUA - National Water Commission
SEMARNAT - Ministry of the Environment and Natural Resources
INE - National Institute of Ecology
PROFEPA - Federal Protection Agency for the Environment
SAGARPA - Ministry of Agriculture, Livestock, Fisheries, and Rural Development
SEDESOL - Ministry of Social Development

SEDATU - Ministry of Agrarian Development, Territorial and Urban
CONANP - National Commission of Protected Natural Areas

10.3.2 Basin Wide

CCRB - Basin Council of the Rio Bravo
CCRC - Basin Council of Rio Conchos
CCSJ - Basin Council of Rio San Juan
IDsRB - Irrigation Districts of the Rio Bravo: ID-004 Don Martin, ID-005 Delicias, ID-006 Palestina, ID-009 Valle de Juárez, ID-025 Bajo Rio Bravo, ID-026 Bajo Rio San Juan, ID-031 Las Lajas, ID-050 Acuña-Falcon, ID-090 Bajo Rio Conchos and ID-103 Rio Florido
WWF - World Wildlife Fund, Chihuahuan Desert Program

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