

## **Managing Transboundary Aquifers: Lessons from the Field**

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### **ABSTRACT**

What are the factors that foster or impede the creation and implementation of international agreements for the management of transboundary groundwater? While legal scholars and management experts tend to highlight the importance of scientific knowledge and institutional frameworks in the norm-making process, others connect the development of institutions for international waters to the existence of threats to States' security, to sovereignty, and to the existence of stakes in the resource's management. This study focuses on three markedly different experiences of transboundary groundwater management, drawing on the analysis of historical documents and more than 40 semi-structured interviews from the field. While the management of the French-Swiss G n vois Aquifer is the subject of a formal international agreement, the authorities dealing with the Guaran  Aquifer System have preferred the implementation of coordinated policies to an overarching international agreement. Conversely, in the case of the U.S.-Mexican Hueco-Bols n Aquifer, the transboundary aquifer is competitively exploited, without any joint-management policies or agreements, and official cooperation is limited to local-level dialogues about the shared resource. In line with the literature, this study suggests that hydrogeological conditions, the compatibility of institutional frameworks, and geopolitics are key factors behind alternative approaches to groundwater governance. This research, however, emphasizes the substantive role of mutually-recognized local-level assessments of transboundary resources—knowledge about the aquifers—in the configuration of the usual explanatory variables. In fact, the governance of transboundary aquifers depends ultimately on calculations and decisions at the local level. Actors at the local level with an interest in the resolution of transboundary groundwater problems may bypass formal institutional restrictions to implement less formal, if nonetheless functional, governance solutions. They can also shield themselves with geopolitical differences, or the incompatibility of institutional settings, in order to block the development and effective implementation of governance initiatives that threaten their interests. These findings contribute to the study of international norm-making processes by shedding light primarily on the dynamics of international environmental governance, and secondarily on issues of local-level policy-making in border settings.

**Key words:** Transboundary Groundwater Governance, Knowledge, Hueco-Bols n Aquifer, G n vois Aquifer, Guaran  Aquifer system

### **1. INTRODUCTION**

Groundwater is a critical component of the global supply of freshwater. Its increased exploitation has resulted in significant economic and welfare gains, as well as declines in the quantity and quality of the resource that seriously threaten the sustainability of ongoing practices (Llamas and Custodio 2003). Despite the vital role played by these resources, international agreements dedicated to the protection and governance of groundwaters that span across boundaries are rare (Burchi and Mechlem 2005, Delli Priscoli and Wolf 2009). In fact, most of the international agreements currently dealing with international waters either incorrectly define or do not properly include transboundary groundwaters, and the few working governance schemes addressing these waters are marked by their uneven geographic distribution, reach, and political contentiousness (Jarvis, et al. 2005, Matsumoto 2002). What are the factors that foster or impede the creation and implementation of international agreements for the management of these waters?

## 2. THEORETICAL EXPLANATIONS FOR TRANSBOUNDARY WATER REGIMES

International Relations theories suggest that the creation of environmental regimes<sup>1</sup> is exclusively a matter of State power (Ruggie 1998, Young 1989). In other words, the creation of water management agreements is a tool for rational territorially-based sovereign States. In depth studies of water regimes, particularly those of the "water wars" literature, use hydropolitical analyses to argue that water management institutions are responses to geopolitical tensions created by threats of water scarcity (Dinar 2000, Elhance 1999). Water regimes are presented as rational instruments for the prevention of conflicts fostered by specific environmental conditions (Gleick 1993, Homer-Dixon 1999). The explicit assumptions of these studies are that states require minimum quantities of water, or at least stability in the access to the water resources, and that threats of scarcity are resolved either through violence or institutions. According to this approach, international agreements over the management of transboundary groundwater develop from threats posed by scarcity to state security. The resulting agreements are conditioned by the relative power of each party to push for the establishment of regimes serving its interests.

Socio-legal and political science studies focus on issues of knowledge and institutions to explain agreements over shared waters. Framing groundwater as common pool resources, some point to the functional-rational nature of institutional arrangements (Gardner, et al. 1997). Rules permit more effective access to resources, as well as their protection and sustainable exploitation, and can prevent competitive use of groundwater. Agreements are hence connected to rational calculations by users, which in turn depend on the specific properties of the shared resources (Chermak and Brookshire 2005). More specifically, it is the interpretation of knowledge of hydrogeologic conditions that determines the urgency of agreements, and the goals of the management arrangements (Blatter and Ingram 2001). The creation of new rules occurs within the boundaries set by culture, politics and institutional frameworks, which may, however, not always be compatible with new regulatory initiatives for transboundary groundwater.

This paper aims to challenge two aspects of existing theoretical approximations: the macro-scale of analysis proposed by International Relations theory and the relevance of structural restrictions in the making of rules in institutionalist perspectives. Drawing from more than 40 semi-structured interviews and original documents gathered in the field, this study presents three alternative cases of transboundary groundwater governance: the Franco-Swiss G n vois Aquifer, the Argentinean, Brazilian, Paraguayan and Uruguayan Guaran  Aquifer System, and the U.S.-Mexican Hueco-Bols n Aquifer. These case-studies highlight three different approaches to managing these resources, and suggest that the development of governance mechanisms always depends on the availability of mutually-recognized assessments of transboundary resources. Indeed, this sort of knowledge is necessary for the common framing of groundwater management problems and can foster the creation of cooperative solutions. More generally, the selected cases expose that different hydrogeologic conditions, institutional frameworks and geopolitics dictate distinct logics in the development of groundwater agreements. However, the cases also show that the implementation of joint, or coordinated, governance mechanisms is effectively determined by local-level users and decision-makers. Actors at the local level with an interest in the resolution of transboundary groundwater problems can sometimes bypass formal institutional restrictions and implement less formal, albeit functional, governance solutions. They can also shield themselves in geopolitical differences or the incompatibility of institutional settings to prevent the development and effective implementation of transboundary groundwater governance initiatives that threaten their interests.

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<sup>1</sup> Regimes are defined by Young as "social institutions that consist of agreed upon principles, norms, rules, decision-making procedures, and programs that govern the interactions of actors in specific issue-areas" (1989: 5-6).

### 3. THREE APPROACHES TO TRANSBOUNDARY GROUNDWATER MANAGEMENT

#### 3.1. *The G n vois Aquifer: Governance through a Formal Groundwater Management Agreement*

The G n vois aquifer is located at the border of the canton of Geneva, Switzerland, and several French collectivities in the Haute-Savoie region. Relatively small in size, it spans across about 19 kilometers and is used to complement the freshwater supply of the city of Geneva and a few French towns along the border. The aquifer's waters are relatively close to the surface, at depths that range from 15 to 80 meters, and are recharged naturally principally from infiltrations of the Arve River, a torrential river fed by the Alps' glaciers (Amberger, et al. 1981, De Los Cobos 2002). The main management problem of the G n vois aquifer is the over-pumping of its waters. During the sixties and seventies, the water levels in the aquifer began to decrease significantly as a consequence of higher demand from the growing regional urban centers. The lowering water table jeopardized infrastructure investments, namely wells and water supply infrastructure (De Los Cobos 2002) and exposed the need to find solutions to guarantee regional urban freshwater supply.

The deteriorating conditions of the aquifer and its acknowledged bi-national nature pushed regional stakeholders and policy-makers to consider alternative strategies for its protection and sustained exploitation. In 1978, the region of Haute-Savoie and the Geneva Canton signed a thirty-year renewable agreement, the first of its kind for a transboundary aquifer, which mandated the construction of an artificial recharge facility (managed and constructed by the Swiss) and established a water pricing scheme to charge the French for groundwater exploitations beyond a specific quota (Wohlwend 2002). The artificial recharge plant compensated over-pumping of the aquifer with the injection of waters from the Arve River into the aquifer. The agreement regulated groundwater exploitation, the protection of the resource, and engaged the Canton of Geneva and neighbouring French collectivities in the systematic exchange of information about the use of the aquifer<sup>2</sup>.

Multiple factors contributed to the formulation of the agreement. The artificial recharge of aquifers had been successfully implemented in other Swiss aquifers, and tests showed that the aquifer would respond appropriately to injection. In addition, in 1975, the construction of the artificial recharge facility cost about 20 million Swiss francs, while a treatment plant to exploit waters from the L man Lake was estimated at 150 million Swiss francs (De Los Cobos 2002). The chosen approach also permitted the city of Geneva to maintain a diversified water supply that insured it against unexpected contamination of the surface water sources. Furthermore, the agreement guaranteed the continued exploitation of wells, which depends on the maintenance of certain water levels in the aquifer. Knowledge about the aquifer's properties and the economic and strategic viability of the recharge solution supported decision-making. The agreement permitted the parties to focus on the resolution of the concrete technical issues of groundwater management at the local level. However, although the legality of the agreement was never effectively questioned, its actual legal validity remained dubious until the agreement's renewal in 2008. This is because while the canton of Geneva had the legal authority to engage in international negotiations, the French local-level counterparts lacked, nominally, the autonomy to sign international agreements. The agreement was signed by the Prefect of Haute-Savoie. To summarize, in this case the development and implementation of the agreement was possible because of the national-level indifference about the issues of transboundary groundwater management on the French-Swiss border, good knowledge of hydrogeologic conditions, and local interest in effective management of the transboundary aquifer.

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<sup>2</sup> In 2008, after 30 years, the agreement was renewed with minor adjustments. The content of the agreement was mostly preserved. The addendums specified the legal precedents that legitimize the agreement.

### *3.2. The Guaraní Aquifer System: Local-Level Coordination of Groundwater Governance*

The Guaraní Aquifer System spans over one million square kilometers underneath Argentina, Brazil, Paraguay and Uruguay, and has an estimated total reserve of more than 30 trillion cubic meters of water, 90 percent of which is potable (Cox, et al. 2009). As a consequence of its size and complex geologic composition, the aquifer's groundwater can be found at different depths and with different and diverse chemical compositions, depending on the location. For example, at the Brazilian city of Riberão Preto, the Guaraní aquifer is relatively shallow and is used for urban water supply. It is threatened by potential pollution, contamination and over-drafting. In contrast, at the border of Uruguay and Argentina, the sister cities of Salto and Concordia exploit the aquifer for geothermal tourism. There, the Guaraní's water-bearing formations are at depths of more than 200 meters and are confined by a thick layer of basalt. The management problems include the competitive use of the aquifer and the lack of both standardized well perforation techniques and control of discharges.

The increasing acknowledgement of the transboundary nature of the aquifer and the diversity of issues posed by groundwater management triggered proposals for the creation of a joint management framework for the aquifer. Talks about the aquifer were initially fuelled during the nineties by regional hydrogeologists. They led, in 2001, to a project supported by the four countries and financed by the Global Environmental Fund to study the Guaraní Aquifer System. The "Environmental Protection and Sustainable Management of the Guaraní Aquifer System Project" was preventive in nature: it would create a knowledge base to support protection of the aquifer and to prevent potential conflicts that could arise between the countries. The project successfully concluded in 2009 and permitted the characterization of the aquifer and the development of management solutions. It also created awareness of groundwater issues at both the local and national levels.

Initial treatment of the Guaraní aquifer in political debates framed the challenges of its management in terms of upstream-downstream dynamics (as if they were surface waters); the countries voiced fears that competitive exploitation of the shared resource could hinder them. Research derived from the joint project showed, however, that the aquifer's general lateral flow of water is naturally slow, as dictated by the hydraulic gradient, and significantly accelerates only with human intervention at the local level (Cox, et al. 2009, Tujchneider, et al. 2007). As a result, for local transboundary areas with potential risk of conflict, the countries developed specific coordinated policies. For example, the cities of Concordia and Salta agreed upon common regulation of drilling practices, waste disposal and the establishment of minimum distances between wells. The city of Riberão Preto began regulating groundwater abstraction and the protection of the aquifer's local recharge zones. In lieu of a formal agreement for the joint management of the aquifer, the countries opted for specific local-level operational arrangements. The official joint assessment simplified the common framing of groundwater problems and simplified policy-making at the local level. It also helped dispel ill-informed assumptions about the aquifer's features that, paradoxically, had initially mobilized the countries to undertake further research about the transboundary aquifer. In this case, although the formalization of an agreement did not occur, countries introduced groundwater into their agendas and coordinated policies for its management. The compatibility of institutional frameworks was not an issue because transboundary impacts were restricted to border cities with the autonomy and will to enact coordinated policies. In this case, hydrogeologic information helped reframe geopolitical concerns and supported the creation and implementation of local-level solutions for the management of the transboundary aquifer.

### *3.3. Hueco-Bolsón: Informal Cooperation for Groundwater Governance*

The Hueco-Bolsón Aquifer is located underneath the sister cities of El Paso, Texas, and Ciudad Juárez, Chihuahua, in a region known as the "Paso del Norte" at the center of the U.S.-Mexico border and

the northern section of the Chihuahua Desert biome. The aquifer spans between two U.S. states, New Mexico and Texas, and the Mexican state of Chihuahua. Aquifer recharge is limited and its reserves consist mostly of "fossil" waters that accumulated during the more humid conditions of the Pleistocene (Cliett 1969). In fact, the aquifer freshwaters constitute only a fraction of the total groundwater reserve, and they are being progressively mined. Measurements show the aquifer's water level has been reduced by as much as 45 meters since the nineteen forties, and water quality continues to deteriorate (Chavez 2000). Consequently, for the main users of the aquifer, the cities of El Paso and Ciudad Juárez, management challenges include the establishment of limits to groundwater pumping, the definition of allocation principles among different users (irrigators, cities, industry), and the minimization of groundwater treatment costs.

Regional water regulation is a sensitive and highly contentious political issue. In fact, the region's water availability is restricted not only due to the region's arid conditions, but also by existing surface water allocation agreements. Agreements signed in 1906 and 1944, which regulate the use and allocation of surface waters between the U.S. and Mexico, have asymmetrically allocated the shared surface waters between the two countries, and local-level stakeholders fear that groundwater regulation will impose new limits and inequalities in access to transboundary groundwater resources. In addition, new overarching agreements for groundwater would defy established ownership rules and historical power allocations (Mumme 2003). Indeed, the rules governing groundwater on both sides of the border and among different U.S. states are incompatible (Milman and Scott 2010, Schlager 2005). While groundwaters are controlled by the federal government in Mexico, the American federal government has limited jurisdiction over them. In the U.S., authority over groundwater depends on individual state legislation. In Texas, groundwater property rights are akin to those of mineral resources and provide property owners with unfettered rights to pumping, while in New Mexico, groundwater is subject to adjudication by the State Engineer's office.

The geopolitical tensions and institutional incompatibilities have not, however, stopped local-level actors from acknowledging the problems of the Hueco-Bolsón Aquifer. Indeed, understanding the complexity of the institutional situation and pressing environmental conditions, local water planners have managed to develop informal information-sharing mechanisms about hydrogeologic conditions, as well as about their long-term water supply planning strategies. In 1997 and 1998, the water utilities of Ciudad Juárez and El Paso signed agreements, under the auspices of the International Boundary and Water Commission, for the exchange of data to update and refine the hydrogeologic characterization of the aquifer<sup>3</sup>. These arrangements did not seek to regulate groundwater exploitation. The local water utilities have independently pursued strategies to deal with the increasing costs of the exploitation of the shared aquifer. Although the transboundary governance concerns are similar, the parties have failed to cooperate in the creation of joint solutions to resolve groundwater problems. In this case, large-scale geopolitical tensions and institutional incompatibilities, as well as local-level concerns about the potential threats posed by groundwater regulation to current exploitation schemes have prevented the development of cooperative solutions.

#### 4. KNOWLEDGE AND THE LOCAL IN TRANSBOUNDARY GROUNDWATER GOVERNANCE

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<sup>3</sup> Respectively, the "Joint Report Of The Principal Engineers Regarding Information Exchange And Mathematical Modeling In The El Paso, Texas And Ciudad Juarez, Chihuahua Area Aquifer" from 1997, and the "Transboundary Aquifers and Binational Ground Water Database For the City of El Paso / Ciudad Juarez Area Report" of 1998. More recently, the U.S. Congress passed a "Transboundary Aquifer Assessment Act" aimed at encouraging and funding research of the transboundary groundwater resources along the US-Mexico border. The 2008 Act provides financial support for the regional universities to develop joint-research projects about transboundary groundwaters.

Dealing with groundwater presents challenges different than those posed by surface watersheds. Indeed, transboundary groundwater problems depend on complex geographically-specific factors (Llamas and Custodio 2003). Although the lack of knowledge about these elements makes governance agreements either vacuous or impossible, controversies over what constitutes politically legitimate knowledge and how to translate it into formal international arrangements are recurring issues of environmental governance. The understanding of the hydrogeologic features of the Guaraní Aquifer System, the Hueco-Bolsón and the Génévais Aquifer does not necessarily lead to joint management solutions. In all cases, however, because groundwater problems are always geographically specific, the local level is the scale on which governance effectively operates. Scientific knowledge is necessary for the specification of the problems and reaching consensuses, but its translation into policy is conditioned by institutions and politics.

Politics and institutions condition local-level action. Nonetheless, actors at the local level are ultimately those that make or break transboundary groundwater regimes. The first and one of the few formal agreements exclusively dedicated to transboundary groundwaters, the agreement for the Génévais aquifer, was signed by parties whose legal authority was questionable. Regardless, the 1978 agreement was implemented because the substantive content of the agreement could be enforced without the intervention of third parties. The canton of Geneva had the resources to build and manage the artificial recharge facility, while the French collectivities had the ability to pay for groundwater abstractions beyond the pre-specified quota. The extant institutional framework was not a barrier to the implementation of the agreement. In the case of the Guaraní Aquifer, once the countries understood that transboundary impacts (geopolitical concerns) were limited, national-level authorities eschewed the need to formalize a large-scale agreement. Local authorities ultimately coordinated rule-making. In the case of the Hueco-Bolsón Aquifer, notwithstanding geopolitical tensions and institutional incompatibilities, joint-solutions have lacked because local stakeholders actively refuse to regulations that may affect local interests of autonomy and the maintenance of current exploitation patterns.

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