

FACTORS ENABLING TRANSBOUNDARY AQUIFER COOPERATION

A Global Analysis



KIRSTIN I. CONTI

Factors Enabling Transboundary Aquifer Cooperation: A Global Analysis

Westvest 7
2611 AX Delft
The Netherlands
P +31 (0)15 215 2325
E info@un-igrac.org
W www.un-igrac.org

Cartography by Friedemann Scheibler
Formatting, Layout and Graphics Completed by Erik Geerts

 Except where otherwise noted, this work is licensed under
<http://creativecommons.org/licenses/by-nc-sa/3.0/>

(c) 2014 Kirstin I. Conti



International Groundwater Resources Assessment Centre

IGRAC, the International Groundwater Resource Assessment Centre facilitates and promotes international sharing of information and knowledge required for sustainable development, management, and governance of groundwater resources worldwide. Since 2003, IGRAC has been providing independent content and process support, focusing on transboundary aquifer assessment and groundwater monitoring.



United Nations
Educational, Scientific and
Cultural Organization



Government of
The Netherlands



World Meteorological
Organization

Table of contents

Factors Enabling Transboundary Aquifer Cooperation: A Global Analysis

1.	INTRODUCTION	1
2.	BACKGROUND	3
2.1	PHYSICAL CHARACTERISTICS OF TRANSBOUNDARY AQUIFERS	3
2.2	USES OF TRANSBOUNDARY AQUIFERS	5
2.3	GOVERNANCE OF TRANSBOUNDARY AQUIFERS	6
2.4	INTERNATIONAL LAW AND TRANSBOUNDARY GROUNDWATER RESOURCES	7
2.5	PEACE, SECURITY, AND TRANSBOUNDARY AQUIFERS	9
2.6	TRANSBOUNDARY WATER INTERACTIONS	10
2.7	DRIVERS OF TRANSBOUNDARY WATER INTERACTIONS	14
2.8	COMPLEXITIES IN TRANSBOUNDARY WATER INTERACTIONS: AN EXAMPLE	16
3.	FACTORS ENABLING COOPERATION	18
3.1	IDENTIFYING ENABLING FACTORS	19
3.2	OVERVIEW OF CASE STUDIES	19
3.3	IDENTIFYING AND DEFINING ENABLING FACTORS	22
3.4	TRENDS IN ENABLING FACTORS	27
4.	LINKING ENABLING FACTORS, TRANSBOUNDARY AQUIFER EVENTS, AND TRANSBOUNDARY AQUIFER INTERACTIONS	31
4.1	TRANSBOUNDARY AQUIFER EVENTS	31
4.2	TRANSBOUNDARY AQUIFER INTERACTIONS	32
4.3	LEVELS OF ENGAGEMENT FOR TRANSBOUNDARY AQUIFERS	33
5.	SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	39
5.1	SUMMARY OF FINDINGS REGARDING ENABLING FACTORS	39
5.2	CONCLUSIONS REGARDING ENABLING FACTORS	41
5.3	RECOMMENDATIONS	42
5.4	AREAS FOR FURTHER RESEARCH	43
	APPENDIX A: PROFILES OF TRANSBOUNDARY AQUIFER COOPERATION	A-1
A.1	INDEX OF CASE STUDIES	A-2
A.2	INDEX OF ENABLING FACTORS	A-3
A.3	METHODOLOGY FOR CASE IDENTIFICATION	A-3
	APPENDIX B: REFERENCES	B-1
	APPENDIX C: LIST OF INTERVIEWEES	C-1

Preface and Acknowledgements

Enabling Factors for Transboundary Aquifer Cooperation: A Global Analysis is the result of a research project initiated by IGRAC for the 2013 United Nations International Year Water Cooperation. The research was ongoing during 2013 and preliminary findings from that year were viewed and reviewed through various means including publication in the UNESCO book Free Flow and presentation at the 2013 Stockholm World Water Week. The final publication is released with the understanding that the global overview could be updated in the future since the nature and locations of transboundary aquifer cooperation are continually changing. IGRAC hopes that this initial attempt to capture the state of cooperation as of 2013 will be a starting point for future projects and research concerning this subject.

I would like to thank everyone at IGRAC who supported the publication of this report, especially Dr. Neno Kukuric and Stefan Siepmann. Special thanks are also owed to Geert-Jan Nijsten and Raya Stephan for their review and feedback on multiple drafts as well as interim brainstorming, input and recommendations; there is no doubt that the quality of this research was greatly improved by their suggestions. I would like to thank Dr. Sarah Hendry at the Centre for Water Law, Policy and Science of University of Dundee for her support of my Master's research, which formed the basis of the content here. The adaptation of the TWINS framework was completed in consultation with Dr. Naho Mirumachi of Kings College London and I am grateful for her personal attention and continued interest in this project. Also Lena Heinrich and Friedemann Scheibler are responsible for the wonderful cartography featured here. So I thank them for their patience and ingenuity with the maps. Many thanks are owed to my mother, Donna Clay-Conti, who reviewed the final version of this report. Finally, I would like to thank my family and friends for supporting me in all my endeavors.

LIST OF ACRONYMS AND ABBREVIATIONS

APRONA	Observatoire de la Nappe d'Alsace [Association for the Protection of Groundwater in the Plain of Alsace]
BAR	Basins at Risk Intensity Scale
Berlin Rules	Berlin Rules on Water Resources
BMP	Best Management Practice
CEDARE	Centre for Environment and Development for the Arab Region and Europe
CONAGUA	National Water Commission of Mexico
Danube Convention	Convention on Cooperation for the Protection and Sustainable Use of the Danube River
DIKTAS	Dinaric Karst Transboundary Aquifer System
Draft Articles	Draft Articles on the Law of Transboundary Aquifers
EAC	East African Community
eds.	editors
EPDRB	Environmental Programme for the Danube River Basin
EU	European Union
EU WFD	European Union Water Framework Directive
FAO	Food and Agriculture Organization
FGEF	French Global Environmental Facility
G-77	Group of 77
GEF	Global Environmental Facility
GIZ	German Agency for International Cooperation
Helsinki Rules	Helsinki Rules on the Uses of Water of International Rivers
IAEA	International Atomic Energy Agency
IBWC	International Boundary and Waters Commission (United States and Mexico)
ICPDR	International Commission for the Protection of the Danube River
IGRAC	International Groundwater Resources Assessment Centre
IJC	International Joint Commission (United States and Canada)
ILA	International Law Association
ILC	United Nations International Law Commission
INTERREG	European Union Interregional Cooperation Programme
INWeb	International Network of Environment Water Centres
ISARM	UNESCO-IHP Internationally Shared Aquifer Resources Management Programme
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
Joint Authority	Joint Authority for the Study of the Development of the Nubian Sandstone Aquifer Waters
JSET	Joint Supervision and Enforcement Teams of Israel and Palestine
JWC	Joint Water Committee of Israel and Palestine
km ²	Square kilometers

Madrid Convention	European Outline Convention on Transfrontier Co-operation Between Territorial Communities or Authorities
MERCOSUR	Common Market of the South
Mm ³	Million cubic meters
MRC	Mekong River Commission
NSAS	Nubian Sandstone Aquifer System
NWSAS	Northwestern Sahara Aquifer System (same as SASS)
OAS	Organization of American States
OSS	Observatoire du Sahara et du Sahel [Sahara and Sahel Observatory]
PCCP	UNESCO-IHP From Potential Conflict to Cooperation Potential Programme
PNAS	Post Nubian Aquifer System
RBC	River Basin Management Commission
RBO	River Basin Management Organizations
SADC	Southern Africa Development Community
SADCC	Southern African Development Coordination Conference
SAG	Sistema Acuífero Guaraní [Guaraní Aquifer System]
SAP	Strategic Action Program
SASS	Système Aquifère du Sahara Septentrional (same as NWSAS)
ScaldWIN	Contribute to a better quality of surface and groundwater bodies in the Scheldt International River Basin District
SEE	South Eastern Europe region
Seoul Rules	Seoul Rules on International Groundwaters
T-JAM	Thermal Joint Aquifer Management
TWINS	Transboundary Water Interaction Nexus
UN	United Nations
UN Watercourses Convention	United Nations Watercourses Convention
UNDP	United Nations Development Programme
UNECE Water Convention	United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes
UNEP	United Nations Environmental Programme
Upper Rhine Agreement	Agreement between the Swiss Federal Council, the Government of the Federal Republic of Germany and the Government of the French Republic on Cross-border Co-operation in the Upper Rhine Region
US	United States of America

1. INTRODUCTION

In recent years, significant attention has been given to the potential for conflict over water resources, particularly transboundary resources. However, research has shown that it is considerably more likely that stakeholders will use cooperative approaches than adversarial ones (Yoffe et al. 2004; de Stefano et al. 2010). While cooperative events are relatively well-documented through media and publicly available information, there is a gap in understanding what conditions facilitate sustained cooperation over water resources. This gap is even more evident when it comes to transboundary aquifers because researchers and practitioners have given them less attention than their surface water counterparts (Jarvis et al. 2011; Linton & Brooks 2011; Feitelson 2003; Machard de Gramont et al. 2011). However, the importance of transboundary aquifers cannot be emphasized enough. There are 608 identified transboundary aquifers worldwide underlying almost every nation – excluding most but not all islands (International Groundwater Resources Assessment Centre 2014). These resources are of considerable importance given that groundwater from TBAs fulfills basic human needs and irrigates arable lands worldwide (Siebert et al. 2010; Döll & Hoffmann-Dobrev 2012). Further, countless habitats rely on groundwater flow for their survival, such as groundwater-dependent wetlands and desert ecosystems. Given the critical importance of groundwater resources worldwide, this report will present a global analysis of factors that enable and facilitate cooperation over transboundary aquifers.

The focus of current water diplomacy and conflict resolution research is methodologies for and “best practices” in dismantling existing water conflict. Yet, conflict over groundwater has rarely risen to the international scale. In light of this, managing potential conflict may not be the appropriate goal for groundwater resources. Instead, focusing on enabling cooperation could prove more fruitful given that most aquifer states (states sharing a transboundary aquifer) are not yet interacting about transboundary aquifers. Therefore, the purpose of this report is to link theory and observations about real occurrences of transboundary aquifer cooperation and answer the question: What factors enable and facilitate cooperation over transboundary aquifers?

To respond to this question, the report outlines current theories about why international water cooperation occurs and subsequently matches these theories with the identified factors that lead to cooperative events. In other words, it will describe where reality and theory meet. It also makes conjectures as to why. To accomplish this, a multi-step analysis is conducted. First, instances of transboundary aquifer cooperation are identified, along with the mechanisms by which the aquifer states are cooperating. Next, the context under which the cooperation occurs is assessed. Each incidence of cooperation is then indexed according to the intensity of cooperation resulting from the various cooperative mechanisms and cooperative contexts. This index allows the specific enabling factors to be correlated with two metrics of transboundary cooperation: transboundary aquifer events and transboundary aquifer interactions. Patterns and trends in the occurrence of these “enabling factors” are then extrapolated.

Data for the analysis comes from a range of resources. Information regarding transboundary aquifers at the global level is primarily sourced from the International Groundwater Resources Assessment Centre (IGRAC). A review of academic literature and practitioner guides identified theories and frameworks for cooperative management of transboundary water resources. Instances of cooperation are identified through project documents from IGRAC, the International Shared Aquifer Resources Management Initiative (ISARM), the Global Environmental Facility (GEF), the UNESCO-IHP from Potential Conflict to Cooperation Potential Programme (PCCP), as well as a general internet search. Details surrounding the nature of transboundary aquifer cooperation are gathered from these project documents and supplemented by academic research on the aquifers. This constitutes a new research effort that addresses an existing gap in water cooperation/

conflict theory regarding practical motivations for cooperation. In the end, the report recommends how the “enabling factors” can be used to encourage future transboundary groundwater cooperation.

Section 1 provides an overview of the report and the theoretical background on cooperation over transboundary aquifers by describing the transboundary aquifers of the world, summarizing current theories of cooperative water resources management, and generally describing instances of cooperation and conflict over transboundary aquifers. Section 2 extrapolates enabling factors from observed cases of transboundary aquifer cooperation and accounts for the context in which the cooperation occurred. Section 3 identifies trends in the presence of enabling factors such as geographic trends, trends in physical extent, and temporal trends. Section 4 discusses the correlation between enabling factors and the intensity of cooperative interactions. Section 5 presents conclusions and recommendations along with implications for ‘good practices’ in transboundary groundwater management. Full profiles of the transboundary aquifer cooperation cases evaluated in this analysis are found in Appendix A.

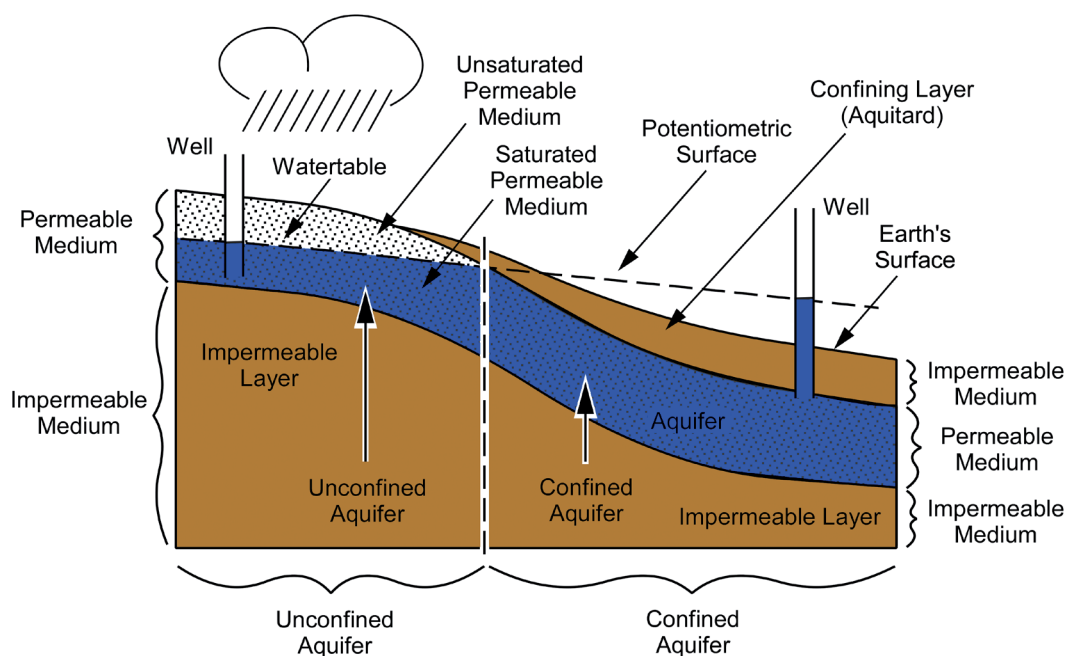
2. BACKGROUND

2.1 PHYSICAL CHARACTERISTICS OF TRANSBOUNDARY AQUIFERS

A broad definition of groundwater is water which fully saturates pores and fissures in the earth's subsurface geological formations (Fitts 2002). Using this definition, groundwater can be distinguished from surface water and the water contained in partially saturated soils (also called the vadose zone). In most cases, groundwater moves very slowly taking tens to thousands of years to move a few meters. Groundwater is formed when rainwater falling on land or water flowing over land is absorbed into the soil and percolates into the underlying geological formation. Depending on the characteristics of the sub-surface geology, the groundwater, together with the rock matrix, can form an aquifer. Hydrogeologists do not rely on any one definition of an aquifer. Consequently, this report relies on the definition provided by the United Nations International Law Commission's Draft Articles on the Law of Transboundary Aquifers (Draft Articles). The Draft Articles define an aquifer as "a permeable water-bearing geological formation underlain by a less permeable layer and the water contained in the saturated zone of the formation" (International Law Commission 2008). The Draft Articles further define a transboundary aquifer or a transboundary aquifer system as "an aquifer or aquifer system, parts of which are situated in different States."

There are two types of aquifers discussed in this analysis: unconfined and confined. In an unconfined aquifer, the water table occurs within the aquifer layer. This means that the groundwater comes in contact with the atmosphere through soil pores or fissures (Fitts 2002; Margat & van der Gun 2013). On the other hand, confined aquifers are sandwiched between layers which are wholly or partially impermeable (Fitts 2002; Margat & van der Gun 2013). Some aquifers only receive negligible amounts of recharge on a human timescale and are therefore considered non-recharging. These aquifers contain 'fossil' groundwater.¹

Figure 1. Visualization of a Confined and Unconfined Aquifer

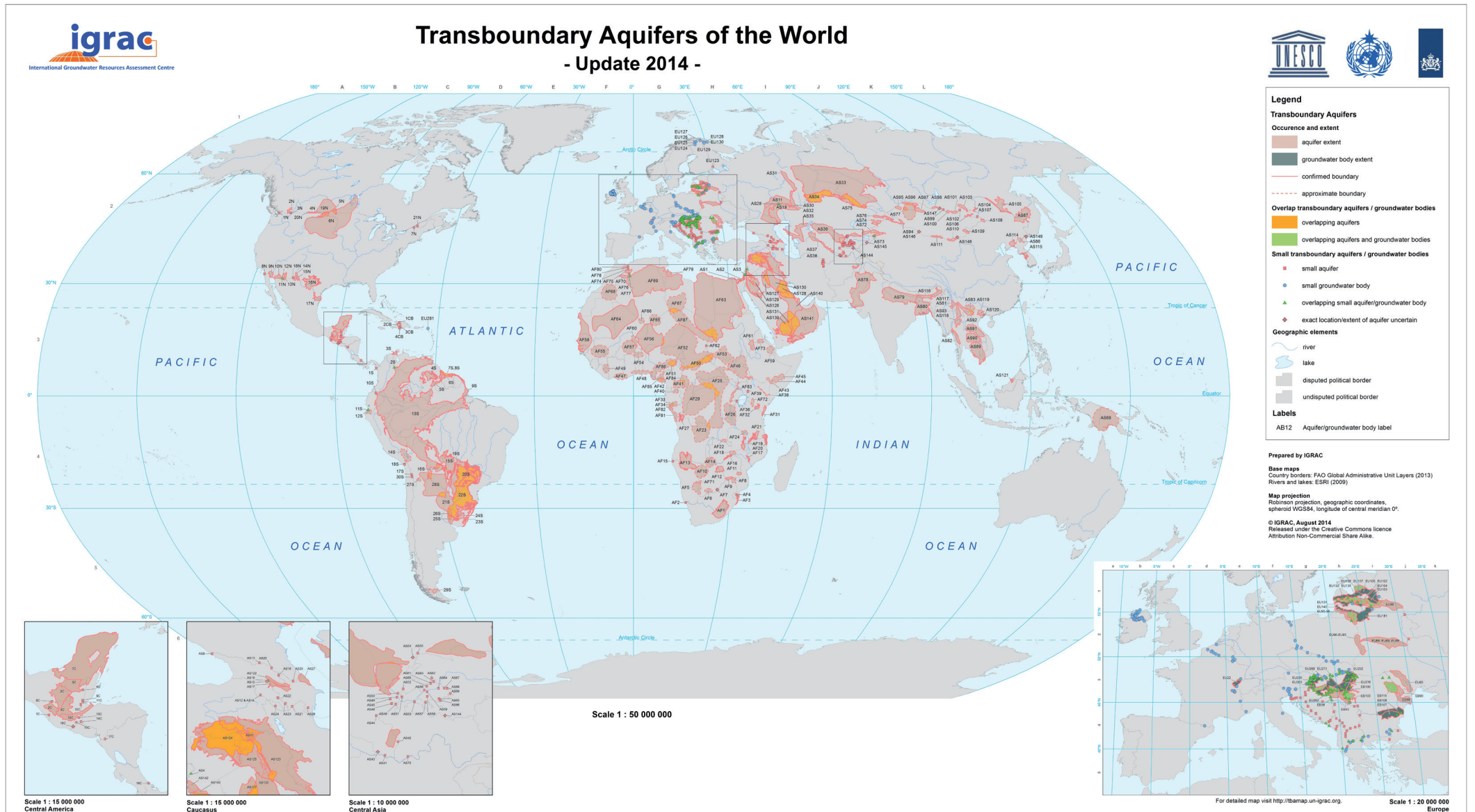


Source: Hermance 1999:17

The CC license does not apply to this picture.

¹ Although commonly used, the term 'fossil aquifer' is a misnomer. "Fossil" describes the groundwater rather than the aquifer itself.

Figure 2. Transboundary Aquifers of the World



Eckstein and Eckstein (2005) put forth six conceptual models of transboundary aquifers to depict scenarios under which groundwater resources have transboundary impacts. These models are representative of the vast majority of aquifers around the world. The attributes of these models are summarized in Table 1. While scientists' understanding of aquifers is significant, there is a lack of aquifer-specific data and knowledge in large parts of the world, especially when compared with that of surface water resources (Jarvis et al. 2011). Hydrogeologists agree that many aquifers - particularly non-recharging aquifers - are at high risk of overexploitation and contamination. Unfortunately, an aquifer with these problems is often difficult to remediate and rehabilitate (Linton & Brooks 2011).

Table 1. Models of Transboundary Aquifers

	Aquifer Type	Associated Surface Water	Potential for Transboundary Pollution Impacts	Potential for Transboundary Extraction Impacts	Example Aquifers Cases
Model A	Unconfined, transboundary	River forming an international border	Limited	Yes	Rio Grande Aquifer Danube Aquifer
Model B	Unconfined, transboundary	River intersects international border	Yes	Yes	Abbotsford-Sumas Aquifer Mures/Maros Aquifer San Pedro Basin
Model C	Unconfined, transboundary	River flows within a single state	Yes	Yes	Mimbres Basin
Model D	Unconfined, within a single state	River intersects international border	Yes	Yes	Mesopotamian Basin
Model E	Confined recharging, Transboundary	None	Yes	Yes	Syr Darya Aquifer Mountain Aquifer Guaraní Aquifer
Model F	Confined non-recharging, transboundary	None	Yes	Yes	Nubian Sandstone Aquifer Complex Terminal Aquifer Qa-Disi Aquifer

Source: based on Eckstein & Eckstein 2005

2.2 USES OF TRANSBOUNDARY AQUIFERS

In many arid, semi-arid, and temperate regions, groundwater composes a vast majority of the water supply. Worldwide, a significant portion of the human population relies on groundwater to meet their basic needs — drinking, bathing, hygiene, cooking and cleaning. In terms of commercial agriculture production, most recent estimates show that 43% of water used for crop irrigation is groundwater (Siebert et al. 2010). However, some estimates are as high as 65%. (Machard de Gramont et al. 2011). Worldwide, 50% of municipal water withdrawals and 40% of industrial withdrawals originate from groundwater (Zektser & Everett 2004). In Europe over 80% of drinking water is supplied from groundwater (Struckmeier et al. 2005). Meanwhile in Africa, Latin America and Asia increasing access to groundwater has been a major catalyst of growth and development (Wijnen et al. 2012).

Groundwater resources are not only critical to the human, but also the natural environment. Environmental impacts most often arise when ecosystems, partially or wholly dependent on groundwater, receive reduced or contaminated flows. Therefore, the volume and quality (e.g. temperature, chemical composition, and pollutant load) of groundwater discharge can be of critical importance to maintaining biodiversity (Puri et al. 2001). Discharges into coastal areas can also influence the marine environment. For example, groundwater discharges in the Adriatic Sea are significant and maintain the saline balance many of the species require.

Given that groundwater constitutes 97% of the world's non-frozen freshwater resources, it is expected to have a more critical role in meeting expanded water needs in the future. Demand for water in developing countries is expected to grow 25% between 2010 and 2025 due to increased preference for water intensive foods, technological advancement, and economic development (UNESCO 2012). Increased pumping and subsequent discharge of groundwater may also have a noticeable impact on sea level rise (Konikow 2011). Simultaneously, groundwater use has the potential to combat impacts of climate variability by serving as secondary supply when availability of surface water is reduced and by buffering the effects of flood and/or drought through managed aquifer recharge schemes.

2.3 GOVERNANCE OF TRANSBOUNDARY AQUIFERS

Governance of transboundary aquifers is becoming a critical need. Over abstraction, contamination and degradation of recharge areas are the main threats to the sustainability of aquifers worldwide (Wijnen et al. 2012). Increased areas with impermeable surfaces, deforestation and desertification are also reducing the volume of groundwater recharge globally. Consequently, the planet is in the midst of a “silent revolution,” stemming from the proliferation of groundwater use and the near absence of legal and managerial oversight (Llamas & Martínez-Santos 2005).

Lack of scientific and technical knowledge about specific transboundary aquifers is one of the major challenges to proper governance. Without adequate technical understanding of aquifers, states may not properly identify the source of aquifer pollution or depletion and may be prone to blaming each other for mismanagement. Thus, absent some efforts to manage the aquifers, it is unlikely that any advanced technical understanding will be pursued. This paradox is the crux of the groundwater governance challenge and perhaps explains why groundwater governance regimes are so sparse today.

Further, weak institutional structures and the absence of legal frameworks involving aquifer states likely result in poor communication regarding the allocation and quality of the resource. In the case of non-recharging aquifers, which contain fossil groundwater, one state's extraction of the water resource would cause the other aquifer states to permanently lose the opportunity to utilize the groundwater (see Table 1, Model F). This type of extraction could cause a state to believe their sovereignty is threatened, possibly increasing the potential for conflict (Jarvis et al. 2011).

The 'out-of-sight, out-of-mind' nature of aquifers adds a dimension of complexity to assessing conflict potential, especially when considering the impact of unilateral development. Developments within a transboundary aquifer may occur over an extended period of time before any of the aquifer states recognize a problem. The unexpected drying of wells, reduction of base flow, or emergence of communal health problems may spark conflict in areas where groundwater management was not previously a priority.

Comprehensive governance of groundwater resources is critical to preventing and mitigating the aforementioned threats to groundwater resources. The United Nations Development Programme (UNDP) has defined governance as the 'exercise of political, economic and administrative authority in the management of a nation's affairs at all levels.' The Global Water Partnership has defined water governance as the "range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society" (Rogers & Hall 2013). Most recently, Varady et. al. (Varady et al. 2013) specifically defined groundwater governance as "the process by which groundwater is managed through the application of responsibility, participation, information availability, transparency, custom, and rule of law. It is the art of coordinating administrative actions and decision making between and among different jurisdictional levels—one of which may be global." Compared to surface water, there are few legal and institutional tools designed to specifically manage groundwater resources and those that do exist are generally at the sub-national level and perhaps the aquifer or sub-aquifer scale (Linton & Brooks 2011; Feitelson 2003). According to Wijnen et al. (2012), proper governance frameworks will embody five main attributes:

1. an Integrated Water Resources Management (IWRM) modality that can allocate water in accordance with the institution's policy goals;
2. a robust legal framework including laws, appropriative rights, and regulatory tools;
3. economic incentives that promote good management including subsidies, taxes, cost-recovery, and [tradable] licenses;
4. a framework which facilitates groundwater management at the lowest appropriate administrative level and supports local management; and
5. data and information from groundwater monitoring networks and from the observations of community level stakeholders.

There are myriad obstacles to adopting groundwater governance frameworks, particularly at the international level. Groundwater is a common-pool resource and is often utilized at an individual scale regardless of overall impacts to an aquifer. This approach creates a 'tragedy of the commons' situation, wherein the resource is utilized only with regard to current benefits to the individual user. Meanwhile the likelihood for future, detrimental impacts to the resource and the users, as a collective, is ignored. The fact that most groundwater is accessible without many costs or requirements for monitoring exacerbates these issues. Negative impacts to the resource remain unseen and become evident only when adverse impacts to human and ecological health occur due to contamination and/or over pumping. In the absence of good groundwater governance and in the face of threatened transboundary aquifers, some states have experienced conflict and others have been motivated to seek out cooperative mechanisms for management. Legal regimes, in particular treaties, are commonly espoused mechanisms for cooperation. The following section highlights the current status of international legal regimes for groundwater.

2.4 INTERNATIONAL LAW AND TRANSBOUNDARY GROUNDWATER RESOURCES

In general, legal instruments for transboundary aquifer governance are nascent and customary in nature (Dellapenna 2011). This could be explained by understanding how international law itself develops. The most influential source of international law is state practice. In other words, how states are interacting with each other regarding a certain topic in the legal regime. While, numerous states have developed national frameworks

governing groundwater there is very little to be said about state practice with regard to transboundary aquifers.

There is only one international agreement that goes so far as to establish a system for allocating transboundary groundwater resources.² There are several international rules and agreements that set forth specific legal principles for the management for transboundary groundwater and/or aquifers. They can be divided into two broad categories: those that are legally-binding upon the ratifying parties and those that are non-binding rules that serve as guidelines for the international community.

‘Until quite recently, transboundary groundwater resources were treated as the neglected stepchild of international water law. Transboundary aquifers were habitually ignored in projects with international implications, consistently omitted from treaties and cursorily understood in much of legal discourse. To a large extent, these resources were “out of sight, out of mind,” largely because few realized that the resource they pumped was shared with another county.’

– Gabriel Eckstein

Legally binding agreements include the United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention) (1992) and the United Nations Convention on the Non-Navigational Uses of International Water Courses (UN Watercourses Convention) (1997). It is worth noting that the UNECE Water Convention was originally a European regional instrument and is now amended such that it is open to accession by all UN Member States (United Nations Economic Commission for Europe 2003). It clearly includes all transboundary water resources in its scope and facilitates cooperation through the formation of joint management bodies. In contrast, the UN Watercourses Convention was negotiated and created at the global level, but defines its scope as any “system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus [...] parts of which are situated in different States” (see Article 2(a)). However, this does not include all types of transboundary groundwater resources, notably confined non-recharging aquifers, among others.

There are three sets of non-binding rules developed by the International Law Association's (ILA), an epistemic community of lawyers that seek to articulate and progressively development international law. These are the Helsinki Rules on the Uses of Water of International Rivers (Helsinki Rules) (International Law Association 1966), Seoul Rules on International Groundwaters (Seoul Rules) (International Law Association 1986), and Berlin Rules on Water Resources (Berlin Rules) (International Law Association 2004a). The Berlin Rules are the first set of rules to dedicate a chapter to transboundary groundwater resources, yet they are considered controversial in that their scope includes both transboundary and domestic water resources (International Law Association 2004b).

² The only international treaty including volumetric allocation of groundwater resources is the 2008 Convention Genevois between France and Switzerland (Convention on the Protection, Utilization, Recharge and Monitoring of the Franco-Swiss Genevois Aquifer). This convention was originally ratified in 1978 and was constructed for a 30 year term. The new convention is further aligned to new developments in international and supranational water law including the United Nations Economic Commission for Europe ‘Convention on the Protection and Use of Transboundary Watercourses and International Lakes’ and European Union Water Framework Directive respectively.

The United Nations International Law Commission's Draft Articles – which are currently appended to the United Nations General Assembly Resolution on the Law of Transboundary Aquifers – are still under review by the UN General Assembly and have not yet taken a final form. They are an outcome of the first efforts of the global legal community to establish a generally applicable, legal agreement for the governance of transboundary aquifers. The United Nations General Assembly endorsed them in 2008 and again in 2010 after member states submitted comments. As of October 2013, the General Assembly has proposed to further discuss the final form of the Draft Articles. They will be reviewed again in 2016 and may become a stand-alone declaration of principles, may become a protocol to the UN Watercourses Convention, or remain in an indeterminate form (Eckstein & Sindico 2014).

In addition to the uncertain future of the Draft Articles, there is an ongoing debate in the international legal community about the merits of the Draft Articles because they include the sovereignty principle (Article 3 of the Draft Articles). The inclusion of sovereignty is viewed as a reversal of several decades of legal developments in the area of international water law (McCaffrey 2011; McIntyre 2011; Tanzi 2010). Others believe this language to be appropriate given that the sovereignty text within the Draft Articles is “balanced” by the provisions of equitable and reasonable use, no significant harm, as well as multiple references to the need to cooperate in the management of transboundary aquifers (Sindico 2011; Eckstein 2007; Stephan 2011; Yamada 2011). Despite the uncertainty and controversy surrounding the Draft articles, they have undoubtedly contributed to the development of international law as it relates to groundwater resources and may eventually become part of a suite of legal texts utilized by the international community to govern transboundary groundwater resources.

2.5 PEACE, SECURITY, AND TRANSBOUNDARY AQUIFERS

While water is essential for life, human civilization has not necessarily settled in locations with consistent water availability. Water shortages have existed as long as history has been recorded. Thus far, humanity has been able to cope with these local challenges to water security. However, the exponential increase in human population, the vast spread of contamination and degradation of water resources and the more noticeable impacts of climate change are increasing the threat to global water security. At this juncture, it is critical to discern the nature of the water security threats. It has been determined that there is enough water available to meet human needs, but poor resource management consistently undermines attempts to properly allocate and conserve the global water supply (Lautze et al. 2011; UNESCO - World Water Assessment Programme 2006). Consequently, there is an ongoing discourse about whether competing user groups, such as agriculture and industry, and the aforementioned water security threats will lead to conflict or inspire cooperation.

Theorists and practitioners that believe cooperative approaches will prevail have history on their side. Studies of past cooperative and conflictive water events show that cooperation is far more prevalent than conflict. Out of 2,586 recorded “water events,” documented between 1948 and 2008, only 31% were considered conflicts (de Stefano et al. 2010). Further, it is argued that the benefits of cooperation far outweigh those that could be gained via conflict. Cooperation could create ecological benefits to the water body itself (ecological and intrinsic values) and from the water body for humans and ecosystems (economic and ecological values) (Sadoff & Grey 2002). Benefits to aquifers could include pollution prevention, enhanced recharge, as well as sustainable and reasonable use. Benefits from aquifers might be more consistent base flows to surface waters, improved drinking water quality, more reliable conjunctive uses, halted subsidence, affordable water

for agricultural irrigation, and even hydropower in karst formations.³

Some believe that water conflict will result from political and economic tensions combined with increased climatic variability, resource depletion and degradation (Gleick 1993; Shiva 2002; Solomon & Turton 2000). However, according to Sadoff and Grey, tensions surrounding international waters extend far beyond issues concerning water itself. They can include 'historic, cultural, environmental and economic' factors, which together can greatly influence the nature of water-related interactions (Sadoff & Grey 2002). Peter Gleick also notes that conflicts involving water are not usually about the water resource itself. Rather the water resource is used as a means to a political or militaristic end (Gleick 1993). Further data that shows the proportion of conflicts increased in the period between 2000 and 2008 relative to the period between 1948 and 1999.

'...Violence over water is strategically irrational, hydrographically ineffective and not economically viable.'

– Aaron t. Wolf

Unfortunately, the discourse about cooperation and conflict is often disjointed to the point that it presents two false dichotomies. The first is that cooperation and conflict are mutually exclusive and occur in opposition to each other. The second that cooperation is 'good' and that conflict is 'bad' (Zeitoun & Mirumachi 2008). The reality, more often than not, is that cooperation and conflict co-exist within a single event and/or locale (Wolf 2008). Further, conflict may lead to a more optimal long-term outcome than a seemingly cooperative event that consists of a series of acquiesces and avoidances. 'Cooperative' events that lack political nuance, exclude key parties, or are the result of hegemonic coercion can undermine effective cooperation, reinforce conflict, and render attempts to create an equitable management framework moot. Therefore, the approach this report takes in its analysis is to examine interactions between aquifer states over time, utilize water events as an indicator of their level of interaction and determine the level of engagement between states regarding a transboundary aquifer.

2.6 TRANSBOUNDARY WATER INTERACTIONS

In conducting a literature review regarding transboundary water cooperation and conflict, it became clear that opting to characterize a particular transboundary aquifer in a binary way — as being in a state of cooperation or conflict — would be overly simplistic and potentially deceptive. The reality for transboundary aquifers, as well as other transboundary resources, is that governing them often incites both cooperation and conflict between the relevant stakeholders. The concept that these seemingly separate concepts often co-exist is discussed in a range of disciplines, including political psychology, conflict resolution, transboundary environmental negotiation and water management (Zeitoun & Mirumachi 2008). To facilitate an understanding of the various transboundary groundwater interactions presented in this report, the Transboundary Water Interactions NexuS (TWINS) model is employed (Mirumachi & Allan 2007).

³ Karst is a geological formation composed of carbonate rock, which over time has dissolved into conduit systems such as caves. In these formations, groundwater flows rapidly (as high as 400 m/hr), sometimes as though it is in a river (adapted from descriptions in Domenico & Schwartz 1998).

As adopted from the work of Zeitoun and Mirumachi (2008), transboundary groundwater interaction is defined here as the relation of co-existing cooperation and conflicts among communities, groups, or states over international aquifers and associated sub-national aquifers, with a focus on transboundary interaction.

The TWINS model is founded on the work of Craig (1993), which plots high and low levels of conflict and cooperation on a 2x2 grid – composed of low and high conflict on one axis and low and high cooperation on the other. TWINS builds upon Craig's grid by enabling transboundary water interactions to be characterized 3-dimensionally using conflict intensity, cooperation intensity, and time. Therefore, the dynamics of the interactions can be diagramed based on events and actions occurring between the basin stakeholders. The location of an event on the cooperative scale (x-axis) reflects the intension of the parties to reach consensus or take collective action for the management of water resources. The scale moves from least cooperative interactions on the left to most cooperative on the right. Mirumachi and Allan (2007) define each of the five cooperative labels on the scale as follows:

- Confrontation on the issue – the issue is acknowledged but there is no specific joint action or identification and sharing of goals
- Ad hoc – joint action but no shared goals
- Technical cooperation – shared goals but no joint action is taken
- Risk-averting – joint action and shared goals, in addition to the belief that the other will do as expected to execute the action
- Risk-taking – states will assume costs without evident reciprocation

On the conflict scale (y-axis), the intensity is based on the work of the Copenhagen School, Warner and Zeitoun (Zeitoun & Warner 2006; Zeitoun & Mirumachi 2008). The premise is that issues presenting an increasing threat to the state attract more attention and resources, thereby becoming increasingly politicized. Consequently, the following four conflict labels are defined as follows:

- Non-politicized – issues that do not concern the state, or issues that are not in the public domain
- Politicized – issues with a place on the political agenda
- Securitized – the issue is an existential threat requiring emergency measures and justifying actions outside the normal bounds of political procedure (Buzan et al. 1998)
- Violized – violence is employed over the issue

A detailed description of how the TWINS framework is applied in this report is included in Section 3.1. It should also be noted that water event data were critical to implementing the aforementioned frameworks. Consequently, the next section defines and describes water event data and their relevance to transboundary groundwater interactions.

Currently, there is no official or unofficial global tracking mechanism for water –related events and interactions (de Stefano et al. 2010). However, researchers have utilized 'event data' to generate a historical record of water-related events. According to Schrodtt (1995), "event data" are a compilation and indexing of daily news reports of interstate interactions which overtime represent cooperative or conflict. Recently, databases containing a myriad of event data were examined for historical events involving water resources. This vast undertaking was made more difficult by the fact that most event data focus on crises (i.e. military action) with

relatively little attention given to natural resources. The International Water Events Database ⁴ is the sole event database dedicated to documenting state-level interactions related to water.

In addition to providing a comprehensive record of water events, the International Water Events Database creates the Basins at Risk (BAR) intensity scale, to index the intensity of the cooperation or conflict that occurred. The BAR intensity rates water events on a scale where the most intense conflict is rated at -7, and the highest form of cooperation is rated at +7 (see Table 3). Recently, the United Nations World Water Assessment Program presented a modification of the original BAR intensity scale that was initially developed by Yoffe and Larson (2002) to expand the types of events that can be associated with each of the ratings. This modified version will be used in this discussion. Using this rating approach, global analysis of water events can include statistical and quantitative methodologies (de Stefano et al. 2010). However in this report, the BAR intensity scale will be used as an indicator to place each of the cases within the framework of the TWINS model.



The CC license does not apply to this picture.

⁴ The International Water Events Database documents historical international water interaction beginning in 1948. It defines events as ‘instances of media-reported conflict and cooperation that occur within an international river basin, involving nations riparian to that basin and concerning freshwater as a scarce or consumable resource’. Issues related to flooding, flood control or navigation are not included in the database (Oregon State University 2014).

Table 2. Modified Water Event – Basins at Risk (BAR) Intensity Scale

BAR Value	Event Description
-7	Formal Declaration of War
-6	Extensive war acts causing deaths, dislocation or high strategic cost: Using nuclear weapons; full-scale air, naval, or land battles; invading or occupying territory; massive bombing of civilian areas; capturing of soldiers in battle; large scale bombing of military installations; chemical or biological warfare.
-5	Small-scale military acts: Limited air, sea, or border skirmishes; border police acts; annexing territory already occupied; seizing material of target country; imposing blockades; assassinating leaders of target country; materially supporting subversive activities against target country.
-4	Political-military hostile actions: Inciting riots or rebellions (providing training or financial aid for rebellions); encouraging guerilla activities against target country; limited and sporadic terrorist actions; kidnapping or torturing foreign citizens or prisoners of war; giving sanctuary to terrorists; breaking diplomatic relations; attacking diplomats or embassies; expelling military advisors; executing alleged spies; nationalizing companies without compensation.
-3	Diplomatic-economic hostile actions: Increasing troop mobilization; boycotts; imposing economic sanctions; hindering movement on land, waterways, or in the air; embargoing goods; refusing mutual trade rights; closing borders and blocking free communication; manipulating trade or currency to cause economic problems; halting aid; granting sanctuary to opposition leaders; mobilizing hostile demonstrations against target country; refusing to support foreign military allies; recalling ambassador for emergency consultations regarding target country; refusing visas to other nationals or restricting movement in a country; expelling or arresting nationals or press; spying on foreign government officials; terminating major agreements. <i>Unilateral construction of water projects against another country's protests; reducing flow of water to another country, abrogation of a water agreement.</i>
-2	Strong verbal expressions displaying hostility in interaction: Threatening retaliation for acts; making threatening demands and accusations; condemning strongly specific actions or policies; denouncing leaders, system, or ideology; postponing visits by heads of state; refusing participation in meetings or summits; leveling strong propaganda attacks; denying support; blocking or vetoing policy or proposals in the UN or other international bodies. <i>Official interactions only.</i>
-1	Mild verbal expressions displaying discord in interaction: Objecting in a low-key way to policies or behavior; communicating dissatisfaction through a third party; failing to reach an agreement; refusing protest note; denying accusations; objecting to explanation of goals, position, etc.; requesting changes in policy. <i>Both unofficial and official, including diplomatic notes of protest.</i>
0	Neutral or non-significant acts for the inter-nation situation: Making rhetorical policy statements; broadcasting non-consequential news items; inviting non-governmental visitors; making statements of indifference; compensating for nationalized enterprises or private property; making 'no comment' statements.
1	Minor official exchanges, talks or policy expressions, mild verbal support: Organizing meetings of high officials; conferring about problems of mutual interest; inviting junior officials for talks; issuing joint communiqués; appointing ambassadors; announcing ceasefires; allowing non-governmental exchanges; proposing talks; tolerating public non-governmental support of the regime; exchanging prisoners of war; requesting support for policy; stating or explaining policy.
2	Official verbal support of goals, values, or regime: Officially supporting policies, raising legations to embassies; reaffirming friendship; asking for help against third parties; apologizing for unfavorable actions or statements; allowing entry of press correspondents; asking for aid or expressing thanks for it; resuming broken diplomatic or other relations.
3	Cultural or scientific agreement or support (non-strategic): Starting diplomatic relations; establishing technological or scientific communication; proposing or offering economic or military aid; recognizing the government; organizing visits by the head of state; opening borders; conducting or enacting friendship agreements; conducting cultural or academic agreements or exchanges. <i>Agreements to set up co-operative working groups.</i>
4	Non-military economic, technological or industrial agreement: Making financial loans or grants; agreeing to economic pacts; giving industrial, cultural, or educational assistance; conducting trade agreements or granting Most-Favored-Nation status; establishing common transport or communication networks; selling industrial/technological surplus supplies; providing technical expertise; ceasing economic restrictions; repaying debts; selling non-military goods; giving disaster relief. <i>Legal, co-operative actions between nations that are not treaties; co-operative projects for watershed management, irrigation, poverty-alleviation.</i>
5	Military economic or strategic support: Selling nuclear power plants or materials; providing air, naval, or land facilities for bases; giving technical or advisory military assistance; granting military aid; sharing highly advanced technology; intervening with military support at the request of government; concluding military agreements; training military personnel; formulating joint programmes and plans to initiate and pursue disarmament.
6	International Freshwater Treaty; Major strategic alliance (regional or international): Fighting a war jointly; establishing a joint military command or alliance; conducting joint military maneuvers; establishing an economic common market; joining or organizing international alliances; establishing joint programs to raise the global quality of life.
7	Voluntary unification into one nation: Merging voluntarily into one nation or state, forming one nation with one legally binding government.

Source: de Stefano et al. 2009

2.7 DRIVERS OF TRANSBOUNDARY WATER INTERACTIONS

As discussed above, there are numerous theories about what drives cooperative and conflictive transboundary water interactions. While each of them cannot be discussed in detail in this report, they are broadly grouped into five categories: ecological drivers, economic drivers, geopolitical drivers, legal/institutional drivers, and social drivers. This section will provide a brief overview of each.

2.7.1. ECOLOGICAL DRIVERS

The dominant water cooperation/water conflict discourse has posited that water stress and water scarcity are the main drivers of water conflict. This includes Falkenmark's 'water stress index' and Ohlsson's adaptation, the 'Social Water Stress Index' (Ohlsson 2000; Falkenmark & Allard 1991). Gleick (1993) also uses four indicators to characterize water conflict risk, two of which are directly related to water availability.⁵ While, the aforementioned analysis of event data by Yoffe and Larson indicates that quantity is one of most common subjects of water disputes, the general presence of water scarcity at the country level is not a good indicator of overall conflict potential. Related research by Wolf et al. indicates that water stress is not a "significant" indicator of water conflict and that climatic conditions do not impact cooperation potential (Wolf et al. 2003).

Since the debunking of the scarcity-water conflict myth, ecological drivers are now seen as a potential source of cooperation. The use of the Integrated Water Resources Management (IWRM) approach is put forth as one of the 'Seven Pillars' of water cooperation by UN-Water (UN-Water 2008). This approach requires stakeholders from various sectors and levels of governance to manage surface waters, groundwaters, and associated ecological resources as an integrated unit. Integrated management across jurisdictional boundaries has the potential to yield a range of benefits including enhanced ecosystems services and improved water quality. These benefits would be shared by all the aquifer states and could incentivize them to interact cooperatively (Sadoff & Grey 2002). To this end, the need for exchange of information as well as joint monitoring and assessment are increasingly viewed as drivers for cooperation, particularly when the water resources are suffering from depletion and degradation (UN-Water 2008). Increased availability of scientific information may not have a direct impact on the diplomatic track, but could make potential ecological benefits more transparent to stakeholders, facilitate communication, and thus drive increased cooperation (Sálamé & van der Zaag 2010).

2.7.2. ECONOMIC DRIVERS

The desire for economic development is frequently sighted as a source of potential conflict between countries sharing water resources. For example, if one country's water allocation or availability changes due to the actions of another country, it is possible that their agricultural or hydropower industries will suffer negative consequences. If this is the case, there could be potential for conflict over the resource. Wolf et al. (2003) indicate that the socio-economic condition within a basin is weak indicator of conflict potential. Due to the theory of benefit sharing, as initially framed by Sadoff and Grey, economic factors are increasingly viewed as a source of cooperation rather than conflict.

Benefit-sharing emphasizes enlarging the scope of potential gains from water cooperation by looking beyond the water resources themselves. This includes the potential to share economic gains from hydropower,

⁵ The four indices are (1) ratio of water demand to supply; (2) water availability per person; (3) fraction of water supply originating outside a nation's borders, and (4) dependence on hydroelectricity as a fraction of total electrical supply.

agricultural and/or industrial trade, managed aquifer recharge and ecosystem services. While Sadoff and Grey (2002) only apply this model to surface water, groundwater has the potential to create a similar range of benefits and gains for aquifer states, such as revenue shared from regional geothermal energy production or hydropower in large karst formations. UN-Water and Zeitoun, among others, cite benefit and cost sharing as well as economic development goals as potential drivers of cooperation (Zeitoun et al. 2010; UN-Water 2008).

2.7.3. GEOPOLITICAL DRIVERS

The role of geopolitical factors in transboundary water interaction is a highly complex and the subject of a large volume of academic research. The political dynamics between basin/aquifer states can potentially determine whether there is cooperation or conflict. While, the types of governmental entities that share an aquifer do not have a large bearing on cooperative potential, significant changes in the political regime, such as dissolution of a single country into multiple countries, can increase conflict potential. It is also important to note that cooperation relative to non-water issues does not necessarily predict cooperation with respect to water (Wolf et al. 2003).

Two circumstances can have substantial effects on transboundary water interaction. The first is power asymmetries between the basin or aquifer states; the second is actions with disproportionate effects on one or more basin states. According to Zeitoun, power asymmetries can both promote and interfere with cooperation. For example attitude of a hydro-hegemon, a very strong state towards regional water management will largely determine the nature of transboundary water interactions. Transboundary water interaction would also be impacted if a single aquifer state, regardless of the distribution of power, chooses to take unilateral action that would disproportionately harm the other states.

Costs of non-cooperation would be high for some if not all of the aquifer states. While short-term interests of development or economic gain may be fulfilled, long-term interests of sustainable resource management could be irreparably compromised. Therefore, the states may move towards cooperative action. However, unilateral development within a basin, in the absence of a basin-wide management institution, greatly increases the probability of conflict (Wolf et al. 2003).

2.7.4. LEGAL/INSTITUTIONAL DRIVERS

The legal and institutional landscapes of shared aquifers are critical drivers of transboundary interaction. As discussed in Section 2.4 above, there are several international rules and agreements that significantly contribute to the development of international law as applicable to groundwater resources. Four of the six legal instruments presented include conflict resolution mechanisms.⁶ Institutional mechanisms for governance appear in two of the six documents.⁷ Despite the high potential for legal mechanisms to promote positive transboundary interactions, practitioners are increasingly concerned that this potential is not being fulfilled. Further, several bi-lateral and multilateral legal agreements for surface and groundwater that have not substantially increased the level of cooperation—and in some cases undermined it—due to poor construction of the agreements or unchecked powers of hegemonic states.⁸ Consequently, Canelas de Castro (2002)

⁶ *Mechanisms for conflict resolution (or dispute resolution) are described in the UNECE Water Convention, UN Watercourses Convention, Helsinki Rules, and Berlin Rules.*

⁷ *The creation of institutional mechanisms for the management of water resources is mentioned in the UNECE Water Convention, UN Watercourses Convention, and the Berlin Rules.*

argues that legal instruments should be (re)designed in anticipation of certain types of conflicts or in order to facilitate future cooperation.

The primary conclusion of the water event data analysis is that “[t]he likelihood and intensity of dispute rises as the rate of change within a basin exceeds the institutional capacity to absorb that change” (Wolf et al. 2003). This finding is extremely valuable in the context of this investigation because it implies that institutions (governments as well as intergovernmental and non-governmental organizations) are critical in facilitating transboundary aquifer cooperation.

2.7.5. SOCIAL DRIVERS

Civil society can actively drive transboundary interaction. UN-Water cites utilization of the participatory approach as one of its Seven Pillars for transboundary water cooperation.⁹ At the global level, the importance of public participation has gained prominence over the last two decades through governance texts such as the Aarhus Convention on Public Participation in Decision-Making and Access to Justice in Environmental Matters (United Nations Economic Commission for Europe 1998) and the Rio Declaration (United Nations Conference on Environment and Development 1992). At the national level, public outcries for just management and allocation of waters can have a noticeable impact on decision makers. The “water wars” of Cochabamba, Bolivia are a well-known example, where privatization of water services provision was deemed inequitable by the city's citizens. Additionally, community groundwater management is not only an example of small-scale cooperation for groundwater, but also a phenomenon that has the potential to affect outcomes at larger scales. Management of groundwater at the local level, as in the case of the Franco-Swiss Genevies Aquifer in France and Switzerland, has greatly enhanced the capacity for international cooperation over these resources.

2.8 COMPLEXITIES IN TRANSBOUNDARY WATER INTERACTIONS: AN EXAMPLE

As alluded to in this section, the nature of transboundary interactions can be highly complex. To this end, it is effective to introduce an example that illustrates these complexities. Consequently, the transboundary groundwater interactions in the Mountain Aquifer are briefly discussed. However, several disclaimers are in order. Firstly, this report makes no attempt to comprehensively evaluate the interactions regarding the Mountain Aquifer occurring between Israel and the Palestinian Territories – which are not two sovereign states in eyes of international law but a state and an occupied territory. The purpose of this discussion is to objectively highlight some of the major issues in an extremely complex set of interactions. Further, this discussion is designed to be illustrative of the extent to which groundwater cooperation and management can be influenced by issues that are seemingly disconnected from water management. Yet, the case of the Mountain Aquifer is not very representative of transboundary interactions in most locals - this case is unique in almost every way possible. Therefore, it is not included in the twenty cases analyzed to determine the enabling factors. Nevertheless, useful insights can be gained. With this understanding, we move into the Mountain Aquifer example.

⁸ The conflicts on the Nile and Ganges are examples where legal agreements and their execution have undermined cooperation. Zeitoun et al (2010), provide a more in depth discussion of these issues within the context of power asymmetries.

⁹ The seven pillars are (1) legal instruments, (2) institutional structures and capacity development, (3) an integrated approach, (4) exchange of information and joint monitoring and assessment, (5) participatory approach, (6) benefits and cost sharing, and (7) financing (UN-Water 2008).

The Mountain Aquifer was a critical topic in the Israeli/Palestinian peace talks in the 1990's. This is because, the aquifers shared between Israel and Palestine have been a source of intense interaction over the past 60 years. Rapid groundwater development began on the Israeli side, in the 1950's. In contrast groundwater was only sparsely developed on the Palestinian side prior to 1967 (Feitelson 2003). The high-level of use on the Israeli side contrasts the hydrogeology, in which most groundwater recharges the aquifer on the Palestinian side. This asymmetry has resulted in tensions between Israel and Palestine regarding allocation and use.

The outcome of the peace talks was that Article 40 of the Oslo II agreement recognized Palestine's right to water in the West Bank. The agreement also stated that the future water needs of Palestine were 70-80 Mm³ annually and that Palestine should receive 28.6 Mm³ annually to meet their immediate needs. Further the agreement established a Joint Water Committee (JWC) and Joint Supervision and Enforcement Teams (JSETs) to manage the resources of the aquifer. Additionally, the parties agreed to cooperate on protecting the aquifer (Government of the State of Israel & The Palestine Liberation Organization 1995).

Since the creation of the agreement, the JWC has overseen implementation of the agreement and has created four sub-committees to do so: the Hydrological Committee, the Water Works Committee, the Sewage Committee and the Water Pricing Committee. The JWC meets regularly and reviews projects for development and construction of water supply and sewage projects (Water Authority of the State of Israel 2009). To date the committee has approved 70 new water wells and 22 new observation wells in Palestine. However, the JWC has rejected hundreds of well applications submitted by the Palestinian Territories.

There are several aspects of the Mountain Aquifer case, which point to both cooperative and conflictive interactions. The Transboundary Freshwater Dispute Database places the signing of the Oslo II agreement at +4 on the BAR scale, indicating a cooperative event. Yet implementation of the agreement is associated with a conflictive event ranked -1 on the BAR scale. Some studying interactions over the aquifer believe that relations have been relatively cooperative since the establishment of the agreement, particularly because the JWC continued to function through the Second Intifada. On the other hand, some also question the level of cooperation within the JWC because allocation of water from the aquifer is not in accordance with the full future water right as defined in Oslo II (Linton & Brooks 2011). This dichotomy exists within an even more complex sociopolitical context, where the interactions between the two parties are highly volatile.

A number of questions remain unanswered about the interaction between Israel and Palestine. Is the Oslo II agreement a valid indicator of cooperation, given the lack of implementation of various parts of the agreement? How does the fact that many do not recognize the Palestinian Territories as a sovereign state impact power dynamics between the two parties? How might asymmetries in economic and militaristic power influence interactions within the JWC? These questions and many others illustrate how Mountain Aquifer is a critical example of how understandings of conflict and cooperation can be extremely complex and not suitable for binary classification.

3. FACTORS ENABLING COOPERATION

This section defines and describes the enabling factors identified during the case analysis. There were twenty cases of transboundary aquifer cooperation used to inform this portion of the report. Based on information available in English and Spanish each case was assessed. At this time, it is critical to provide a definition of the term enabling factor and to distinguish it from a “driver” of cooperation. As shown above in Section 2.7, much attention has been devoted to assessing drivers of cooperation. However, the intent of this report is to assess how these drivers manifest as concrete actions or “factors.” This is particularly important because the terms are often conflated and used interchangeably in both academic and grey literature. Defining and distinguishing the two can provide useful insights regarding how to move cooperation forward.

An enabling factor is a circumstance, fact or influence that actively contributes to the occurrence of a cooperative event or the establishment of a cooperative institution.

A “driver” provides impulse or motivation and causes a particular phenomenon to happen or develop. A “factor”, on the other hand, is a circumstance, fact or influence that actively contributes to the production of a result.¹⁰ Therefore, in the context of cooperation, **an Enabling Factor is a circumstance, fact or influence that actively contributes to the occurrence of a cooperative event or cooperative interaction.** For instance, the role of economics and financing in facilitating cooperation can be examined both from the perspective of a driver and of a factor. The potential to share regional economic gains from hydropower production in karst aquifers could be a driver for cooperation because it is a realistic benefit with calculable value. This potential to share benefits, albeit hypothetical, could motivate the aquifer states to cooperate. Funding could be a factor, given that it can provide an active contribution to the cooperative event or interaction. Thus, if funding were used to establish a cooperative groundwater management institution, it could be considered an Enabling Factor for cooperation.

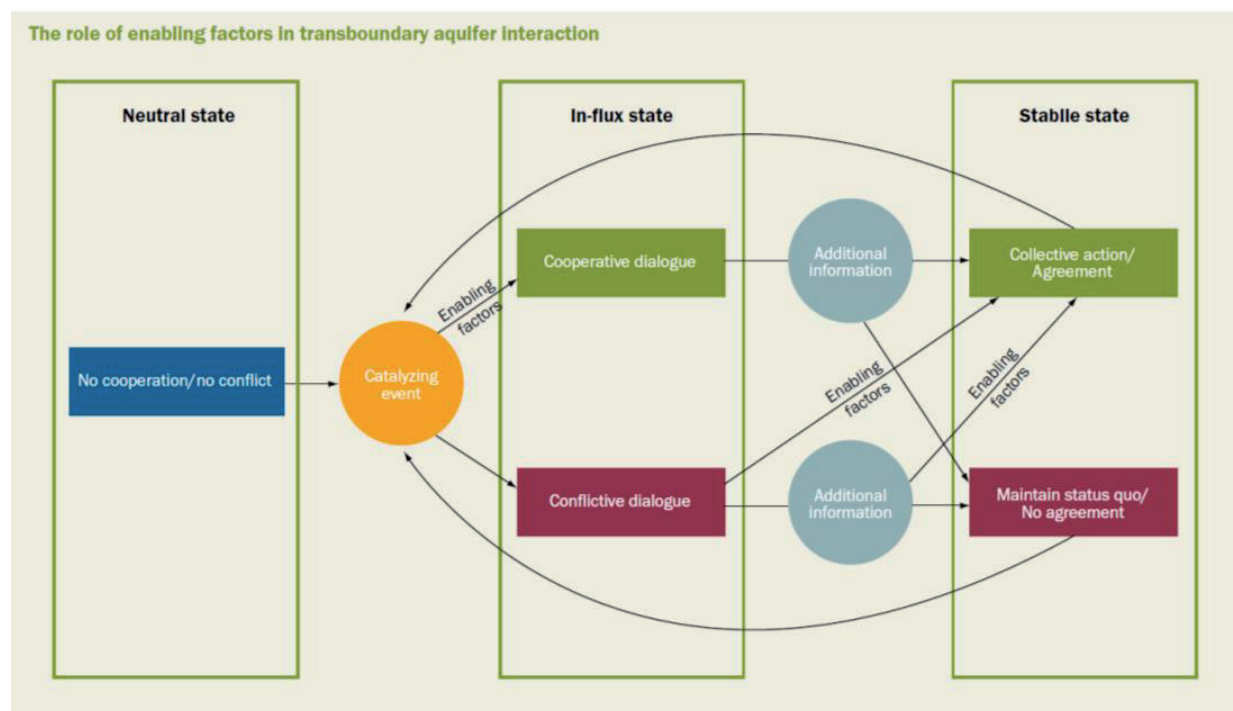
Distinguishing the terms in this manner makes clear that much attention is devoted to analyzing and/or hypothesizing about various drivers such as power asymmetries, benefit sharing, and costs of non-cooperation. Yet, only a few publications have moved towards concretizing elements leading to cooperative action by characterizing them as factors, as proposed here. One such publication worth highlighting is a 2008 report by the German Development Institute (Scheumann 2008). It reviewed literature applicable to transboundary surface water and groundwater cooperation. This review made a preliminary step towards identifying “factors influencing cooperation” over transboundary groundwater. Five factors were proposed:

1. Water relations and water institutions
2. Regional power and relations
3. Advocacy coalitions
4. Domestic policy and economic strength
5. Third-party involvement

¹⁰ These definitions are merged and modified versions provided by the Merriam-Webster Dictionary and the Oxford English Dictionary.

Given that these factors were compiled as part of a literature review, this report seeks to define, refine and augment these factors based on empirical case analysis (Scheumann 2008). Therefore, this section responds to the questions: what are the Enabling Factors or the 'ingredients' in a recipe for cooperation? The subsections identify and define the Enabling Factors, summarize how the Enabling Factors are present in the reviewed cases, and discuss any noticeable trends in the use of the Enabling Factors.

Figure 5. Role of Enabling Factors in Transboundary Aquifer Interaction



Source: Conti 2013

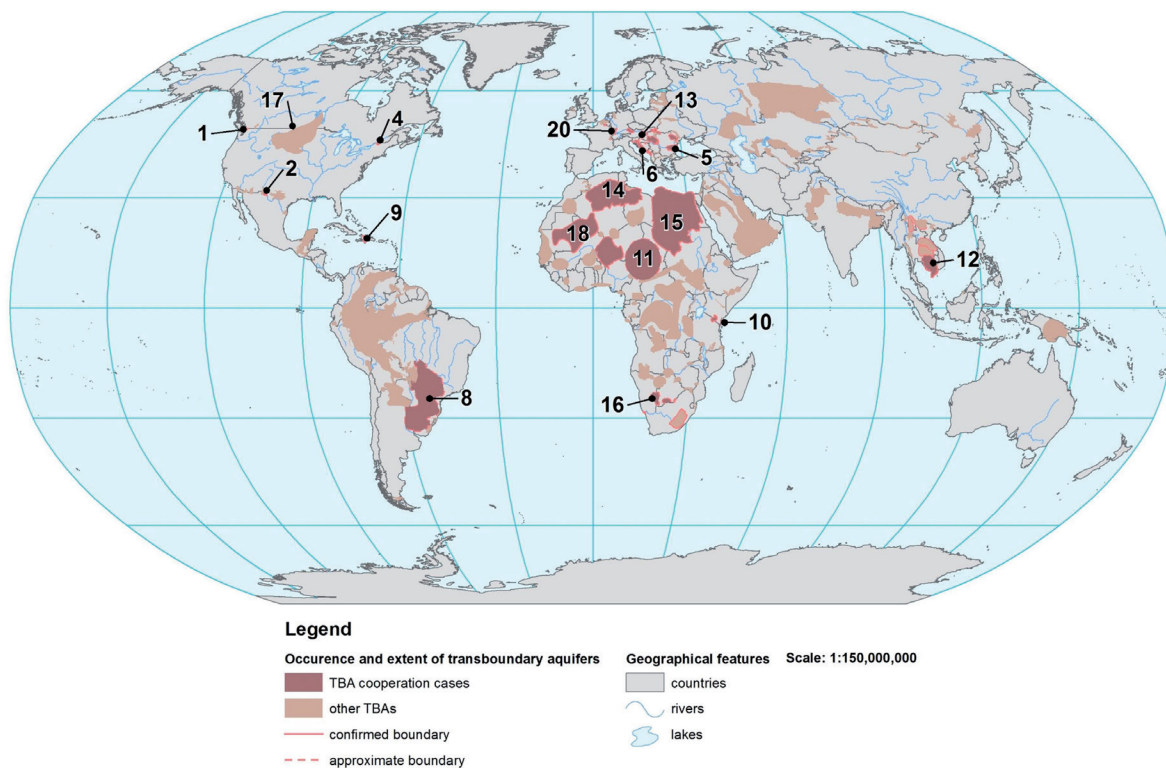
The CC license does not apply to this picture.

3.1 IDENTIFYING ENABLING FACTORS

The purpose of the case analysis is to identify and define Enabling Factors for cooperation. The objective of the case analysis is to provide as complete a picture as possible of the circumstances that lead countries to cooperate over transboundary aquifers. It is determined that a bottom-up approach is necessary assuming that Enabling Factors are most often characterized by concrete, on-the-ground actions. Therefore, each case is assembled and the conditions that spurred cooperation were assessed.

Bearing in mind the drivers of cooperation identified in the literature review (see Section 2.7), reoccurring elements are observed across the different cases. If these elements are fairly concrete manifestations of the theoretical drivers and/or are circumstances present in multiple cases, they are classified as potential Enabling Factors. Finalizing the case studies then allows precise definitions for each factor to be created. Eight Enabling Factors are identified that apply to multiple cases; an additional two Enabling Factors are case specific (see Section 3.3).

Figure 6. Map of Transboundary Aquifer Cases



No.	Aquifer [Group/System] Name	Aquifer States
1	Abbotsford-Sumas Aquifer	Canada, United States
2	Bolsón del Hueco-Valle de Juárez	Mexico, United States
3	Carboniferous Aquifer	Belgium, France
4	Châteauguay Aquifer	Canada, United States
5	Danube River Basin Aquifers	Austria, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Serbia, Slovakia, Slovenia, Ukraine
6	Dinaric Karst Aquifers	Albania, Bosnia & Herzegovina, Croatia, Italy, Greece, Macedonia, Montenegro, Serbia, Slovenia
7	Franco-Swiss Genevois Aquifer	France, Switzerland
8	Guaraní Aquifer System	Argentina, Brazil, Paraguay, Uruguay
9	Hispaniola Island Aquifers	Dominican Republic, Haiti
10	Kilimanjaro Aquifer	Kenya, Tanzania
11	Lake Chad Aquifer System	Cameroon, Chad, Central African Republic, Niger, Nigeria
12	Mekong River Plain Aquifers	Cambodia, Laos, Thailand, Vietnam
13	Mura-Zala Aquifer	Hungary, Slovenia
14	Northwest Sahara Aquifer System	Algeria, Libya, Tunisia
15	Nubian Sandstone Aquifer System	Chad, Egypt, Libya, Sudan
16	Orange-Senqu River Basin Aquifers	Botswana, Namibia, South Africa
17	Poplar Aquifer	Canada, United States
18	Sahel Region Aquifers	Algeria, Benin, Mali, Niger, Nigeria, Mauritania
19	Sava River Basin Aquifers	Croatia, Slovenia, Bosnia & Herzegovina
20	Upper Rhine Aquifer	France, Germany, Switzerland

3.2 OVERVIEW OF CASE STUDIES

A total of twenty cases are evaluated to identify the Enabling Factors described in Section 3.3, below (see Figure 6). Cooperation occurs across a wide range of hydrogeological, geographical, socio-economic, and political contexts. The cases cover transboundary aquifers, aquifer systems and groups of aquifers across five continents including six in Africa, one in Asia, seven in Europe, four in North America, and two in South America.

There are instances of cooperation over all types of transboundary aquifers, aquifer systems and groups of aquifers including unconfined, confined, non-recharging, semi-confined, as well as two in karst formations. Each of the models proposed by Eckstein and Eckstein (2005) (see Table 1) is represented by at least one of the cases reviewed with the exception of Model C because it is for aquifers contained within a single state but connected to a transboundary river or lake. It is possible that a Model C aquifer exists within an aquifer group or system. The aquifers vary greatly in geographic territory, the smallest covering 19 km² and the largest covering 2,199,000 km². Information about storage volumes is not available for all the aquifers studied. Nevertheless, known storage values range from 74 Mm³ to 375,000,000 Mm³. Hydrogeological conditions also vary greatly. In some instances, the aquifers are facing emergent challenges of severe contamination or overexploitation. While in others, cooperation occurs prior to any negative (transboundary) conditions manifesting.

Cooperation occurs between some of the world's least developed countries, such as Chad and Niger, respectively ranked 183 and 187 on the Human Development Index. While it also occurs between some of the world's most developed countries, such as the United States and Canada, respectively ranked 4 and 6 on the Human Development Index. Further, the instances of cooperation can occur under varying political conditions.

Overall, the case studies represent a nearly complete range of archetypal aquifers and of situations under which cooperation may occur. Consequently, the factors identified and described could contribute to fostering transboundary aquifer cooperation in a wide-range of circumstances and locales.



The CC license does not apply to this picture.

3.3 IDENTIFYING AND DEFINING ENABLING FACTORS

3.3.1 ENABLING FACTOR 1: EXISTING LEGAL MECHANISMS

Legal mechanisms existing prior to cooperation over a transboundary aquifer are important Enabling Factors. Legal mechanisms can take many forms. However, only a subset of the potential mechanisms is considered an Enabling Factor in transboundary aquifer cooperation. Laws that place binding obligations on aquifer states are the primary indicator of existing legal mechanisms. These include, but are not limited to:

- laws of individual states and territories governing transboundary aquifers;
- binding legal agreements with requirements for monitoring, modeling or managing an aquifer;
- legal agreements for surface water bodies which include hydrologically connected groundwater in their scope; and
- supranational regulatory requirements for groundwater.

Non-binding mechanisms are also included as factors so long as they specifically address management of groundwater resources between the aquifer states and originate from an international body with legal authority or government officials from the individual states. These include mandates, decrees and declarations.

BOX 1. EXISTING LEGAL MECHANISMS AS AN ENABLING FACTOR *United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes*

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention) was adopted in 1992 and entered into force in 1996. Originally, it was a regional mechanism designed to prevent and control impacts to transboundary waters within Europe. In 2003, the Convention's parties created an amendment that would allow other UN member states to accede to the convention. This amendment entered into force in February 2013, making it a global convention.

One of the key attributes of the UNECE Water Convention that makes it an Enabling Factor is the inclusion of Article 9, Bilateral and Multilateral Cooperation. The provisions of this article require that all riparian parties enter into bilateral or multilateral agreements in order to establish 'joint bodies' for the protection of surface and groundwaters. These joint bodies must delineate the shared water resource as well as take a number of actions to prevent pollution and reduce existing contamination. Further, Article 11 requires joint monitoring and assessment of these transboundary waters. Consequently, the implementation of the UNECE Water Convention and subsequently the European Union Water Framework Directive has spurred cooperation between several European countries. Given its originally regional scope, the UNECE Water Convention notably influenced each of the aquifers studied within Europe. These include the:

- Carboniferous Aquifer
- Danube River Basin Aquifers
- Dinaric Karst Aquifers
- Genevois Aquifer
- Mura-Zala Basin Aquifer
- Sava River Basin Aquifers
- Upper Rhine Aquifer

3.3.2 ENABLING FACTOR 2: EXISTING REGIONAL INSTITUTIONS

There are countless regional institutions operating across the globe focused on a range of tasks. Determining which regional institutions can function as an Enabling Factor requires criteria outlining these institutions' attributes. For this analysis, international institutions whose mandate is promoting cooperation and coordination on issues of regional importance are assessed. This type of mandate indicates that the institution might function as an Enabling Factor for water cooperation, even if environment or water resources are not explicitly within their purview. Nonetheless, institutions must demonstrate a focus on a specific transboundary aquifer or on groundwater more broadly to be considered an Enabling Factor. If a River Basin Organization (RBO) is identified in the same region as a transboundary aquifer, it is only considered an Enabling Factor if the RBO has the explicit intention to address groundwater management issues. This is often accomplished by a task force, working group or as a special project.

3.3.3 ENABLING FACTOR 3: FUNDING MECHANISMS

A funding mechanism is considered an Enabling Factor if at least one of two criteria is met. The first is that funding must be provided by the aquifer states for a project or the creation of an institution. These could include scientific projects designed to advance technical understanding of the aquifer; capacity building projects for persons dealing with transboundary groundwater management; or funding to establish institutions that would monitor or manage the aquifer. The second criterion is that a third party provides funding for the creation of a project or institution, as described above. In some instances, such as Global Environmental Facility (GEF) projects (see Box 2, below) both criteria are met.

BOX 2. FUNDING MECHANISMS AS AN ENABLING FACTOR *Global Environmental Facility (GEF)*

The Global Environmental Facility (GEF) was established in 1991 as a pilot project of the World Bank to protect the global environment and promote 'environmental sustainable development.' Initially the World Bank, the United Nations Development Programme and the United Nations Environmental Programme implemented GEF Projects. In 1994, GEF became independent of the World Bank. Now the GEF is also the financing mechanism for several global legal conventions including the Convention to Combat Desertification and the Framework Convention on Climate Change.

GEF has established seven focal areas for its work, one of which is International Waters. The purpose of the International Waters focal area is to help countries to overcome tensions that may arise in the management of international waters including aquifers. As part of project implementation, participating countries are required to co-finance the project and produce negotiated plans for the management and development of the resources, called Strategic Action Plans. By providing a standardized framework through which funds for groundwater management can be acquired, many aquifer states have significantly increased the level of cooperation over their transboundary aquifers. In the case of the Guaraní Aquifer System, GEF funding played a critical role in the aquifer states' reaching a legal agreement for its management in 2010, although the agreement is not yet in force as of 2014.

Of the transboundary aquifers analyzed, there were six cases where two or more of the aquifer states participated in a GEF project (although not necessarily for the aquifer itself). These include the:

- Dinaric Karst Aquifers
- Guaraní Aquifer System
- Hispaniola Island Aquifers
- Lake Chad Aquifer System
- Northwestern Sahara Aquifer System
- Nubian Sandstone Aquifer System

3.3.4 ENABLING FACTOR 4: HIGH INSTITUTIONAL CAPACITY

Institutional capacity proves to be an Enabling Factor when organizations (including governments) within the aquifer states have demonstrated an ability to address water management issues. In most instances, these institutions are particularly capable in the area of groundwater management. This high-level of capacity is demonstrated by organizations executing significant portions of projects related to groundwater monitoring, modeling or management. Availability of domestic financial resources has a noticeable impact on organizational capacity in that those with less financial resources tended not to display a high-level of capacity in groundwater resource management.

3.3.5 ENABLING FACTOR 5: PREVIOUS WATER COOPERATION

If the aquifer states have cooperated over water resources in the past, previous water cooperation is considered an Enabling Factor. Cooperation does not necessarily occur between all the aquifer states, nor must it to be cooperation specifically with respect to groundwater resources. For counties spanning large geographic areas, cooperation may not occur in the specific region where the aquifer is located, but rather between the states themselves. Analysis shows that willingness to dialogue about water resources in the past, especially within a strong institutional setting, indicates a continued willingness to do so in the future.

3.3.6 ENABLING FACTOR 6: SCIENTIFIC RESEARCH

Scientific research is considered an Enabling Factor if it is conducted specifically for the assessment of transboundary impacts and provides the aquifer states with a significant amount of new information about the aquifer. The research must occur prior to any informal or formal political cooperation on groundwater resources. This could include investigating the physical characteristics of the aquifer, such as extent, depth, storage volume, transmissivity, as well as recharge and discharge areas. It could also include information on groundwater quality, groundwater uses (human and environmental) and analysis of threats to overall sustainability. Research initiatives conducted by the aquifer states and/or third parties are considered.

BOX 3. SCIENTIFIC RESEARCH AS AN ENABLING FACTOR *Internationally Shared Aquifer Resource Management Initiative - Americas*

The Internationally Shared Aquifer Resource Management Initiative (ISARM) began in 2002 and is led by UNESCO and the International Association of Hydrogeologists. The purpose of the initiative is to improve understanding of transboundary aquifers - in particular the scientific, socio-economic, legal, institutional and environmental issues. As part of a range of global and regional initiatives, the UNESCO/Organization of American States ISARM Americas Programme was launched from Mar del Plata, Argentina in 2002.

The focus of ISARM Americas Programme was to execute three region-wide activities: (1) to complete a 'comprehensive inventory' of transboundary aquifers in the Americas; (2) to assemble information on national and international legal and institutional frameworks in the region; and (3) analyze socio-economic aspects of the regions' transboundary aquifers. By completing these assessments, ISARM Americas was able to provide valuable information to aquifer states about the condition of their groundwater resources. In some cases, this information led to the aquifer states beginning or intensifying cooperation over their shared aquifers.

Of the cases reviewed, there were two cases where scientific information provided by ISARM Americas played a critical role in bolstering cooperation. These were the Guaraní Aquifer System and the Aquifers of Hispaniola Island.

3.3.7 ENABLING FACTOR 7: STRONG POLITICAL WILL

When high-ranking government officials prioritize groundwater management, strong political will is an Enabling Factor. A particularly strong indicator is when persons at the ministerial or executive level actively advocate for international cooperation for the aquifer. Open verbal support as well as the facilitation of diplomatic events, such as hosting meetings or negotiations, are examples of actions constituting Enabling Factors.

3.3.8 ENABLING FACTOR 8: THIRD-PARTY INVOLVEMENT

Third-party involvement is when an entity that is not one of the aquifer-state governments contributes significantly to the cooperation process. In many cases of transboundary aquifer cooperation, third parties are involved to some extent. However, their involvement is only considered an Enabling Factor if they contribute via formal programs or partnerships. These contributions range from enhancing the scientific knowledge of the aquifer to promoting institutionalized cooperation.

BOX 4. THIRD-PARTY INVOLVEMENT AS AN ENABLING FACTOR *Observatoire du Sahara et du Sahel - Sahara Sahel Observatory*

The Observatoire du Sahara et du Sahel (Sahara Sahel Observatory [OSS]) is an independent organization created to combat desertification through implementation of early warning systems and by monitoring crop conditions. Over 20 African countries participate in OSS activities as well as five European countries and four sub-regional organizations. UN and civil society organizations also participate. OSS originally began as an international association, which was founded following the 1989 G7 Summit in Paris and was officially inaugurated in 1992.

OSS' efforts are designed to improve food security and mitigate the effects of drought. OSS also has the mission of building capacity to address global challenges such as sustainable development and poverty eradication. One of OSS' major roles is to facilitate 'North-South-South' partnership and mobilization. As a result of OSS participation in various regional initiatives, there has been cooperation between transboundary aquifer states. Of the cases reviewed, three of the instances of cooperation included the involvement of the OSS:

- Lake Chad Aquifer System
- Northwestern Sahara Aquifer System
- Sahel Region Aquifers

3.3.9 CASE-SPECIFIC FACTORS

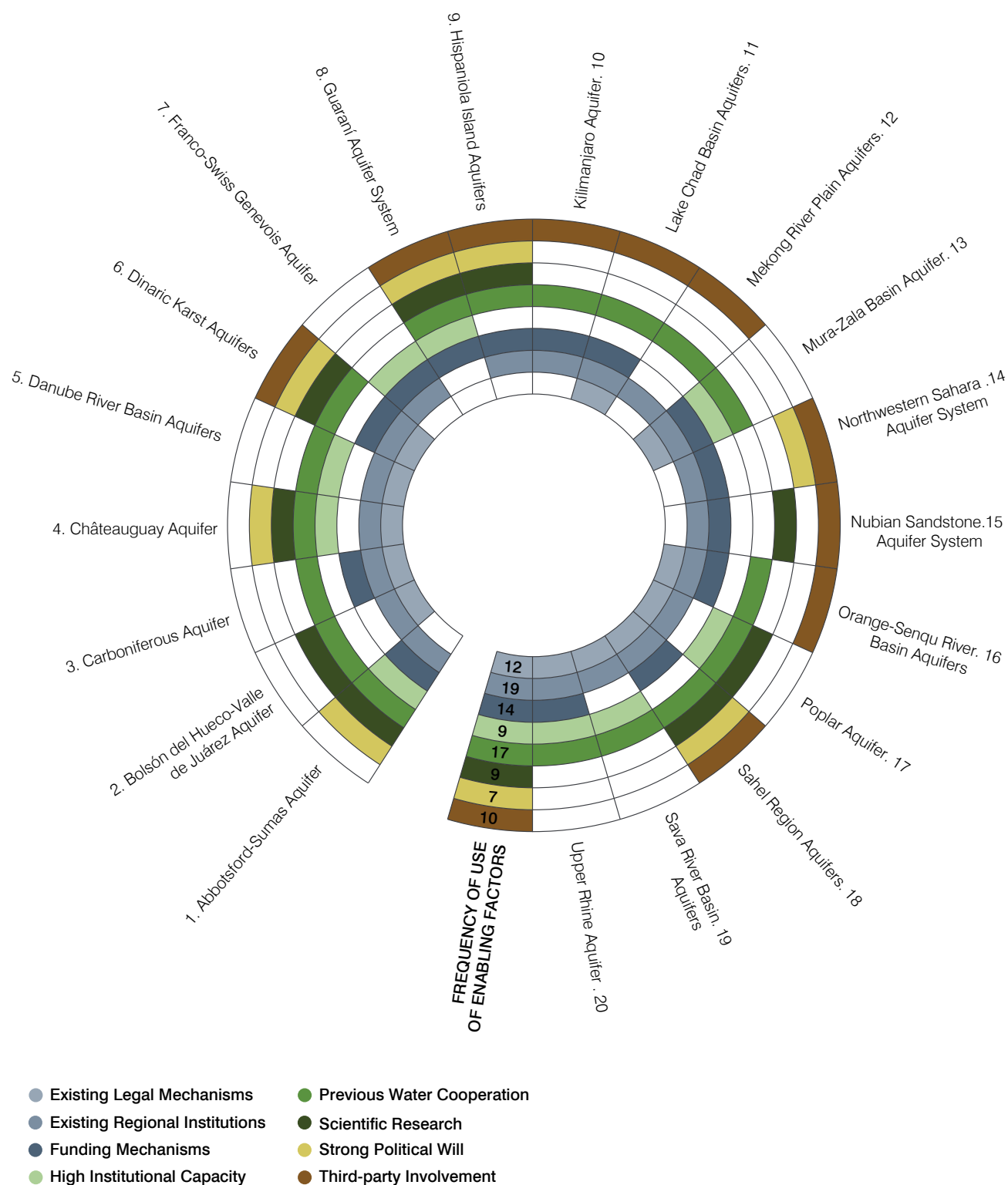
In some cases, there are unique Enabling Factors that play a clear role in facilitating cooperation. These Enabling Factors are highlighted for several reasons. First, they are critical ingredients to creating cooperation. Second, the Enabling Factors link closely to drivers that are frequently discussed in academic literature. Further, there is potential for these factors to be present in undocumented or future occurrences of transboundary groundwater cooperation. Below, each of these case-specific Enabling Factors is briefly described.

Public Participation (Abbotsford Sumas Aquifer)

Public participation in the form of an institutionalized stakeholder group is a prominent Enabling Factor in cooperation over the Abbotsford Sumas Aquifer (see profile in Appendix 1). In addition to a scientific advisory board created to collect and coordinate data about the aquifer, a multi-level stakeholder group is established to enhance public education and participation. Local enforcement of water quality regulations also occurs

through industry self-monitoring programs. The case of the Abbotsford Sumas Aquifer is an example where involvement of the public actively contributes to ongoing cooperation to protect the aquifer. Several theories of cooperation point to public participation and/or public pressure as a potential drivers for cooperation. While public pressure to improve the quality of the Abbotsford Sumas is present, it is eventually the consistent public involvement and investment that generated much of the improvements noted to date.

Table 3. Summary of Enabling Factors Present by Transboundary Aquifer



Small Geographical Extent (Genevois Aquifer)

The legally binding agreement for the apportionment of the groundwater in the Genevois Aquifer, which straddles the French and Swiss, border is unprecedented. Funding Mechanisms, High Institutional Capacity and Strong Political Will facilitated cooperation over the aquifer. It is also possible that the small geographical extent at which cooperation occurred was a critical component. The Convention on the Protection, Utilization, Recharge and Monitoring of the Franco-Swiss Genevois Aquifer is not an agreement between the national governments of France and Switzerland, but instead an agreement between local authorities. When problems with the aquifer arose, local authorities organized consultations and completed negotiations. Consequently, it is possible that the process for creating the agreement was more efficient and expeditious at the local level and that it positively impacted cooperation.

3.4 TRENDS IN ENABLING FACTORS

This section describes identifiable trends in the use of Enabling Factors along the dimensions of frequency, geography, and time. A trend analysis is useful in understanding which of the Enabling Factors may have greater use or application based on these dimensions. It is worth noting that these trends reflect any bias that might be inherent in the available cases. As the Enabling Factors were determined inductively, the trends may be skewed in ways that will only become clear with more research and analysis of additional cases.

3.4.1 FREQUENCY

There are cases where few (less than four), moderate (four or five) or many (six or greater), Enabling Factors are present. The Franco-Swiss Genevois Aquifer and the Mekong River Plain Aquifers, for example, have few Enabling Factors. A moderate number of Enabling Factors are present in over half of the cases assessed (see Table 3). There are five cases where six or more Enabling Factors were present (the Abbotsford-Sumas Aquifer, the Châteauguay Aquifer, Dinaric Karst Aquifers, the Guaraní Aquifer System, and the Sahel Region Aquifers). Section 4 will discuss in detail the relationship between the number of Enabling Factors present and the level of cooperation attained.

3.4.2 GEOGRAPHIC TRENDS

The interplay between Enabling Factors and geography can be categorized into three broad types of trends: no trend observed, strong geographic/regional trend, or the Enabling Factor is present across the globe. The influence of Strong Political Will on transboundary aquifer cooperation is scattered and shows no trend. This variance can be attributed, at least in part, to the fact that the existence of strong political will, in any environment, is often circumstantial. Changing conditions combined with the interests of particular politicians generate political will; this means it is often difficult to predict its influence and is more likely to randomly occur.

Four Enabling Factors showed strong geographic trends: Existing Legal Mechanisms, High Institutional Capacity, Scientific Research, and Third-Party Involvement. Existing Legal Mechanisms are highly influential in North America, Europe and Africa. Both in North America and Europe this could be attributed to the historical use of treaty-making as a cooperative mechanism. In Africa, this can be attributed to the proliferation of the River Basin Organization (RBO) model, which has deeply penetrated the region over the last 30 years. Creating RBOs often requires establishing formal legal mechanisms. One such example is the 1964 Fort Lamy Convention, which formed the Lake Chad Commission. However, these legal mechanisms are generally for transboundary surface waters.

The influence of High Institutional Capacity occurs primarily in Europe and North America. However, it is also present in the Guaraní Aquifer System, the only South American case reviewed. In these regions, intensive water management activities have occurred for the last 40 years or more. A broad range of institutions have continually built their capacity around water management, from the local to state-level. Although the capacities are not necessarily specific to groundwater, they were nevertheless critical in these cases.

New scientific research/information that spurs cooperative action has strong influence in the Americas (North and South) and also has a moderate influence in Africa. With respect to the aquifers shared by Canada and the United States, local-level calls for aquifer assessment catalyze scientific research and future cooperation. The organizations in the Latin American geo-political region and Sahara-Sahel region conducted scientific research with the support of third-party organizations such as ISARM Americas, the Sahara-Sahel Observatory (OSS), and Centre for Environment and Development for the Arab Region and Europe (CEDARE).

Third-Party Involvement plays a critical role in cooperation in the Global South but a less significant role in the North.¹¹ Highly influential parties include ISARM Americas, the Organization of American States (OAS), OSS, CEDARE, the Southern African Development Community (SADC), and GEF. In the eight cases where involvement was significant, six of the third parties are regional – rather than international - institutions. This highlights the key role existing regional institutions play in facilitating and enabling transboundary aquifer cooperation.

Three Enabling Factors had a global geographic influence: Existing Regional Institutions, Funding Mechanisms, and Previous Water Cooperation. Existing Regional Institutions played a significant role in 19 of the 20 cases of transboundary aquifer cooperation, giving this Enabling Factor global geographic influence. This influence is particularly strong in Europe, where all the cases are enabled by this factor. This can be explained by the growing influence of the European Union as a supranational body as well as the development of institutional mechanisms for water cooperation via the implementation of the UNECE Water Convention (see Box 1, above).

Funding Mechanisms are influential in 14 of the 20 cases reviewed. They are also used on all continents with the exception of Asia. There are two main sources of funds. One is intergovernmental partnerships promoting regional environmental cooperation such as the European Union Interregional Cooperation Program (INTERREG), a funding mechanism for interregional cooperation within Europe. The other is funds provided through GEF medium and large-size projects (see Box 2 above). Implementation of these projects also requires contributions from the participating aquifer states. Notably, GEF projects were highly influential for cooperation in aquifers shared by developing countries.

The influence of Previous Water Cooperation is present in 17 of 20 cases reviewed. It is distributed fairly evenly across continents, but shows a particularly strong influence in Europe and North America. Similar to Existing Legal Mechanisms, the prevalence of Previous Water Cooperation may be influenced by the tendency to

¹¹ In this context Global North and Global South are defined using both the member countries of the Organization for Security and Cooperation in Europe to delineate 'Northern' countries and the member of the Group of 77 (G-77) to define 'Southern' countries. Bosnia and Herzegovina is a member of both groups but is considered to be in the Global North for the purposes of this analysis.

formalize cooperation in the region. Previous Water Cooperation in other regions may occur at a rate similar to Europe and North America, but may not be documented to the same extent.

3.4.3 TRENDS RELATED TO PHYSICAL EXTENT OF AQUIFERS

The purpose of assessing trends related to the physical extent of the aquifer is to understand the effect they may have on transboundary cooperation. In this context, aquifers' extent has two components, physical and geopolitical. Aquifers with an area less than or equal to 10,000 km² are considered small. Aquifers between 10,000 km² and 1,000,000 km² are considered medium. Aquifers greater than or equal to 1,000,000 km² are considered large. Aquifers are also divided into three groups based on the number of aquifer states: (1) two aquifer states, (2) three to five aquifer states, and (3) greater than five aquifer states. Specific trends for each component are described below.

Physical Extent

According to the criteria above, there are six small aquifers, eight medium aquifers and five large aquifers and one group of aquifers with unknown extent. Most of the small aquifers are located in Europe, while most of the large aquifers are located in Africa. This data may be skewed given that increased information and knowledge about aquifers often results in their being subdivided into smaller aquifers and thereby reducing their areal extent. Therefore, regions with advanced knowledge of its groundwater systems, such as Europe and North America are likely to have smaller aquifers.

Nevertheless, grouping the aquifers by areal extent revealed three distinct trends. Firstly, cooperation over small transboundary aquifers is associated with Previous Water Cooperation and Existing Regional Institutions. Existing Regional Institutions are critical Enabling Factors for medium-sized aquifers, being present in six of seven cases. However, for large aquifers, Funding Mechanisms is the key Enabling Factor - present in all five cases. This may be attributable to the fact that most of the large aquifers studied are shared by developing countries.

Geopolitical Extent

In the cases reviewed, there are nine transboundary aquifers traversing two aquifer states; seven transboundary aquifers traversing three to five aquifer states; and four transboundary aquifers traversing more than five aquifer states. When there are two states dividing the aquifer, Previous Water Cooperation is a key Enabling Factor (six of eight cases). Where there were three to five states dividing the aquifer, both Existing Regional Institutions and Third-party Involvement were influential. Transboundary aquifers with more than five states had three equally influential Enabling Factors: Existing Regional Institutions, Previous Water Cooperation and Funding Mechanisms. This trend suggests that as the number of states dividing a transboundary aquifer increases, a greater number of Enabling Factors may be required to facilitate cooperative action.

Combined Extent

The areal extent of a transboundary aquifer does not necessarily correlate to the number of aquifer states. For example, the Northwestern Sahara Aquifer System and the Guaraní Aquifer System have very large areal extents, but cover less than five aquifer states. Conversely, the Dinaric Karst Aquifers have a relatively small areal extent but cover six aquifer states. Therefore, it is important to assess the influence of both the areal extent and number of states dividing the aquifer simultaneously. By doing so, we see that Previous Water Cooperation is the most influential Enabling Factor among aquifers with a small extent (small area and two



The CC license does not apply to this picture.

aquifer states). Existing Regional Institutions seem to have a critical influence on cooperation among states with aquifers characterized by moderate extent (medium area and three to five aquifer states). Finally, Funding Mechanisms paired with at least one other Enabling Factor appear to facilitate cooperation among aquifers with a large extent (large area and more than five aquifer states).

3.4.4 TEMPORAL TRENDS

Generally, transboundary aquifer cooperation has occurred in the last 40-45 years. Consequently, cooperative events that occurred in the 1970's were grouped; events in the 1980's and 1990's were grouped; and events occurring after the year 2000 were grouped. In doing so, the following trends emerged. Transboundary aquifer cooperation in North America began predominately in the 1970's due to concerns about groundwater quality deterioration. There was significantly less transboundary aquifer cooperation in the 1980's and 1990's— only five cases occurred in the two decades. After 2000, there was a resurgence of activity (nine cases), in part because of cooperation occurring between countries of former Yugoslavia. At that time, there was also an increased interest in transboundary groundwater management throughout the global community due to the active implementation of in-force, legal mechanisms such as the UNECE Water Convention, the European Union Water Framework Directive, and the SADC Revised Protocol on Shared Watercourses. Further, the United Nations Watercourse Convention and the Draft Articles on the Law of Transboundary Aquifers have also built momentum behind the issue of transboundary groundwater resources management.

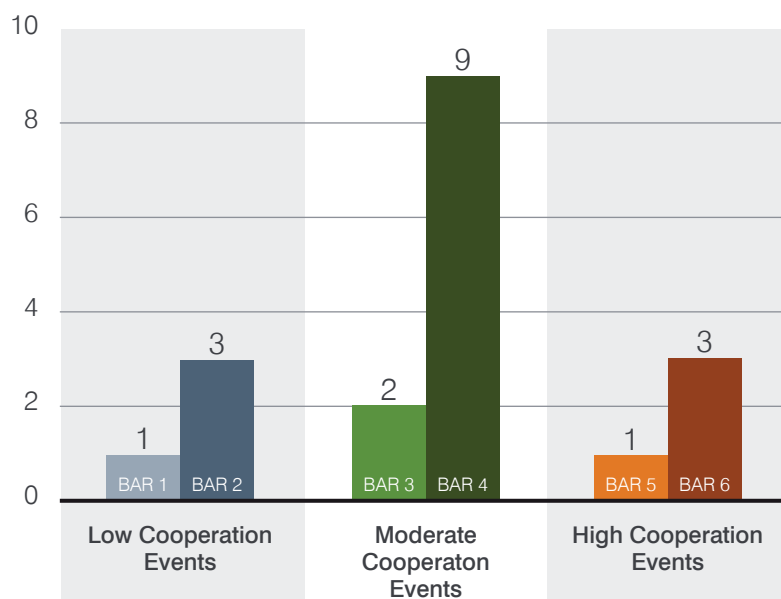
4. LINKING ENABLING FACTORS, TRANSBOUNDARY AQUIFER EVENTS, AND TRANSBOUNDARY AQUIFER INTERACTIONS

This section will describe the interplay between the Enabling Factors, specific cooperative events that take place among the aquifer states (i.e. Transboundary Aquifer Events) and the overall tenor and intensity of the interactions between aquifer states (i.e. Transboundary Aquifer Interactions). The analysis will characterize the overall level of engagement between aquifer states for each case of transboundary aquifer cooperation. The reasons for exploring this interplay are two-fold. First, it will indicate the extent to which Enabling Factors can be associated with the occurrence of cooperative Transboundary Aquifer Events and/or Transboundary Aquifer Interactions. Second, for each transboundary aquifer where cooperation occurs, a comparison between Transboundary Aquifer Events and Transboundary Aquifers is made. This will indicate whether there is good alignment between the occurrence of specific events and the overall interactions between the states, allowing the level of engagement between the aquifer states to be determined. In some cases, specific events and the interaction between the aquifer states may be a good indication of the overall level of engagement. However, in other cases initial events may signal a high level of cooperation, while the subsequent interactions indicate that meaningful cooperation is sporadic, rather than sustained.

4.1 TRANSBOUNDARY AQUIFER EVENTS

Transboundary Aquifer Events are specific events that take place between some or all aquifer states and give an indication of cooperation or conflict within the transboundary aquifer. The Basins at Risk (BAR) scale, described in Section 2.5 above, is used to assign a rank value to Transboundary Aquifer Events taking place in each case (see Table 2, for descriptions of BAR scale ranks). In this report, all Transboundary Aquifer Events fall rank from 1 to 6 on the BAR scale. This is because there is only one BAR scale ranked incidence of conflict over a transboundary aquifer - that which occurred between Israel and Palestine. As, articulated in Section 2.8, this case was excluded from this portion of the analysis. Transboundary Aquifer Events are

Figure 7. Frequency of BAR Scale Transboundary Aquifer Events



classified as low cooperation events (1 or 2 on the BAR scale), moderate cooperation events (3 or 4 on the BAR scale), and high cooperation events (5 or 6 on the BAR scale). Figure 7 depicts the frequency at which each BAR rank occurs among the cases. There are no cases that have a BAR index of 7, because this level indicates unification into a single political state. Level 4 events occur most frequently and level 1 the least.

4.2 TRANSBOUNDARY AQUIFER INTERACTIONS

Transboundary Aquifer Interactions characterize the dynamics between aquifer states, including both cooperative and conflictive elements. This report previously described the concept of transboundary water interaction and presented the Transboundary Water Interaction NexuS (TWINS) framework as a tool for analyzing these interactions. A specific premise of the TWINS analytical framework is that there is always some level of cooperation and some level of conflict occurring in a particular transboundary water interaction. Therefore, transboundary water interactions are plotted on a matrix, which categorizes the nature of transboundary water interactions according to cooperation intensity (x-axis) and conflict intensity (y-axis). Because the intensities have independent categorization, levels of conflict and cooperation interactions can be simultaneously designated. Therefore, it is possible to have a case with both high conflict and high cooperation.

Table 4. Definitions for Modified Transboundary Water Interaction NexuS Matrix

	Level of Cooperation	Level of Conflict
Low	The parties have neutral interactions about groundwater resources. They have considered managing groundwater collaboratively either with preliminary, informal discussions or have had ad hoc interactions regarding groundwater management.	The issue of transboundary groundwater management may have been placed on the political agenda but there is no tension regarding the issue.
Moderate	The parties have either neutral or positive interactions about groundwater resources. There might be an informal agreement specifically for the management of transboundary groundwater resources. There is a transboundary water management institution that includes groundwater management in its activities. This institution intends to deal with groundwater issues collectively through intermittent activities or progress.	The issue of groundwater management may be receiving attention. However, it is happening in the context of absent or strained diplomatic relations with regard to water issues. There may even be cold conflict. Mild verbal aggressions may be exchanged between parties. There may be unchecked power asymmetries or asymmetries in water allocation that could impact interactions between the aquifer states. These asymmetries may or may not result in coercive cooperation over groundwater resources.
High	The parties have positive interactions about groundwater resources. There is a formal agreement to manage transboundary groundwater. There is a formal transboundary management institution with a specific mandate for addressing transboundary groundwaters. This institution reports consistent activities and progress.	Transboundary interactions are violent. Armed conflict is present and may be rooted in authorized use of military force, guerilla warfare or vigilante/terrorist actions.

A 3x3 modified TWINS matrix is proposed for the evaluation of Transboundary Aquifer Interactions (see Figure 8). The original TWINS matrix consists of a 4x5 grid. Populating the 4x5 requires a high level of data availability and a detailed understanding of the political dynamics within a specific set of interactions. For a majority of the cases analyzed for this report, such detailed information was not available. The original TWINS matrix required modification because the conflict intensity category is contingent upon the politicization of water resources management by the actors involved. In other words, the actors must believe that transboundary water resources use is a critical issue, deserving of political attention. This is not often the case for groundwater. Therefore, in the modified framework, the conflict intensity axis takes into consideration political attention regarding surface water and groundwater as well as the tenor of the broader political context and the cooperation intensity axis is used specifically for interaction concerning groundwater. The levels of cooperation and conflict as used in the 3x3 modified TWINS matrix are defined in Table 4. Figure 8 illustrates the number of cases falling within each category of the modified TWINS matrix.

Figure 8. Modified TWINS Matrix for Aquifer Cases

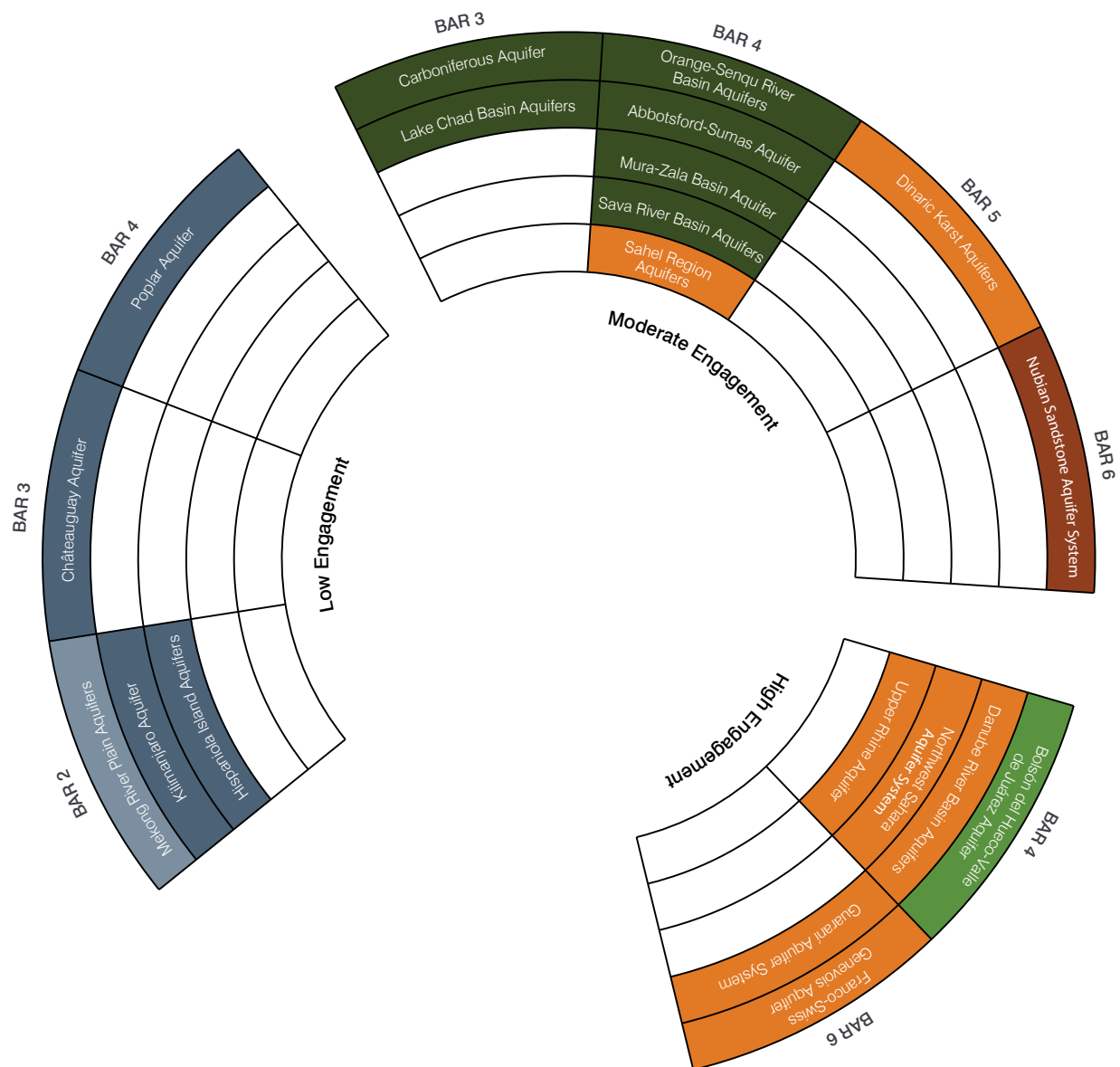
	Low Cooperation	Moderate Cooperation	High Cooperation
Low Conflict	4	6	7
Moderate Conflict	1	1	1
High Conflict	0	0	0

4.3 LEVELS OF ENGAGEMENT FOR TRANSBOUNDARY AQUIFERS

Until now, Transboundary Aquifer Events and Transboundary Aquifer Interactions have been assessed separately. Understanding the interplay between these two components will paint a complete picture of cooperation over transboundary aquifers. The levels of engagement are defined in the sections below and are assigned as an overall indication of the frequency and intensity with which aquifers states are interacting on the subject of the aquifer. The level of engagement takes into account both specific events as well as broader groundwater and water-related interactions. To determine the level of engagement for each transboundary aquifer case, the Transboundary Aquifer Events and Transboundary Aquifer Interactions are considered. In Figure 9, the BAR rank of the Transboundary Aquifer Events and the characterization of the Transboundary

Aquifer Interaction (using the color corresponding to the case's location on the TWINS matrix in Figure 8) are matched with the level of engagement. In the cases where all three metrics are in agreement (i.e. they are each low, moderate or high), we see that Transboundary Aquifer Events and/or Transboundary Aquifer Interactions are a relatively good indicator of the level of engagement for the cooperation case. However, where the metrics are not in agreement, we see that a particular Transboundary Aquifer Event or overall characterization of Transboundary Aquifer Interactions may indicate a different level of engagement.

Figure 9. Relationship between Transboundary Aquifer Events and Transboundary Aquifer Interactions



4.3.1 LOW ENGAGEMENT CASES

Transboundary aquifer states are classified as low engagement if (1) states previously engaged about the transboundary aquifer but those activities are dormant or (2) cooperative activities are nascent, ad-hoc and informal. Using these criteria, five cases are classified as low cooperation: the Châteauguay Aquifer, the Hispaniola Island Aquifers, Kilimanjaro Aquifer, the Mekong River Plain Aquifers, and the Poplar Aquifer. The Transboundary Aquifer Events, Transboundary Aquifer Interactions and Enabling Factors for each of these cases are summarized in Table 5.

In low engagement cases, the number of Enabling Factors present ranges from 3 to 6, with an average of 4 Factors per case. Three factors (Existing Regional Institutions, Previous Water Cooperation, and Scientific Research) were present in 4 of the 5 cases. The highest ranked BAR scale events for the cases ranged from BAR 2 to BAR 4, with an average BAR rank of 2.6. All but one case had Transboundary Aquifer Interactions which are characterized as low cooperation-low conflict. The exception was the Aquifers of the Mekong River Plain case, which had low cooperation-moderate conflict Transboundary Aquifer Interactions.

Table 5. Summary of Low Engagement Cases

Aquifer Name	TBA Event	TBA Interaction	Enabling Factors Present	
Châteauguay Aquifer Canada - United States of America	3	Low Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions High Institutional Capacity	Previous Water Cooperation Scientific Research Strong Political Will
Hispaniola Island Aquifers Dominican Republic – Haiti	2	Low Cooperation Low Conflict	Existing Regional Institutions Funding Mechanisms Previous Water Cooperation	Scientific Research
Kilimanjaro Aquifer Kenya - Tanzania	2	Low Cooperation Low Conflict	Existing Regional Institutions Funding Mechanisms Previous Water Cooperation	Scientific Research Third-party Involvement
Mekong River Plain Aquifers Cambodia - Laos - Thailand - Vietnam	2	Low Cooperation Moderate Conflict	Existing Legal Mechanisms Previous Water Cooperation Third-party Involvement	
Poplar Aquifer Canada - United States of America	4	Low Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions High Institutional Capacity	Scientific Research

4.3.2 MODERATE ENGAGEMENT CASES

A case is in a state of moderate engagement if (1) there is ongoing cooperation, but it is informal or occurring outside of a formal water management institution, (2) a formal water management institution has just begun or (3) formal cooperation has become limited and sporadic. Using these criteria, there are nine moderate engagement cases: the Abbotsford-Sumas Aquifer, the Carboniferous Aquifer, the Dinaric Karst Aquifers, the Lake Chad Basin Aquifers, the Nubian Sandstone Aquifer System, the Mura-Zala Basin Aquifer, the

Orange-Senqu River Basin Aquifers, the Sahel Region Aquifers, and the Sava River Basin Aquifers. The Transboundary Aquifer Events, Transboundary Aquifer Interactions and Enabling Factors for each of these cases are summarized in Table 6.

Moderate engagement cases are characterized by Enabling Factors ranging from 4 to 7, with an average of 5.2 Enabling Factors per case. Three factors showed a great influence on low engagement cases: Existing Regional Institutions, which influenced all nine of the cases; Existing Legal Mechanisms, which influenced seven of the nine cases; and Funding Mechanisms, which influenced eight of the nine cases. The highest ranked BAR scale events for the moderate engagement cases ranged from BAR 3 to BAR 6, with an average BAR rank of 4.2. Seven of the nine cases had moderate cooperation-low conflict Transboundary Aquifer Interactions. The Nubian Sandstone Aquifer System and the Sahel Region Aquifers were categorized as exhibiting moderate cooperation-moderate conflict and high cooperation-low conflict Transboundary Aquifer Interactions, respectively. Although the Nubian Sandstone Aquifer System case was given a high cooperation classification, the absence of recent activity in the aquifer and the stalemate between some of the aquifer states over the governance of the Nile prevented it attaining a high engagement status. The sporadic developments

Table 6. Summary of Moderate Engagement Cases

Aquifer Name	TBA Event	TBA Interaction	Enabling Factors Present	
Abbotsford-Sumas Aquifer Canada - United States of America	4	Moderate Cooperation Low Conflict	Funding Mechanisms High Institutional Capacity Previous Water Cooperation	Scientific Research Strong Political Will
Carboniferous Aquifer Belgium – France	3	Moderate Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions	Funding Mechanisms Previous Water Cooperation
Dinaric Karst Aquifers Albania - Bosnia & Herzegovina - Croatia – Greece – Italy – Macedonia - Montenegro - Serbia - Slovenia	5	Moderate Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms Previous Water Cooperation	Strong Political Will
Lake Chad Basin Aquifers Cameroon - Chad - Central African Republic - Niger - Nigeria	4	Moderate Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms	Previous Water Cooperation Third-party Involvement
Mura-Zala Basin Aquifer Hungary - Slovenia	4	Moderate Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms	High Institutional Capacity Previous Water Cooperation
Nubian Sandstone Aquifer System Chad - Egypt - Libya - Sudan	6	High Cooperation Moderate Conflict	Existing Regional Institutions Funding Mechanisms	Scientific Research Third-party Involvement
Orange-Senqu River Basin Aquifers Botswana - Namibia - South Africa	4	Moderate Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms	Previous Water Cooperation Third-party Involvement
Sahel Region Aquifers Algeria - Benin - Mali - Niger - Nigeria - Mauritania	4	High Cooperation Low Conflict	Existing Regional Institutions Funding Mechanisms Previous Water	Scientific Research Strong Political Will Third-party Involvement

in the Sahel Region Aquifers also placed them in the moderate rather than high engagement category.

4.3.3 HIGH ENGAGEMENT CASES

Cases classified as high engagement over groundwater if (1) there is ongoing cooperation in the context of a formal institution or (2) there is frequent ongoing cooperation in the context of a formal project. Using this criteria, there were six cases identified as high engagement: the Bolsón del Hueco-Valle de Juárez Aquifer, the Danube River Basin Aquifers, the Genevois Aquifer, the Guaraní Aquifer System, the Northwestern Sahara Aquifer System, and the Upper Rhine Aquifer. The Transboundary Aquifer Events, Transboundary Aquifer Interactions and Enabling Factors for each of these cases are summarized in Table 7.

In high engagement cases, the number of Enabling Factors present ranges from 4 to 7 with an average of 4.5 Enabling Factors per case. Three factors had substantial influence on low engagement cases. These included Existing Regional Institutions, which influenced five of six cases; Funding Mechanisms with influenced four of six cases; and Existing Legal Mechanisms and Strong Political Will, both influencing three of six cases. The highest ranked BAR scale events for each of the cases ranged from BAR 4 to BAR 6, with an average BAR rank of 4.7. With one exception, all of the cases had Transboundary Aquifer Interactions that were characterized as high cooperation-low conflict. The NBolsón del Hueco-Valle de Juárez Aquifer showed moderate cooperation-moderate conflict Transboundary Aquifer Interactions because of difficulties

Table 7. Summary of High Engagement Cases

Aquifer Name	TBA Event	TBA Interaction	Enabling Factors Present	
Bolsón del Hueco-Valle de Juárez Aquifer Mexico - United States of America	4	Moderate Cooperation Moderate Conflict	Existing Legal Mechanisms Existing Regional Institutions	Previous Water Cooperation Scientific Research
Danube River Basin Aquifers Austria - Bosnia & Herzegovina – Bulgaria – Croatia - Czech Republic - Germany – Hungary – Moldova – Montenegro – Romania – Serbia – Slovakia – Slovenia - Ukraine	4	High Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions High Institutional Capacity Previous Water Cooperation	
Franco-Swiss Genevois Aquifer France - Switzerland	6	High Cooperation Low Conflict	Funding Mechanisms High Institutional Capacity Strong Political Will	
Guaraní Aquifer System Argentina - Brazil - Paraguay - Uruguay	6	High Cooperation Low Conflict	Existing Regional Institutions Funding Mechanisms High Institutional Capacity Previous Water Cooperation	Scientific Research Strong Political Will Third-party Involvement
Northwestern Sahara Aquifer System Algeria - Libya - Tunisia	4	High Cooperation Moderate Conflict	Funding Mechanisms Strong Political Will Third-party Involvement	
Upper Rhine Aquifer France - Germany - Switzerland	4	High Cooperation Low Conflict	Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms	Previous Water Cooperation High Institutional Capacity

in political relations between the Mexican and US federal governments.

This analysis yielded several noteworthy conclusions. The average number of Enabling Factors varied with the level of engagement, implying that an increased number of factors do not necessarily lead to increased engagement. In contrast, the average value of the highest ranked BAR scale event did increase with the level of engagement – making Transboundary Aquifer Events a better indicator of engagement than number of Enabling Factors. Further, the cooperation component of Transboundary Aquifer Interactions was a very good indicator of the level of engagement, with the exception of two cases, in which the intensity of interaction between the aquifer states reduced after Transboundary Aquifer Events, such as completing a project or concluding a multi-lateral agreement. The critical role of Existing Regional Institutions is observed in all three case types. Previous Water Cooperation and Scientific Research characterize low-engagement cases, but are not major factors at other levels of engagement. Funding Mechanisms influence both moderate and high engagement cases. Yet, Existing Legal Mechanisms were more influential in moderate engagement cases than in high engagement cases. While the role of legal mechanisms may have been reduced in high engagement cases, Strong Political Will was clearly influential.



The CC license does not apply to this picture.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS REGARDING ENABLING FACTORS

Evidence that cooperation occurs across a wide range of hydrogeological, geographic, socio-economic and political contexts indicates that cooperation is not necessarily the byproduct of a narrow set of circumstances. Rather, it indicates that cooperation occurs when a number of observable factors are present. This report identifies eight Enabling Factors for transboundary aquifer cooperation. The report further analyzes how the presence of these Enabling Factors corresponds with Transboundary Aquifer Events and Transboundary Aquifer Interactions. Therefore, this section summarizes the definition of each Enabling Factor, its pattern of occurrence, as well as its influence on Transboundary Aquifer Events and Transboundary Aquifer Interactions.

5.1.1 EXISTING LEGAL MECHANISMS

In the review of the cases, pre-existing binding and non-binding legal texts that place specific obligations on aquifer states constitute Existing Legal Mechanisms. These include, but are not limited to, bi-lateral or multi-lateral legal agreements, supranational legal mechanisms (e.g. the EU Water Framework Directive) as well as mandates, decrees, and declarations for transboundary aquifer management. Existing Legal Mechanisms are present in 12 of the cases. Existing Legal mechanisms also show strong geographic trends in that they were highly influential in North America, Europe and Africa. Overall, Existing Legal Mechanisms play a key role in cases of moderate engagement. They play a relatively minor role in low-engagement cases and are less important in high-engagement cases.

5.1.2 EXISTING REGIONAL INSTITUTIONS

Existing Regional Institutions are considered an Enabling Factor when a transboundary aquifer case involves an institution charged with promoting cooperation and coordination on issues of regional importance and the institution demonstrates some specific focus on groundwater. Such institutions are present in 19 of the 20 cases reviewed. Consequently, this Enabling Factor exerts global geographic influence. Existing Regional Institutions are particularly influential in medium-sized aquifers and in aquifers where there are more than two aquifer states. In summary, of all the Enabling Factors, Existing Regional Institutions were found to have the most significant influence on transboundary cooperation.

5.1.3 FUNDING MECHANISMS

Funding Mechanisms are considered Enabling Factors if the aquifer states and/or a third-party provided the funding for a joint project or institution. Funding Mechanisms are present in 14 of the cases reviewed and across all regions, indicating that it also has a global influence. Funding Mechanisms were highly correlated with the physical extent of the aquifer, they are present in all the cases of cooperation in large aquifers (i.e. 1,000,000 km² or more) and also influential in cases with a large number of aquifer states (i.e. greater than five). This may be attributable to a disproportionately large number of aquifers in developing countries. Funding Mechanisms have a noticeable influence on both moderate and high-engagement cases, indicating that they may be a key ingredient for increasing levels of cooperation between states.

5.1.4 HIGH INSTITUTIONAL CAPACITY

When organizations demonstrate the ability to deal with groundwater governance issues related to monitoring, modeling and/or management, High Institutional Capacity is considered an Enabling Factor. High Institutional Capacity was an Enabling Factor in nine of the cases reviewed. This factor's influence is strongest in Europe and North America. However, it is also present in the Guaraní Aquifer System case. High Institutional Capacity

is not critical to any level of engagement. Instead, it is possible that it further supports existing institutions in their abilities to address groundwater issues.

5.1.5 PREVIOUS WATER COOPERATION

Previous Water Cooperation is identified by past interactions about water resources between two or more of the aquifer states. Previous Water Cooperation was identified as an Enabling Factor in 17 cases. Its influence is distributed fairly evenly across continents, particularly in Europe and North America. In small-sized aquifers, Previous Water Cooperation also proves to be a critical Enabling Factor. With respect to the number of aquifer states, Previous Water Cooperation is instrumental where there were only two aquifer states and where there are five or more aquifer states. It has a significant influence on low engagement cases, being present in four out of five. Analysis of the cases demonstrates that aquifer states are more willing to address groundwater issues via informal and formal exchanges when there is a history of cooperation over water resources. Additional Enabling Factors are required to go beyond ad hoc or informal interactions for higher levels of cooperation to materialize.

5.1.6 SCIENTIFIC RESEARCH

Scientific Research is considered an Enabling Factor when it is conducted specifically for the assessment of transboundary impacts and provides significant new information to the aquifer states. Scientific Research is an Enabling Factor in nine of the reviewed cases. It is an influential factor in both North and South America, with some influence in Africa. Scientific Research also has a noticeable influence on low engagement cases. When new knowledge about a transboundary aquifer becomes available, it can bring about dialogue between the aquifer states. Nonetheless, other factors are necessary to move this dialogue into higher levels of engagement.

5.1.7 STRONG POLITICAL WILL

Strong Political Will was considered an Enabling Factor if high-ranking government officials prioritized groundwater management. This was a factor in seven cases. No geographic trends were present in aquifers of different physical sizes with different numbers of aquifer states. The sporadic occurrence of Strong Political Will illustrates that its presence as an Enabling Factor is highly circumstantial. Nevertheless, it proved influential in achieving a high level of engagement and cooperation regarding transboundary aquifer management.

5.1.8 THIRD-PARTY INVOLVEMENT

Significant contributions to cooperation from entities outside the aquifer states' governments indicate Third-party Involvement. Ten of the cases evaluated include Third-party Involvement as a factor. Third-party Involvement primarily plays a role in the Global South, but is also present in the North. It is influential in cases with between three and five aquifer states. Yet, it was not critical to bringing about a particular level of cooperation. Rather it was linked to Funding Mechanisms in cases, such as Sahara Sahel Observatory's (OSS) involvement in the Nubian Sandstone Aquifer System and the Northwestern Sahara Aquifer System. It remains unclear whether it plays a role in sustained cooperation between aquifer states.

5.2 CONCLUSIONS REGARDING ENABLING FACTORS

Reviewing cases of transboundary aquifer cooperation, identification of Enabling Factors, and analysis of these factors using Transboundary Aquifer Events and Transboundary Aquifer Interactions yielded several key insights about cooperation in general. First, the cases show that cooperative Transboundary Aquifer Events can indicate cooperative engagement. The high frequency of Transboundary Aquifer Events with a BAR 4 ranking implies that transboundary aquifer cooperation often occurs in the context of formal partnerships but less frequently extends into strategic management initiatives or the creation of legal binding agreements for aquifer management. However, Transboundary Aquifer Events also can be red herrings if they rank high on the BAR scale but are only a single instance of cooperation rather than an indicator of sustained cooperative activities. This phenomenon was demonstrated in the cases of the Châteauguay and Poplar aquifers. Therefore, when cooperative events occur, it can be inferred that some level of cooperation exists between the parties. However, the magnitude of the event cannot be mistaken for active and sustained engagement.

Second, most Transboundary Aquifer Interactions were classified as moderate cooperation-low conflict. In other words, most aquifer states have peaceful or neutral interactions with each other with respect to water resources management; they have the intention to manage groundwater resources collaboratively; and are making intermittent progress towards this goal. This level of interaction indicates that states engaged in dialogue or activities about transboundary aquifers are taking notable steps that extend beyond ad hoc and or informal activities. Yet, there may be one or more factors absent that prevent a high level of engagement.

Third, the cases illustrate that cooperation for transboundary aquifer management can occur within otherwise conflictual or politically sensitive contexts as in the cases of the Bolsón del Huevo-Valle de Juárez Aquifer, Aquifers of the Mekong River Plain, and Nubian Sandstone Aquifer System. With the exception of the Mekong River Plain case, the need for transboundary aquifer management was urgent due to rapidly increasing abstraction and sometimes corresponding depletion. These are also cases where management of surface water remains a contentious issue. Thus, the need and motivation for transboundary aquifer cooperation can be strong enough that it supersedes tensions occurring in other political arenas.

Fourth, the cases suggest that the creation of comprehensive and binding legal agreements for transboundary aquifer management are not necessarily a prerequisite for cooperation. Rather, they are a potential outcome of ongoing, high level cooperation between aquifer states, as was the case with the Guaraní Aquifer System and Nubian Sandstone Aquifer System. This is important because legal aspects of cooperation, specifically treaty-making, are frequently discussed and emphasized in the theoretical literature. While legal mechanisms are extremely powerful tools for cooperative governance, they are not the singular signpost for cooperative interactions. Therefore, when discussing instances of transboundary aquifer cooperation, recognition of all types of engagement is critical to capturing the range of dynamics on this subject.

Fifth, some Enabling Factors are more critical for certain levels of engagement. This finding can be instrumental in helping policy makers and practitioners increase the level of cooperation within their respective transboundary aquifers. For example, if there is no cooperation on groundwater, looking for institutions with a history of surface water cooperation and initiating a scientific study could be enough to initiate a dialogue. An existing but low-engagement situation could be bolstered with the support of a cooperative regional institution. And regular dialogue occurring in informal contexts might move toward formalization with dedicated funding and high-level political support. This fifth finding leads to proposing a specific set of recommendations regarding

how each Enabling Factor can be fostered or enhanced for increased cooperation over transboundary aquifers.

5.3 RECOMMENDATIONS

This investigation allowed the identification of 'key ingredients' for transboundary aquifer cooperation. Based on the findings and conclusions above and in keeping with the theoretical background presented in earlier sections, the following set of recommendations is provided for enhancing transboundary aquifer cooperation in the future.

5.3.1 **RECOMMENDATION 1 - ENHANCE AND DEVELOP LEGAL MECHANISMS**

A current focus of the international community is on creating cooperation through the development of binding legal agreements for transboundary waters. Yet the discourse on transboundary water resources management and treaty negotiation has become conflated with cooperative, collective management. Eran Feitelson aptly captures the risk of not clearly distinguishing the two, stating "international agreements are the art of the possible, not an exercise in optimal management" (Feitelson 2005:328). Consequently, this report takes the opportunity to caution against this. The case analysis indicates that cooperative management efforts frequently occur for many years without a formal legal mechanisms being in place. Further, these mechanisms are often the result of ongoing cooperation, rather than the catalyst for it. To that end, we recommend that some (but not all) of the energy put toward developing new treaties is shifted towards enhancing existing mechanisms for transboundary water resources management. For example, basins with well-designed agreements for surface water management should seek to enhance provisions for managing linked groundwaters. If additional mechanisms are required for confined aquifers, they should be appropriately harmonized and adjusted for the specific needs of those resources.

5.3.2 **RECOMMENDATION 2 - UTILIZE EXISTING REGIONAL INSTITUTIONS**

Given that Existing Regional Institutions are a nearly ubiquitous Enabling Factor for cooperation over transboundary aquifers, we strongly recommend that they be leveraged as much as possible to create and enhance cooperation. Review of the cases leads us to conclude that institutions can have a noticeable impact on transboundary aquifer cooperation, even if water management is not their primary focus. Therefore, identifying institutions in which a high level of cooperation already exists and motivating them to address issues of groundwater management could substantially increase transboundary aquifer cooperation. For instance, in the case of the Guaraní Aquifer System, the Southern Common Market (MERCOSUR), created a groundwater task force, which directed the attention and resources of member states to transboundary aquifers.

5.3.3 **RECOMMENDATION 3 - INTEGRATE FINANCING MECHANISMS**

The analysis produced a strong correlation between aquifers with a large physical extent and Funding Mechanisms enabling cooperation in those areas. However, all the large aquifer systems analyzed were also located in lesser-developed regions. The relationship between economic development and transboundary aquifer cooperation was not explored in this research. Nevertheless, Funding Mechanisms had a global geographic influence and cases with funding from international or regional financial institutions were able to significantly increase the level of cooperation within the transboundary aquifer. Therefore, it is recommended that states increase funding directed toward initiatives with potential to enhance groundwater cooperation.

5.3.4 RECOMMENDATION 4 - BOLSTER INSTITUTIONAL CAPACITY

While institutional capacity appears to play an assisting, rather than a catalyzing role in transboundary aquifer cooperation, it is nevertheless an important “ingredient.” Therefore, it is recommended that where possible, water management institutions seek to increase their level of capacity for groundwater resources management through education and partnerships. This is particularly important where there may be large asymmetries in the capacities of the aquifer states. Ideally, each state would be confident that their knowledge and skills are sufficient for them to participate in cooperative activities. If this confidence is lacking, moving from dialogue to action may be difficult.

5.3.5 RECOMMENDATION 5 - CAPITALIZE ON PREVIOUS WATER COOPERATION

Previous Water Cooperation is a critical factor in low engagement cases. Consequently, areas with previous surface water cooperation may also be ripe for initiating groundwater cooperation. Therefore, we recommend that organizations such as existing River Basin Organizations and international task forces for water management serve as starting points for transboundary aquifer cooperation.

5.3.6 RECOMMENDATION 6 - GENERATE SCIENTIFIC RESEARCH

Low-level engagement occurred as a result of aquifer states receiving new scientific information about a transboundary aquifer, especially if this information indicated potential risk to the transboundary aquifer. As shown in Figure 6, such an event has the potential to result in conflict. However, previous cooperation over water resources and/or existing cooperative regional institutions makes conflict less likely. Therefore, we recommend that in the context of existing regional institutions and/or in the wake of previous cooperation over surface water resources, it would be beneficial to extend scientific and technical efforts to groundwater resources.

5.3.7 RECOMMENDATION 7 - FOSTER STRONG POLITICAL WILL

While in most cases Strong Political Will was circumstantial, it was still an important Enabling Factor for attaining high levels of engagement. As such, we recommend enhancing education and communication mechanisms for politicians and government officials regarding groundwater resources. The ability to effectively convey the value of a transboundary water resources and the importance of its management can strengthen cooperative efforts.

5.3.8 RECOMMENDATION 8 - ENCOURAGE THIRD-PARTY INVOLVEMENT

The involvement of global or regional organizations that can objectively facilitate transboundary interaction was critical to cooperation in several cases. Therefore, it is recommended that organizations with the appropriate mandate, capacity, and financing to facilitate cooperation over transboundary resource management dedicate some of their efforts towards taking action on transboundary aquifers. In particular, regional organizations that have the trust of the aquifer states could be well-equipped to bring about cooperative engagement over transboundary aquifers.

BOX 5.
Implications for good practices in transboundary water cooperation

In 2004, the Swedish Development Corporation adopted the following definition and described a 'good practice.' "A good practice is simply a process or a methodology that represents the most effective way of achieving a specific objective. Some people prefer to use the term 'good practice' as in reality it is debatable whether there is a single 'best' approach – and of course approaches are constantly evolving and being updated. So another way of defining a good practice is one that has been proven to work well and produce good results, and is therefore recommended as a model. The essence of identifying and sharing good practices is to learn from others and to re-use knowledge. The biggest benefit consists in well-developed processes based on accumulated experience."

Subsequently, the Food and Agriculture Organization (FAO) also developed criteria through which good practices can be identified. According to FAO, a good practice is:

- Effective and successful
- Sustainable
- Environmentally sound
- Socially acceptable
- Technically practicable
- Economically efficient
- Inherently participatory
- Replicable and adaptable

From the definition, description and criteria, it is clear that 'good practices' are developed over time and the result of sustained interaction between stakeholders. 'Good practices' can be viewed as outcomes of cooperation. Enabling Factors that lead to cooperation can also have an effect on good practices. For example, well-constructed legal mechanisms and effective regional institutions would facilitate transboundary aquifer management practices that meet all the aforementioned criteria. Appropriate financing mechanisms would promote sustainable, economically efficient and socially acceptable means of funding cooperation. Scientific research and improvements in institutional capacity would be technically practical, replicable and adaptable over time as the resources change and knowledge advances. Further, participation of third parties would ideally be contingent upon their ability to incorporate all of the criteria into their approach and project design as applicable. Overall, there are several areas where the Enabling Factors and good practices can reinforce each other.

5.4 AREAS FOR FURTHER RESEARCH

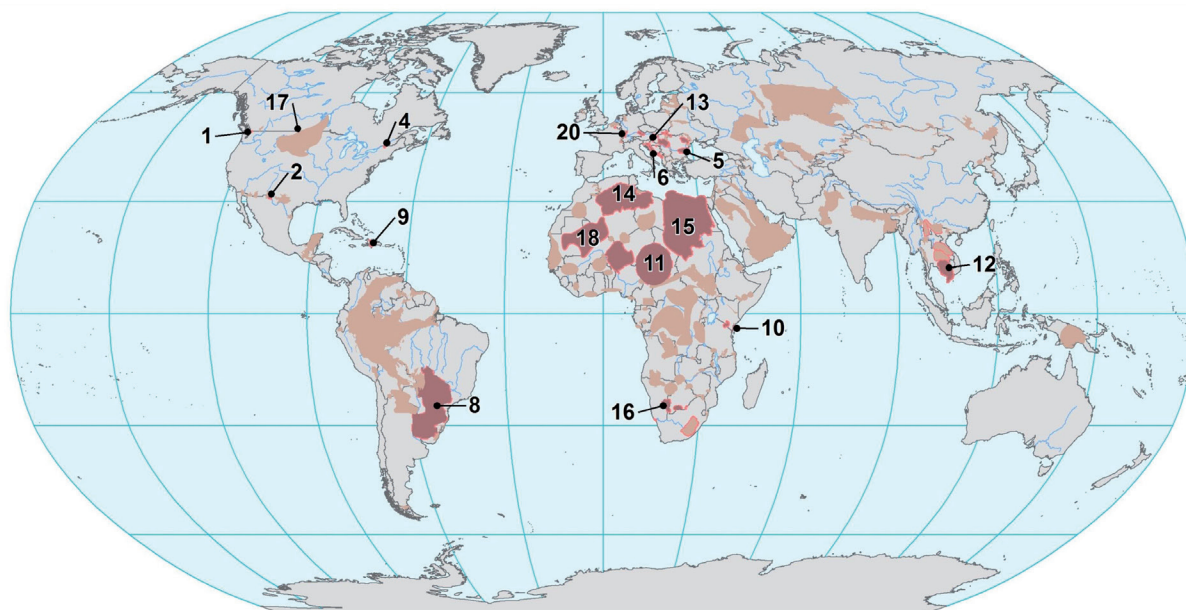
Hopefully, this report is the beginning of greater research efforts on transboundary aquifer cooperation. In the beginning, the largest barriers to the research were lack of information and narrow definitions of cooperation and cooperative activities as applied to groundwater resources. As the project developed, it became clear that there are more stories of transboundary aquifer cooperation than previously acknowledged. Consequently, there are probably many more cases that did not find their way into this report. Therefore, the most fervent recommendation is that those still hidden cases are sought out and understood as much as possible.

The primary purpose of this research was exploratory. As a result, the outcomes are mainly descriptive. Hypotheses about causal links between any of the Enabling Factors and cooperation are avoided. Ideally, future research will make a more direct attempt to establish a causal link between the Enabling Factors and the levels of cooperative engagement. Doing so may require more cases to be identified – especially if statistical analysis is used. However, now that some of the 'ingredients' for cooperation are known. It would be beneficial to have some 'recipes' as well.

APPENDIX A:
PROFILES OF TRANSBOUNDARY AQUIFER
COOPERATION

A.1 INDEX OF CASE STUDIES

No.	Aquifer [Group/System] Name	Aquifer States
1	Abbotsford-Sumas Aquifer	Canada, United States
2	Bolsón del Hueco-Valle de Juárez	Mexico, United States
3	Carboniferous Aquifer	Belgium, France
4	Châteauguay Aquifer	Canada, United States
5	Danube River Basin Aquifers	Austria, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Serbia, Slovakia, Slovenia, Ukraine
6	Dinaric Karst Aquifers	Albania, Bosnia & Herzegovina, Croatia, Italy, Greece, Macedonia, Montenegro, Serbia, Slovenia
7	Franco-Swiss Genevois Aquifer	France, Switzerland
8	Guaraní Aquifer System	Argentina, Brazil, Paraguay, Uruguay
9	Hispaniola Island Aquifers	Dominican Republic, Haiti
10	Kilimanjaro Aquifer	Kenya, Tanzania
11	Lake Chad Aquifer System	Cameroon, Chad, Central African Republic, Niger, Nigeria
12	Mekong River Plain Aquifers	Cambodia, Laos, Thailand, Vietnam
13	Mura-Zala Aquifer	Hungary, Slovenia
14	Northwest Sahara Aquifer System	Algeria, Libya, Tunisia
15	Nubian Sandstone Aquifer System	Chad, Egypt, Libya, Sudan
16	Orange-Senqu River Basin Aquifers	Botswana, Namibia, South Africa
17	Poplar Aquifer	Canada, United States
18	Sahel Region Aquifers	Algeria, Benin, Mali, Niger, Nigeria, Mauritania
19	Sava River Basin Aquifers	Croatia, Slovenia, Bosnia & Herzegovina
20	Upper Rhine Aquifer	France, Germany, Switzerland



Legend

Occurrence and extent of transboundary aquifers

- TBA cooperation cases
- other TBAs
- confirmed boundary
- approximate boundary

Geographical features

- countries
- rivers
- lakes

Scale: 1:150,000,000

A.2 INDEX OF ENABLING FACTORS

Enabling Factor 1	Existing Legal Mechanisms
Enabling Factor 2	Existing Regional Institutions
Enabling Factor 3	Funding Mechanisms
Enabling Factor 4	High Institutional Capacity
Enabling Factor 5	Previous Water Cooperation
Enabling Factor 6	Scientific Research
Enabling Factor 7	Strong Political Will
Enabling Factor 8	Third-Party Involvement

A.3 METHODOLOGY FOR CASE IDENTIFICATION

This section presents a detailed methodology for the identification and analysis of the cases of transboundary aquifer cooperation. The first step to identifying the cases of transboundary aquifer cooperation was consulting authoritative documents on cooperation on international water resources; cooperation on transboundary aquifers; and scientific research on transboundary aquifers. If these documents identified specific cases of transboundary cooperation involving groundwater resources it was flagged for further investigation. This preliminary review yielded a list of over 40 potential instances of transboundary aquifer cooperation. At this time, making the distinction between cooperative interactions and cooperative events was required. The initial list reflected a number of cooperative events and/or the existence of proposed cooperative programs such as making informal and formal agreements (e.g. Memorandums of Understanding) or undertaking joint scientific research projects. However, in several cases there was a cooperative event, such as announcing an agreement or project, but no evidence of subsequent action to this effect. Consequently, the cooperative event indicated the potential for cooperative interactions, but such interactions did not materialize.

Next a desk study and preliminary consultations with IGRAC and UNESCO-IHP staff were conducted. The desk study and consultations helped determine whether these instances should have been further developed into complete case studies. Availability of information in English and/or Spanish was a major determinant at this stage. Limited information eliminated approximately ten instances from further consideration. The desk study and consultations also revealed that several of the individual instances of transboundary aquifer cooperation that were identified, in fact, occurred under broader regional programs. In other words, a single cooperative scenario involved multiple aquifers. Consequently, some of the aquifers were clustered in order to facilitate analysis of cooperative actions occurring regionally.

Appropriately clustering the aquifers required differentiating between aquifers, which exist in the same geographic region and are hydrologically linked and those that are not hydrologically linked. Aquifer clusters that are hydrologically linked were considered 'aquifer systems' and those that are not were considered 'aquifer groups'. Once the aquifers were clustered, a total of 26 aquifers, aquifer systems and aquifer groups had the potential to further develop into case studies.

At this point an in-depth investigation into each transboundary aquifer began. Multiple sources including academic literature, grey literature, and web resources were consulted to construct each of the case profiles.

To develop the full case studies, the following information was required:

- data about the geographic extent and physical characteristics of the aquifer;
- data about the major uses and threats to the sustainability of the aquifer;
- details regarding the history of cooperation between the aquifer states; and
- details regarding the nature of ongoing cooperative activities between the aquifer states.

During the in-depth research, another six aquifers were removed from further study due to lack of information in one or more of the aforementioned areas. In the end, a total of 20 case studies were compiled and analyzed.

As part of the case research, at least one person involved with each cooperation case was contacted. The purpose was to verify the results of the desk study, clarify how cooperation occurred, and acquire additional information that may be relevant to the cases. Over 20 persons were contacted for interviews. Eight people were interviewed via phone or Skype. Two people corresponded via email. The remaining eleven persons were unavailable. The verbal interviews were semi-structured. Each person was asked the questions that appear in the draft questionnaire available in Appendix C. In some cases they also reviewed the text of the aquifer profile featured below.

ABBOTSFORD-SUMAS AQUIFER

| Canada | United States of America |



ABBOTSFORD-SUMAS AQUIFER

| Canada | United States of America |

Canada and the United States have a long history of conflict and cooperation over water resources. Cooperation was formalized by the 1909 Boundary Waters Treaty (United States of America & United Kingdom of Great Britain, 1909). Since then, numerous transboundary institutions have been put in place to promote cooperation (see Key Facts, below). Nevertheless, conflicts related to transboundary groundwater resources are less prevalent than for surface water resources. In total, the two countries share 17 aquifers one of which is the Abbotsford-Sumas aquifer. However, water resources are governed at different administrative levels in Canada and the United States: primarily at the provincial level in Canada and at the federal level in the US.

The Abbotsford-Sumas Aquifer straddles the province of British Columbia and Washington state, providing drinking water for approximately 110,000 people. While groundwater flows from north to south, contamination originating from both sides of the border has caused significant impacts, since the 1950's. Impacts have been especially pronounced in Washington. Nitrate concentrations are the main threat to human health (Norman & Melious, 2004) and mapped and monitored since the 1970s (Council of Canadian Academies, 2009). However, concerns were elevated when a high occurrence of Blue Baby Syndrome (Methemoglobinemia) was affecting the families using the aquifer for their drinking water supply (E. Norman, personal correspondence).

The Abbotsford-Sumas Aquifer International Task Force (Task Force) is a bi-national advisory board, which collects and coordinates scientific data; oversees activities posing potential threats to the aquifer; and advises in policy-making related to the aquifer. It began as a stand-alone entity and later the Environmental Cooperation Council incorporated it as one of its first committees. Due to waning political interest and financial difficulties, the Task Force was dormant between 2008 and 2012, but monitoring and some stakeholder consultation activities still continued. In January of 2013, the Task Force resumed activities (E. Norman, personal correspondence). Additionally, the Abbotsford-Sumas Aquifer Stakeholder Group was established in 1995 and is still functioning with reduced activities (Council of Canadian Academies, 2009). The group's primary function is to address municipal supply issues in the City of Abbotsford. It is composed of federal, provincial, state and local government agencies; agricultural and industrial interests; and non-governmental organizations. At the height of these activities in the 1990's and early 2000's, cooperation and coordination occurred across multiple sectors and multiple levels of governance. In addition to these groups, the use of Best Management Practices (BMPs) was and is still widely promoted through Canada's government, industry self-monitoring programs, and local sustainability groups. However, these efforts have not mitigated the pollution problem.

The presence of existing institutions for environmental cooperation, a history of interaction over water resources as well as political will to study and manage the Abbotsford-Sumas Aquifer were clear factors that facilitated cooperation. During a period of over 50 years, the condition of the aquifer received increasing attention from international institutions, high-level government officials, and local communities on both sides of the border. The need to fund scientific investigations of the aquifer as well as local-level education was recognized early on, in part because of the institutional capacity that existed in the various organizations.

Despite the considerable cooperative efforts in the past, there have been few cooperative actions within the last five years. The quality of the groundwater in the Abbotsford-Sumas is still considered poor and major problems with transboundary pollution persist because effective governance is severely hindered by weak implementation mechanisms and competing user groups. British Columbia only introduced groundwater regulation legislation in 2004. Further, there is little oversight to ensure that measures and protocols for pollution prevention are being implemented on the ground (Council of Canadian Academies, 2009). However, as of early 2013, it appears that cooperative activities may begin again via the Task Force. Additionally, a recent plea for the International Joint Commission to investigate the conditions of the aquifer may further motivate cooperation (T. Takaro, personal correspondence).

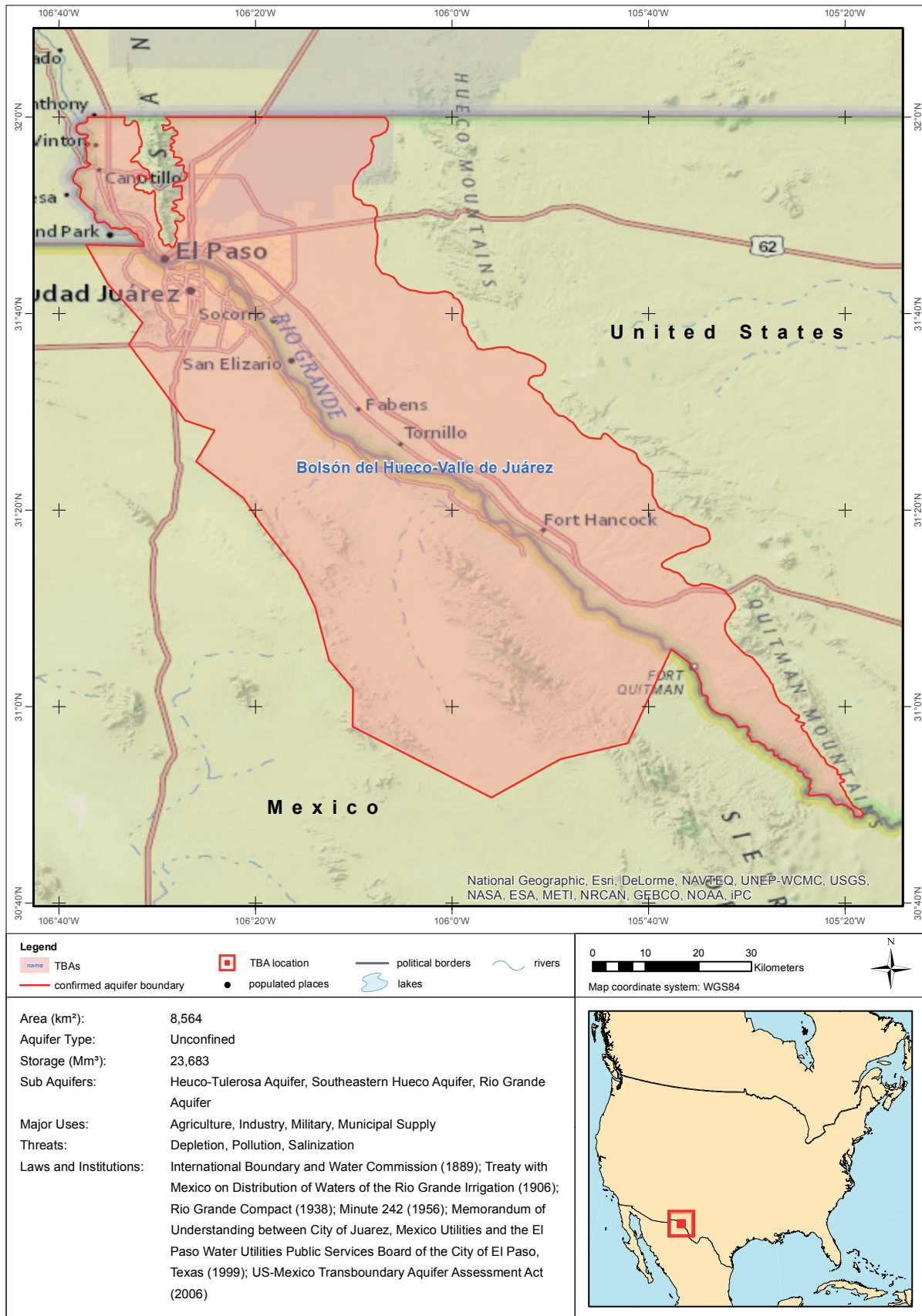
Level of Cooperation
4
Catalyst for Cooperation
Health impacts due to pollution
Enabling Factors
Existing Regional Institutions
Funding Mechanisms
High Institutional Capacity
Previous Water Cooperation
Scientific Research
Strong Political Will

References:

- Council of Canadian Academies. (2009). *Sustainable Management of Groundwater in Canada – Report of the Expert Panel on Groundwater*. Ottawa, Canada.
- Norman, E. S., & Melious, J. O. (2004). Transboundary environmental management: A study of the Abbotsford Sumas aquifer in British Columbia and western Washington. *Journal of Borderlands Studies*, 19(2), 101–119. doi:10.1080/08865655.2004.9695628
- United States of America, & United Kingdom of Great Britain. (1909). *Treaty Relating to the Boundary Waters and Questions Arising Along the Boundary Between the United States and Canada (Washington)* (p. 10 IPE 5158). Washington, D.C.: 11 January 1909, entered into force 5 May 1910.

BOLSÓN DEL HUECO-VALLE DE JUÁREZ AQUIFER

| Mexico | United States of America |



BOLSÓN DEL HUECO-VALLE DE JUÁREZ AQUIFER

| Mexico | United States of America |

The Bolson del Hueco-Valle de Juarez Aquifer straddles the Mexican state of Chihuahua and the American states of New Mexico and Texas. It also underlies the Rio Grande River. It provides water for 1.5 million residents in Ciudad Juarez and 730,000 in El Paso (Eckstein 2011). Due to boundary disputes arising with the meandering of the Rio Grande and Colorado rivers, the International Boundary and Waters Commission (IBWC) was created in 1889. One of the primary aims of this institution is to prevent conflict over transboundary water resources. Apportionment of Rio Grande's waters began over 100 years ago when the US and Mexico agreed that Mexico should receive 60,000 acre-feet of water from the US annually. In 1938, a surface water new apportionment was outlined but the terms of these agreements remain unmet and resulting in a reduction of surface water downstream. The reduced flows caused many farmers in both Texas and Mexico, to drill wells and pump the underlying groundwater (Day 1978).

Level of Cooperation
4
Catalyst for Cooperation
Overexploitation
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Previous Water Cooperation Scientific Research

Between 1952 and 2007, water levels in the aquifer fell over 23 meters. In the 1970's, local scientists from the US and Mexico began joint research initiatives to better understand the nature of the aquifer and the implications of international appropriation. In 1973, the International Boundary Waters Commission (IBWC) launched an investigation to solve salinity problems in the Rio Grande and aquifers in the western section of the border. Attempts to create a treaty were thwarted by both governments, but in the end they signed Minute 242, which functions as an Annex to the Boundary Waters treaty. This is now the only formal agreement addressing transboundary groundwater between each country's federal governments. Disparate legal regimes at the state level have also prevented effective management of the aquifer. At the state level, Texas groundwater law allows property owners to pump any water available beneath their property with limited oversight from conservation and subsidence districts. Whereas, in Mexico, local authorities were recently placed in charge of groundwater management (although the National Water Commission [CONAGUA] still has notable influence in this regard). Action has primarily been taken by the utilities of El Paso and the City of Juárez, which have a Memorandum of Understanding to manage surface and groundwater via activities such as conservation and reuse measures, consumer education and technologies including desalination.

After over 40 years of silence on the issue of the transboundary aquifers at the Federal Level, the US passed the US-Mexico Transboundary Aquifer Assessment Act in 2006. While some perceived this as a unilateral action, the Act was drafted in collaboration with CONAGUA and the IBWC as an effort to consolidate knowledge networks addressing transboundary aquifers at the US-Mexico border (M. Walter, personal communication). The act requires the US government to evaluate the status of the aquifer; create a GIS database for aquifer information; and consider expanding or modifying existing data-sharing agreements between the US and Mexico; and to designate the aquifer as a 'Priority Transboundary Aquifer' in the US (190th Congress 2006).

The apparent lack of direct interaction about the aquifer in recent years between state and federal actors in the two countries indicates that cooperation is localized (Eckstein 2013). High-level political will for cooperation on issues other than data sharing is nearly absent. Nevertheless, the local utilities have succeeded in mitigating groundwater depletion and extending the expected longevity of the aquifer by more than 50 years. However, the situation with the Bolson del Hueco-Valle de Juarez Aquifer shows that the presence of transboundary institutions can serve as a 'container' within which the desire for cooperation can ebb and flow. It also highlights the importance of local actors and the influence of informal knowledge networks. Since groundwater levels have stabilized there is more space for relaxed stakeholder dialogues about next step for management. Yet, it remains to be seen if this will increase the level of cooperation.

References:

- 190th Congress, 2006. *Senate Bill 214 – United States Mexico Transboundary Water Assessment Act*, 109th Congress.
- Day, J.C., 1978. International Aquifer Management: The Hueco Bolson on the Rio Grande River. *Nat. Resources J.*, 18, p.163.
- Eckstein, G.E., 2011. Buried Treasure or Buried Hope? The Status of Mexico-U.S. Transboundary Aquifers under International Law. *International Community Law Review*, 13(3), pp.273–290.
- Eckstein, G.E., 2013. Rethinking Transboundary Ground Water Resources Management: A Local Approach along the Mexico-US Border. *Georgetown International Environmental Law Review*, 25(1), pp.95–128.

CARBONIFEROUS AQUIFER

[CALCAIRES DE L'AVESNOIS]

| Belgium | France |



CARBONIFEROUS AQUIFER

[CALCAIRES DE L'AVESNOIS]

| Belgium | France |

The Carboniferous Aquifer is hydrologically linked to the Scheldt River, which flows through France, Belgium and the Netherlands. The aquifer, however, only underlies France and the Walloon and Flemish regions of Belgium. Cooperation and consultation about the Scheldt between the riparian countries has occurred since the mid 1800's. In 1994, their cooperation became institutionalized with the signing of the Treaty for the Protection of the Scheldt and the establishment of the International Commission for the Protection of the Scheldt. In 2002, the countries renewed and strengthened their cooperation by signing the Treaty of Ghent. In this treaty, the Belgian federal government was the signatory as opposed the individual provinces and there were provisions for coordination under the EU Water Framework Directive (EU WFD) (International Commission for the Protection of the Scheldt 2005). The EU WFD requires that all waters attain 'good' quantitative and qualitative status by 2015. The Carboniferous Aquifer is currently failing the test for good quantitative status because of overexploitation. Consequently, the International Scheldt Commission has prioritized management of the aquifer and sought funding through the INTERREG program to support these efforts.

Level of Cooperation
3
Catalyst for Cooperation
Implementation of legal mechanisms
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms Previous Water Cooperation

The INTERREG IVB Programme enabled the establishment of the Contribute to a Better Quality of Surface and Groundwater Bodies in the Scheldt International River Basin District (ScaldWIN) initiative. The ScaldWIN project includes with the goal of creating 'a set of cost-effective, innovative and transactional actions aimed at attaining good water quality status of surface and groundwater bodies' and to establish a transnational water monitoring system (Lefébure 2012). Work Package 3 entitled 'Transnational cooperation for a sustainable management of transboundary aquifers' is specifically dedicated to groundwater. The work package has two main objectives: (1) increased monitoring of the Carboniferous Aquifer and (2) assessing the possible effects of saline intrusion due to sea level rise. As part of this work package, France and the Walloon and Flemish regions entered a trilateral agreement for the monitoring of groundwater levels in 2009 (ScaldWIN 2009). As a result of the strong foundation for cooperation and the increase in technical knowledge about the aquifer, the Scheldt Commission may be on their way to creating a declaration and trilateral agreement on the joint management of the Carboniferous Aquifer (Lefébure 2012).

It is clear that an increased level of cooperation over the Scheldt has been occurring for many years. More recently, adoption of the EU WFD placed a focus on management of groundwater resources within the Scheldt river basin including the Carboniferous Aquifer. As a result of funding acquired through the INTERREG IVB Programme, the riparian countries have increased technical capacity for and monitoring of the aquifer. Further, the advancement of these initiatives has potentially created an opportunity for the aquifer states to create a formalized cooperative mechanism, specifically for the Carboniferous Aquifer.

References:

Contribute to a better quality of surface and groundwater bodies in the Scheldt International River Basin District, 2009. Work Package 3. Available at: <http://www.scaldwin.org/project-NL/stand-van-zaken/wp-3/2009/> [Accessed September 8, 2014].

International Commission for the Protection of the Scheldt, 2005. *Scheldt International River Basin District Roof Report* F. van Sevenscoten, ed..

Lefébure, A., 2012. Challenges And Successes In The Implementation Of The WFD And The Achievement Of The Good Status Objective: Experience From Western Europe: The Case Of The International Scheldt Commission. In *World Water Forum*. Marseille, France.

CHÂTEAUGUAY AQUIFER

| Canada | United States of America |



CHÂTEAUGUAY AQUIFER

| Canada | United States of America |

Canada and the United States have a long history of conflict and cooperation on surface water resources. Since the early 1900's, numerous transboundary cooperative institutions have been established. The Châteauguay aquifer lies within the province of Quebec and the state of New York. It underlies the Châteauguay River (Council of Canadian Academies 2009) and is the only international aquifer within the Great Lakes Basin (Great Lakes Science Advisory Board to the International Joint Commission 2010). Approximately 65% of Canadians living within the aquifer bounds rely on it for drinking water and it is tapped by an estimated 20,000 wells (Nastev et al. n.d.). The accumulation of industrial pollution in the 1970's made the Châteauguay one of the most famous groundwater contamination cases in Canada. Other portions of the aquifer are overlain by land uses including apple farming, peat mining and extraction for water bottling. Groundwater flows from south to north and use on the American side is minimal. Canadians both cause and experience most of the effects of quantity reductions and quality deterioration. Therefore, impacts resulting from these uses are not generally transboundary in nature.

Level of Cooperation
3
Catalyst for Cooperation
Reduction in groundwater quantity and quality
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions High Institutional Capacity Previous Water Cooperation Scientific Research Strong Political Will

While concerns regarding the state of the Châteauguay have existed for 40 years, specific measures to study and manage the aquifer in a transboundary context only began in 2003. Increased groundwater use, coupled with regional droughts, have strained the aquifer. This has resulted in several large-scale Canadian initiatives to study the major aquifer units and their properties; create a groundwater budget; as well as assess quality, vulnerability, and sustainability (Nastev et al. n.d.). The United States Geological Survey partnered with the Canadian government to conduct data collection and sharing for the project. To date, this joint research initiative is the only cooperation occurring specifically on the Châteauguay. However, the aquifer is part of the Great Lakes Basin System and there is considerable attention given to the state of groundwater in the Basin at large. Numerous laws and planning instruments have called for increased technical understanding and more rigorous legal instruments for the protection of the Basin's groundwater. Yet, these instruments have only been applied at the state and provincial level and transboundary aspects have not been addressed from a legal perspective.

The incidence of severe contamination in 1969 drew attention to the Châteauguay on the Canadian side. However, international cooperation did not begin until 2003, when potential transboundary impacts were first observed. While these impacts were primarily due to climatic variation and increased utilization in Canada, the partnership of the aquifer states is underlain by a foundation of regional institutional capacity; a long history of bi-national cooperation; multiple legal mechanisms for management at the regional level; and a high-level of political will to manage groundwater. It is clear that Canada and the United States are willing to cooperate at the regional and aquifer level. However, the current conditions in the aquifer do not necessitate a higher level of cooperation given the limited transboundary impacts. Nevertheless, if groundwater usage patterns change in the United States, enhanced cooperation mechanisms may be required.

References:

Council of Canadian Academies, 2009. *Sustainable Management of Groundwater in Canada – Report of the Expert Panel on Groundwater*, Ottawa, Canada.

Great Lakes Science Advisory Board to the International Joint Commission, 2010. *Groundwater in the Great Lakes Basin*, Windsor, Ontario, Canada.

Nastev, M. et al., *Hydrogeology of the Transboundary Sedimentary Rock Aquifers in the Chateauguay River Basin, Canada-United States*.

DANUBE RIVER BASIN AQUIFERS

| Austria | Bosnia & Herzegovina | Bulgaria | Croatia | Czech Republic | Germany | Hungary | Moldova | Montenegro | Romania | Serbia | Slovakia | Slovenia | Ukraine |



DANUBE RIVER BASIN AQUIFERS

| Austria | Bosnia & Herzegovina | Bulgaria | Croatia | Czech Republic | Germany | Hungary | Moldova | Montenegro | Romania | Serbia | Slovakia | Slovenia | Ukraine |

There is a long history of cooperation over the Danube River, dating back to the 1856 Treaty of Paris. Initially, navigation was the focal issue, but over the next 130 years, cooperative mechanisms continued to develop and expand in scope to include other water management issues. In 1991, the Environmental Programme for the Danube River Basin (EPDRB) was created to monitor and assess transboundary impacts as well as develop guidelines for environmental protection. Three years later, as part of forming the Strategic Action Programme for the EPDRB Programme, the Convention on Cooperation for the Protection and Sustainable Use of the Danube River (Danube Convention) was created (ICPDR, n.d.).

The second article of the Danube Convention details the objectives and principles of cooperation for each party. Article 6 requires the identification of groundwater that needs long-term protection or should be placed in a protection zone in order to preserve quality for drinking water. The convention also calls for pollution prevention, especially protection from nitrates and pesticides. The International Commission for the Protection of the Danube River (ICPDR) is integrating the requirements of the European Union Water Framework Directive (EU WFD), into its ongoing initiatives and policies. In particular it is increasing the focus on groundwater in order to align with the EU WFD's Integrated Water Resources Management (IWRM) approach (International Commission for the Protection of the Danube River n.d.). Consequently, a Groundwater Task Group was established in 2002 to facilitate identification of groundwater bodies of basin-wide importance; develop guidelines for their characterization; and collect information on groundwater quality and quantity monitoring, among other tasks (ICPDR 2010).

The Danube Groundwater Task Group identified 11 transboundary groundwater bodies of basin-wide importance. These are defined as being greater than >4,000 km² in size. It is worth noting that the transboundary nature of each groundwater body had to be agreed upon by each country. Therefore, with increased availability of data, more transboundary aquifers might be identified in the future. This could be facilitated by the monitoring requirements, which have been set forth in the European Union Water Framework Directive (EU WFD) and further elaborated by the ICPDR Groundwater Task Group.

Overall, cooperation on transboundary aquifers in the Danube stems primarily from the implementation of the EU WFD. However, within the context of the ICPDR this process has occurred smoothly. A long history of water cooperation, high institutional capacity, and implementation of legal mechanisms were clearly Enabling Factors that facilitated this level of cooperation on the Danube's transboundary groundwater bodies.

Level of Cooperation
4
Catalyst for Cooperation
Implementation of legal mechanisms
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions High Institutional Capacity Previous Water Cooperation

References:

Convention on Cooperation for the Protection and Sustainable use of the Danube River (Danube River Protection Convention), Sophia, Bulgaria: (29 June 1994, entered into force 22 October 1998).

International Commission for the Protection of the Danube River, 2010. *Groundwater Guidance*.

International Commission for the Protection of the Danube River, Groundwater Webpage. Available at: <http://www.icpdr.org/main/issues/groundwater> [Accessed September 8, 2014a].

International Commission for the Protection of the Danube River, Short History of Cooperation Webpage. Available at: <http://www.icpdr.org/main/icpdr/short-history-cooperation> [Accessed September 8, 2014b].

DINARIC KARST AQUIFERS

| Albania | Bosnia & Herzegovina | Croatia | Greece |
| Italy | Macedonia | Montenegro | Serbia | Slovenia |



DINARIC KARST AQUIFERS

| Albania | Bosnia & Herzegovina | Croatia | Greece |
| Italy | Macedonia | Montenegro | Serbia | Slovenia |

After the dissolution of the Socialist Federal Republic of Yugoslavia, the Stability Pact for South Eastern Europe provided a foundation for peace and cooperation in the Southeast Europe (SEE) region. Since that time, the SEE region has been a hot bed of activity for cooperation on water resources. There have been numerous bilateral agreements signed with the intention of managing water resources and hydropower development. Additionally, international organizations including branches of the United Nations and World Bank have sponsored several regional projects.

The Dinaric Karst Aquifers are one of the most important karst aquifer systems in the world. It is the primary source of drinking water for Albania, Bosnia & Herzegovina, Croatia, and Montenegro. Two large aquifer systems are in the Dinaric Karst region. Groundwater in the systems flows either towards the Adriatic Sea or into the Sava River Basin (see page A-41). It is estimated that karstic groundwater flows are the largest source of fresh water entering the Adriatic Sea (Merla 2009). There are several transboundary issues in Dinaric Karst region including: lack of understanding of the resource, need to balance competing uses and demands, lack of harmonized policy, and negative impacts of hydraulic infrastructure (Governments of Albania Bosnia & Herzegovina Croatia and Montenegro n.d.).

Cooperation on transboundary aquifers in the Dinaric Karst region began 1999 when the UNECE began an inventory of transboundary waters. Initial efforts were made to map the karst aquifers in the region and these continued about 10 years later during the UNECE's second assessment. In 2004, UNESCO's Internationally Shared Aquifer Resource Management initiative formally recognized the Dinaric Karst region as a having transboundary aquifer system. For the next four years, country experts and officials conferred and in 2008 endorsed the Dinaric Karst Transboundary Aquifer System (DIKTAS) Project through the Global Environment Facility (GEF). Recipient countries for the project include Albania, Bosnia & Herzegovina, Croatia, and Montenegro and Greece, Italy and Slovenia are non-recipient countries (Governments of Albania Bosnia & Herzegovina Croatia and Montenegro n.d.). The project requires a high level of participation and cooperation from all countries, including a commitment to project development, data exchange, and co-financing.

The DIKTAS project is the first attempt to integrate sustainable management principles into a large, transboundary karstic aquifer system. The project has the objectives of attaining (1) greater scientific knowledge of the aquifer system; (2) equitable and sustainable utilization of the aquifer system; (3) greater protection for groundwater dependent ecosystems; and (4) enhancing long-term public participation (Governments of Albania Bosnia & Herzegovina Croatia and Montenegro 2011). Further, one of the expected outcomes of the project is that the participating countries will reach a political commitment to implement legal, institutional and policy reforms via a multi-country consultative body.

The DIKTAS project exemplifies high-level transboundary cooperation that was enabled by existing regional cooperation on water resources, political will, availability of funding, and third party participation. The project is ongoing, but is laying a foundation for long-term technical and political cooperation that includes sustainable development and stakeholder involvement.

Level of Cooperation
5
Catalyst for Cooperation
Third party investigation
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms Previous Water Cooperation Scientific Research Strong Political Will Third-Party Involvement

References:

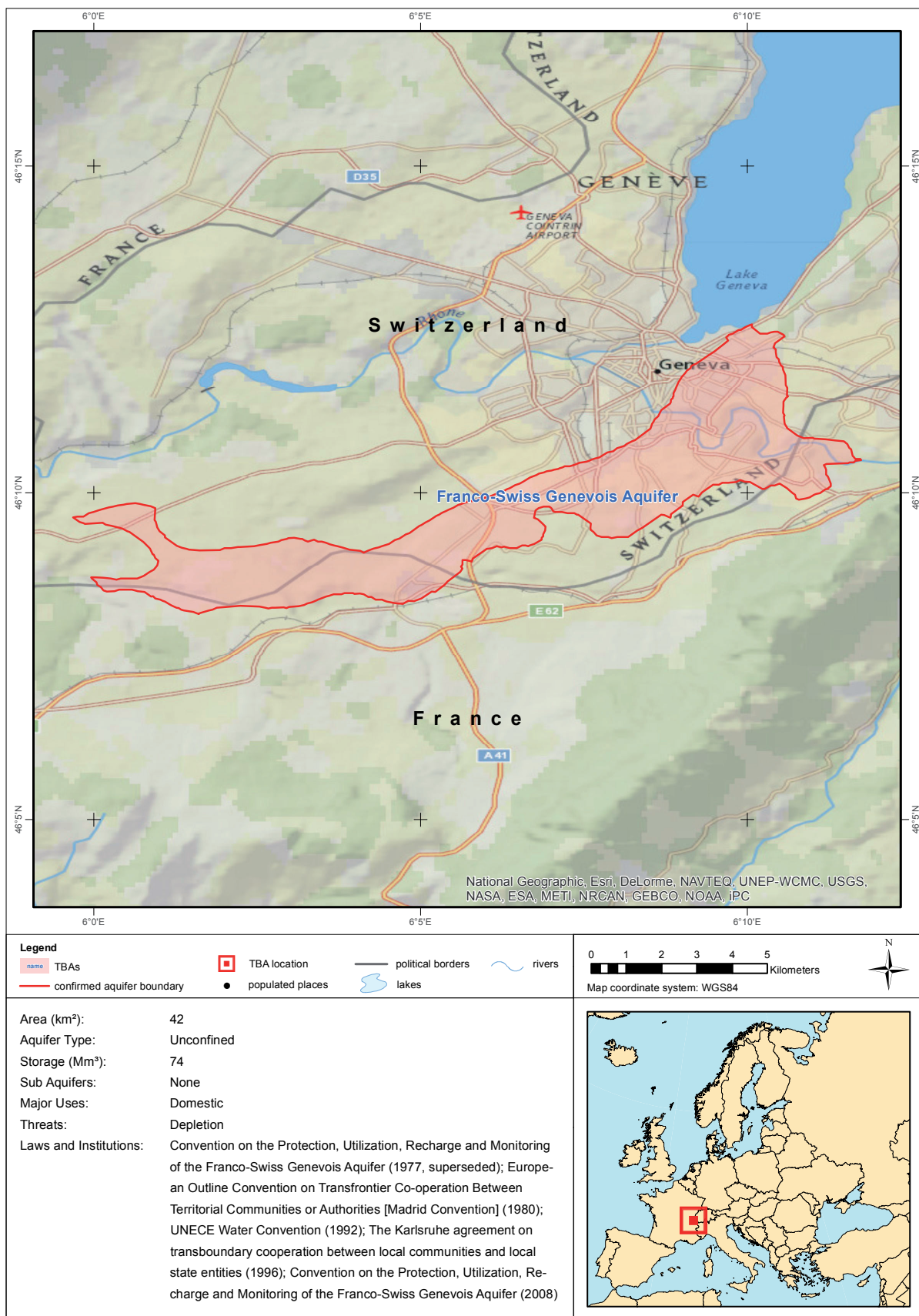
Governments of Albania Bosnia & Herzegovina Croatia and Montenegro, 2011. *DIKTAS Project Inception Report*.

Governments of Albania Bosnia & Herzegovina Croatia and Montenegro, *Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System*.

Merla, A., 2009. GEF-UNDP-UNESCO Protection and Sustainable use of the Dinaric Karst Aquifer System (DIKTAS). In *GEF 5th International Water Conference, Australia*.

FRANCO-SWISS GENEVOIS AQUIFER

| France | Switzerland |



FRANCO-SWISS GENEVOIS AQUIFER

| France | Switzerland |

The Franco-Swiss Genevois Aquifer (Genevois Aquifer) is an unconfined aquifer that is hydrologically linked to the River Arve. Since the 1940's the aquifer has been used as a source of drinking water supply by both aquifer states (Wohlwend 2002). However, both groundwater use and groundwater recharge occur primarily on the Swiss side. The Swiss Canton of Geneva relies on the aquifer for approximately 20% of its water supply (De los Cobos 2010). During the 1960's and 1970's groundwater level in the Genevois Aquifer fell dramatically, due to uncontrolled pumping. Several wells ran dry and were forced to close. These events spurred dialogue between the parties sharing the aquifer, namely the Swiss Canton of Geneva and the French Prefect of Haute-Savoie. Meetings about the aquifer between the French and the Swiss began in 1972. In the next few years there were inventories of pumping patterns and a hydrological characterization of the aquifer was completed. By 1978, the parties has created and ratified the Convention on the Protection, Utilization, Recharge and Monitoring of the Franco-Swiss Genevois Aquifer (Convention) (Community of the "Annemassienne" region et al. 2007).

Level of Cooperation
6
Catalyst for Cooperation
Overexploitation
Enabling Factors
Funding Mechanisms High Institutional Capacity Strong Political Will

The Convention was, and is, unique in that it is the only treaty for a transboundary aquifer, which allocates specific volumes of groundwater to the parties. The originally the French were allocated 2 million cubic meters annually. The 1978 Convention also established a monitoring network and makes provisions for artificial recharge of the Swiss portion of the aquifer. By 1980, an artificial recharge system was established. The system abstracts water from the Arve River, which is the natural source of recharge for the Genevois Aquifer, then subsequently treats it and injects it into the aquifer. Additionally, a Commission was established to propose annual management plans, oversee the artificial recharge system and deal with challenges related to the aquifer as a whole. The committee is composed of an equal number of French and Swiss members and is required to meet at least once per year.

The Convention had a 30-year term and thusly expired in 2008. It was renewed and modified at that time. Changes from the original convention text were designed to bring it into closer alignment with developments in international law. Firstly, the parties to the convention were amended on the French side to be the communities of Annemassienne, the Genevois rural districts and the Rural District of Viry. Secondly, the ownership of the aquifer recharge facility was transferred from a private Swiss water company to independent community authorities. Further, the 2007 Convention stipulates that disputes over interpretation of the articles shall be resolved in accordance with Swiss law.

The creation of the Convention highlights the importance that local action can have on transboundary cooperation. While over extraction was clearly the impetus for cooperation, the small scale upon which the issue was addressed allowed for a sophisticated legal mechanism to be developed. A high-level of political will, institutional capacity as well as availability of funding from the parties also facilitated the creation of the Convention. Further, the renewal of the Convention in 2007 indicates that cooperation will likely continue into the future.

References:

- Community of the "Annemassienne" region et al., 2007. *Convention on the Protection, Utilization, Recharge and Monitoring of the Franco-Swiss Genevois Aquifer*.
- De los Cobos, G., 2010. *The transboundary aquifer of the Geneva region (Switzerland and France): successfully managed for 30 years by the State of Geneva and French border communities*.
- Wohlwend, B., 2002. An Overview Of Groundwater In International Law A Case Study: The Franco-Swiss Genevese Aquifer. In *Harmonization of Diverging Interests in the Use of Shared Water Resources*. Beirut, Lebanon: United Nations Economic and Social Commission for Western Asia in cooperation with the German Technical Cooperation.

GUARANÍ AQUIFER SYSTEM

| Argentina | Brazil | Paraguay | Uruguay |



GUARANÍ AQUIFER SYSTEM

| Argentina | Brazil | Paraguay | Uruguay |

The Guaraní Aquifer System (Sistema Acuífero Guaraní [SAG]) is the second largest known freshwater reservoir in the world. The major threats to the aquifer's sustainability are deterioration of quality and reduction in recharge volumes. Documented groundwater levels in the SAG have been falling since the 1970's. However, the areas of the aquifer susceptible to these problems are localized to specific "hot spots" in each of the aquifer states (Foster et al. 2006). Consequently, most of the management and protection needs for the SAG are not transboundary in character, with the exception of managing the quantity of groundwater used for irrigation (Foster et al. 2006). Several institutions and regional laws for water resources have promoted a high-level of communication and cooperation among the SAG states for over 60 years. These institutions include the Organization of American States (OAS) and the Common Market of the South (MERCOSUR), which have focused on a range of political, economic, environmental and humanitarian issues.

Cooperation on the SAG began in the 1990's when scientists from academic institutions in the SAG states began studying the aquifer collaboratively. It was these scientists who realized that the SAG is, in fact, a single aquifer system rather than three separate aquifers as previously thought. Shortly thereafter, the International Development Research Centre sponsored the first joint technical project on the SAG, for the purpose of establishing legal instruments and joint management measures for the aquifer. Then, the Global Environmental Facility (GEF) sponsored the Guaraní Aquifer System Project between 2003 and 2009. The OAS implemented the project and significantly increased understanding about the SAG. It also improved trust between the key stakeholders (Villar & Ribeiro 2011). Also in 2004, MERCOSUR created a "Guaraní Aquifer High Level Group" which was tasked to draft an agreement for the management of the SAG (Sindico 2011). This flurry of activity seemingly created a climate ripe for the development of an international management agreement.

The tipping point for creating a final agreement appears to be the creation of the International Law Commission's Draft Articles on the Law of Transboundary Aquifers, because shortly thereafter the Guaraní Aquifer Agreement was finalized and ratified. The Agreement is now one of the only two treaties created for the holistic management of a transboundary aquifer. The Guaraní Aquifer Agreement was ratified by Argentina and Uruguay in 2010 but still awaits ratification from Brazil and Paraguay before it enters into force. It is worth noting that two of the four SAG countries are federations: Brazil and Argentina. Consequently, implementation of the agreement will require improved coordination mechanisms so that state and provincial groundwater management activities occur in accordance with the agreement. Also potentially conflicting management regimes such as groundwater and overlying land uses will have to be reconciled at the state and municipal levels (L. Amore, personal communication).

As demonstrated above, prior to the creation of the Agreement, there were a several regional institutions active in the area of water management. Additionally, there were multiple levels of cooperation occurring on various topics of regional importance. The increase in technical understanding and availability of funding from the Guaraní Aquifer System Project in combination with the creation of the Draft Articles served as critical influences in the creation of the Agreement. The SAG states are now implementing their Strategic Action Programme (SAP) and entering a new phase of implementation for the Agreement under the 'Programa Marco.' The Programa Marco will ensure the work of the SAP is carried out and will explore the possibility of co-implementation of the agreement with the La Plata River Basin Commission. However, the governments of Brazil and Paraguay must first ratify the Guaraní Aquifer Agreement in order for these processes to begin.

Level of Cooperation
6
Catalyst for Cooperation
New scientific information
Enabling Factors
Existing Regional Institutions Funding Mechanisms High Institutional Capacity Previous Water Cooperation Scientific Research Strong Political Will Third-Party Involvement

References:

- Foster, S. et al., 2006. *The Guaraní Aquifer Initiative for Transboundary Groundwater Management* GW MATE Ca., Washington, D.C.: World Bank.
- Sindico, F., 2011. The Guaraní Aquifer System and the International Law of Transboundary Aquifers. *International Community Law Review*, 13(3), pp.255–272.
- Villar, P.C. & Ribeiro, W.C., 2011. The Agreement on the Guaraní Aquifer: a new paradigm for transboundary groundwater management? *Water International*, 36(5), pp.646–660.

HISPANIOLA ISLAND AQUIFERS

| Dominican Republic | Haiti |



HISPANIOLA ISLAND AQUIFERS

| Dominican Republic | Haiti |

While the Dominican Republic and Haiti share Hispaniola Island, each country is faced with different sets of challenges and priorities, especially with respect to the environment and water resources management. The Dominican Republic and Haiti present a stark contrast due to disparate economic and political climates within a close geographic context. Both countries have struggled to introduce democratic systems over the last 50 years, with Haiti continually plagued by riots, coups, and other forms of civil unrest. The Dominican Republic is ranked 98th on the 2011 Human Development Index, while Haiti is ranked significantly lower as number 158. Haiti lost 44% of its land cover between 1990 and 2000 (United Nations Environment Programme 2009). Consequently, there is concern that these differences could create tensions between the countries since transboundary resources are negatively impacted by development on both sides of the border.

Level of Cooperation
2
Catalyst for Cooperation
Initiative of regional institution
Enabling Factors
Existing Regional Institutions Funding Mechanisms Previous Water Cooperation Scientific Research Third-Party Involvement

Regional cooperative forums have existed in the Americas for over 100 years and became institutionalized with the Organization of American States (OAS), which was originally designed to promote commercial integration, peaceful political relations, and to establish specialized regional institutions. Water cooperation began between the two countries in 1929, when they signed the Treaty of Peace, Friendship, and Arbitration. Article 10 of the treaty restricts construction of works that may affect the flow of international rivers and states that the countries have the right to utilize international waters in a fair and equitable manner (United Nations International Law Commission 1978). Beginning in the early 2000's, the countries became part of several cooperative initiatives in the Caribbean Region in conjunction with OAS, the Global Environment Facility (GEF), and United Nations Environment Programme (UNEP). Generally, the initiatives focus on poverty alleviation and sustainable development for small island developing nations. However, there are two GEF projects focused specifically on international waters.

ISARM Americas identified four transboundary aquifers on the island of Hispaniola: the Artibonito, Masacre, Los Lagos and Perdenales Aquifers. In 2004, the OAS decided to make the Artibonito and Masacre aquifers priority cases for project implementation. As a result of the projects, the countries established the goal of "sustainably managing the aquifers in the intermountain and coastal regions of Hispaniola with a view to reducing land degradation, excess erosion-sedimentation, and poverty" (Organization of American States n.d.). Approximately one year later, the Haitian and Dominican governments, with the support of the OAS and UNEP, submitted a request for a GEF Medium Sized Project titled Reducing Conflicting Water Uses in the Artibonite River Basin through Development and Adoption of a Multi-focal Area Strategic Action Programme. During the preparatory work for the GEF project, the participants determined that a framework for the management of water resources should be developed in order to create sustained environmental and economic benefits for both countries. The identification of additional water resources for improved water security as well as poverty reduction were also cited as objectives of cooperation.

As of yet there is no institutionalized mechanism for cooperation over groundwater resources on Hispaniola Island. However, there is clear intention to develop such mechanisms within the context of ongoing development projects. Previous cooperation on water resources had a notable impact on the willingness of the countries to focus on groundwater. The influence of regional organizations and third-party involvement are also clear factors enabling an increased level of cooperation over the island's transboundary aquifers.

References:

Organization of American States, OAS in Haiti. Available at: [http://www.oas.org/fpdb/natoff/docs/OAS work in Haiti - with Foncier Haiti.doc](http://www.oas.org/fpdb/natoff/docs/OAS%20work%20in%20Haiti%20-%20Foncier%20Haiti.doc) [Accessed September 8, 2014].

United Nations Environment Programme, 2009. From Conflict to Peace Building – *The Role of Natural Resources and the Environment*, Nairobi, Kenya.

United Nations International Law Commission, 1978. Legal problems relating to the utilization and use of international rivers - Report by the Secretary-General. *Yearbook of the International Law Commission*, II(2), p.88.

KILIMANJARO AQUIFER SYSTEM

| Kenya | Tanzania |



KILIMANJARO AQUIFER SYSTEM

| Kenya | Tanzania |

Cooperation between Kenya and Tanzania dates back to 1927 with the creation of a customs agreement between the two countries and Uganda. Since, then numerous cooperative mechanisms have been established between the three countries for a range of issues. Currently the East African Community (EAC) is the primary regional cooperative mechanism. A main focal area of the EAC is managing shared natural resources (East African Community 2014). Interaction about transboundary natural resources between Kenya and Tanzania has been ongoing for a number of years. A large portion of this dialogue has concerned the state of shared water resources, particularly as it is connected to biodiversity and wetlands. The aquifer states interact within the context of the Lake Victoria Basin Commission and are both party to the EAC's Protocol on Environment and Natural Resources Management.

The Kilimanjaro aquifer system underlies three river basins: the Pangani and Athi River Basins and the Lake Amboseli Internal Drainage Basin. The aquifer system also contributes base flows to Lake Jipe and Lake Chala. These basins are highly important water supply sources for both aquifer states. However, the available surface water resources are almost completely allocated (possibly over-allocated in the Pangani River Basin), making the Kilimanjaro Aquifer System a resource of great importance. Currently extraction for the aquifer is low and occurs primarily on the Tanzanian side, in the Pangani River Basin. Unfortunately, the physical characteristics of the aquifer are not well understood. There are no studies that confirm the extent and hydrogeological characteristics of the aquifer as a whole (Grossmann 2008). However, monitoring and data collection is ongoing in the section of the aquifer underlying the Pangani River Basin, where there is significant potential for groundwater resources development. Kenya also hopes to use the water contained in Lake Chala (which is completely fed by groundwater) to develop and expand its agricultural industry. These plans were cited as a source of controversy in 2006 (Ihucha 2006).

Historical use of groundwater resources in Kenya, dating back to 1931 has caused the rapid drying of Lake Jipe. There are now efforts to address this issue with the overall goal of recharging the lake. The ongoing dialogue about the management of Lake Jipe also brought about broader cooperation and coordination for the developments on Lake Jipe and continues within several forums, one of which is the 'Greater Pangani Basin Cross-Border Dialogue' initiative (German Technical Cooperation Agency 2005). The multi-stakeholder initiative is supported by PAMOJA Kilimanjaro Joint Action Project, International Network of Environment Water Centres (INWeb), German Agency for International Cooperation (GIZ), and International Union for Conservation of Nature (IUCN). One of the purposes of the initiative is to develop an integrated management plan for Lake Jipe, Lake Chala and the Uмба River and to address groundwater recharge issues in the basin at large (East African Community 2014).

While cooperation over the groundwater resources of the Kilimanjaro Aquifer System is in its infancy, there are indications that it will increase in the coming years. This will occur in response to the stresses being posed on the region's surface water resources and the reduction surface water availability caused by deforestation on Mt. Kilimanjaro. To date, the major factors enabling cooperation include previous water cooperation, existing regional institutions, and third-party involvement. Given the need for technical data on the aquifer, both for the purposes of conservation and development, it would be likely that scientific research will play a role in the near future.

Level of Cooperation
2
Catalyst for Cooperation
Loss of surface water availability
Enabling Factors
Existing Regional Institutions Funding Mechanisms Previous Water Cooperation Third-Party Involvement

References:

- East African Community, 2014. History of the EAC. Available at: http://www.eac.int/index.php?option=com_content&view=article&id=44&Itemid=54 [Accessed September 8, 2014].
- German Technical Cooperation Agency, 2005. *GTZ Wildlife Programme Tanzania Brochure*.
- Grossmann, M., 2008. The Kilimanjaro Aquifer - A case study for the research project "Transboundary groundwater management in Africa." In W. Scheumann & E. Herrfahrdt-Pähle, eds. *Conceptualizing Cooperation on Africa's Transboundary Groundwater Resources*. Bonn, Germany: German Development Institute.
- Ihucha, A., 2006. Tanzania, Kenya in row over Lake Chala waters. *Guardian*.

LAKE CHAD AQUIFER SYSTEMS

| Camaroon | Central African Republic | Chad | Niger | Nigeria |



LAKE CHAD AQUIFER SYSTEMS

| Camaroon | Central African Republic | Chad | Niger | Nigeria |

Lake Chad is the African continent's fourth largest lake and is located in the Sahel region. There is a long institutional history surrounding water resources management in the Sahara/Sahel region. In 1964, Fort Lamy Convention was signed and formed the Lake Chad Commission (the Commission), whose purpose is to manage issues related to the lake's degradation. Initially, the Commission only included four of the six states sharing the lake and its underlying aquifer: Cameroon, Chad, Niger and Nigeria; then the Central African Republic joined in 1994 and Sudan joined in 2000. In addition to the Fort Lamy Convention, there are two bilateral agreements between pairs of the aquifer states, both of which address groundwater issues. These are the 'Mondou Agreement' between Chad and Cameroon and an agreement brokered by the Niger-Nigeria Joint Commission (Adelana 2004).

Groundwater is the main source of drinking water in the Lake Chad Basin. Over the past 40 years, Lake Chad has experienced significant declines in water levels due to a combination of drought, desertification and poor management (Adelana 2004). Problems were particularly grave in the 1980's when a massive drought hit the region and over 500 boreholes were drilled to serve basic human needs (Adelana 2004). Given that the lake also supports local fishing and agricultural practices, the result has been an increase in poverty, malnutrition and out-migration from the area (Ngatcha 2009). By 2010, much of Lake Chad was declared a protected wetland under the Ramsar Convention, which underscores the significance of groundwater to the regional ecosystems and livelihoods of the people.

Investigations related to groundwater in the Lake Chad basin began 45 years ago with the Commission and various partners, including the French and German governments as well as the Global Environmental Facility (GEF). These projects have completed a range of activities including a survey of groundwater resources in the basin as well as monitoring and management support (Adamu 2007). A major project in the basin was the GEF/UNDP/UNOPS Project 'Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem' (GEF Project), which was implemented between 2003 and 2006. Major outcomes of the project were enhanced regional policy initiatives; increased stakeholder engagement; a complete diagnostic of transboundary issues; a 'synthetic' management framework; and the creation of regional programs and initiatives. Further, the GEF Project highlighted a lack of knowledge about the aquifer system and the need for capacity building on groundwater resources (Governments of Cameroon, Central African Republic, Chad, Niger, and Nigeria 2008). As a result, the aquifer states are taking increased action to improve groundwater management.

In recent years, some of the aquifer states have implemented national level legislation regarding management and protection of groundwater resources. The Lake Chad Basin Commission is also implementing the Strategic Action Programme (SAP), as a continuance of the GEF Project. Target 2 of the SAP is to develop and implement groundwater management strategies. SAP implementation is planned over a 15-year time frame (Governments of Cameroon, Central African Republic, Chad, Niger, and Nigeria 2008).

The case of the Lake Chad Aquifer Systems demonstrates that much effort can be required to move transboundary water management initiatives forward. While there is a long history of formal cooperation on Lake Chad, third-party influences and funding were critical to progress. With enhanced financial and institutional capacity it appears the Commission is now focusing on transboundary aquifer management more directly.

Level of Cooperation
4
Catalyst for Cooperation
Rapid environmental change
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms Previous Water Cooperation Third-Party Involvement

References:

Adamu, M.S., 2007. *Groundwater as part of the Work of the Lake Chad River Basin Commission*.

Adelana, S., 2004. Groundwater resources and environmental management in Niger Basin Authority and Lake Chad Basin Commission agreements. In *International Conference: Network of International Commissions and transboundary basin organizations and African network of basin organizations*. Dakar, Senegal.

Governments of Cameroon Central African Republic Chad Niger and Nigeria, 2008. *Strategic Action Programme for the Lake Chad Basin*.

Ngatcha, B.N., 2009. Water Resources Protection in the Lake Chad Basin in the Changing Environment. *European Water*, 25(26), pp.3-12.

MEKONG RIVER PLAIN AQUIFERS

| Cambodia | China | Laos | Myanmar | Thailand | Vietnam |



MEKONG RIVER PLAIN AQUIFERS

| Cambodia | China | Laos | Myanmar | Thailand | Vietnam |

Cooperation in the Mekong River Plain dates back to the 1950's when the United Nations formed the Mekong Committee as part of a major development project. At the time, hundreds of hydrologic surveys were conducted along the river for a preliminary assessment of its characteristics. In 1995, international cooperation was solidified when the Mekong Agreement (the Agreement) was signed. As a result, the UN's Mekong Committee was transformed into an independent management institution, the Mekong River Commission (MRC). The intension of the Agreement was to shift the focus from development of large-scale projects to that of sustainable development and natural resources management. It should be noted that China and Myanmar are not part of the MRC, even though, hydrologically, they are basin/aquifer states. China and Myanmar are however 'dialogue partners' and observe MRC activities (Mekong River Commission for Sustainable Development 2010).

Level of Cooperation
2
Catalyst for Cooperation
Third-party initiative
Enabling Factors
Existing Regional Institutions Previous Water Cooperation Third-Party Involvement

In the Mekong River Basin, there are four, major transboundary aquifers. The primary uses of the groundwater are for drinking water supply (both urban and rural), irrigation and industry. Uses are highest in Cambodia, Thailand and Vietnam. In the Mekong River Delta Aquifer, there has been a documented decline in groundwater levels and groundwater quality over the last 30 years (International Union for Conservation of Nature 2011). Other aquifers within the basin are facing challenges of over extraction and contamination by agriculturalists (Foster 2008; International Union for Conservation of Nature 2011). However, these problems are generally local and consequently have not received much attention from the MRC. The exceptions are two projects conducted in the late 1990's - a groundwater monitoring project completed in partnership with Sweden and a groundwater modeling project completed in partnership with the Netherlands (Radosevich & Olson 2009).

Groundwater has not been a focus of the MRC's work until recently. In 2009, there was an informal meeting of organizations working in the lower Mekong Delta regarding increasing cooperation and capacity on groundwater resources (International Union for Conservation of Nature 2009). In 2011, the MRC completed drought management studies and groundwater monitoring as part of establishing a basin-wide monitoring network. They also developed a groundwater concept note. In late 2012, the MRC planned to conduct a rapid appraisal of agricultural groundwater use (Mekong River Commission for Sustainable Development 2012).

While cooperation for the Mekong River Basin Aquifers remains tangential to the other foci of cooperation in the region, attention towards the issue is growing. Lack of data and low institutional capacity in groundwater management are cited as major barriers to increased cooperation. However, concerns about climate change adaptation and growing interest in conjunctive use schemes are bringing more attention to groundwater. Thus far, cooperation on groundwater resources has been driven by the long history of regional water cooperation, the work of the MRC, and partnerships with third-party institutions. Nevertheless, current planning indicates that groundwater may receive more attention from the aquifer states in the near future.

References:

- Foster, S., 2008. Thailand: *Strengthening Capacity in Groundwater Resources Management* GW Mate Ca., Washington, D.C.: World Bank.
- International Union for Conservation of Nature, 2011. *Groundwater in the Mekong Delta*.
- International Union for Conservation of Nature, 2009. *Information on Groundwater Issues Lacking on the Lower Mekong Basin*.
- Mekong River Commission for Sustainable Development, 2010. *15 Years of Cooperation for Sustainable Development 1995-2010*.
- Mekong River Commission for Sustainable Development, 2012. *MRC Work Programme 2012*.
- Radosevich, G.E. & Olson, D.C., 2009. Existing And Emerging Basin Arrangements In Asia: Mekong River Commission Case Study. In *Third Workshop on River Basin Institution Development*. Washington, D.C.: World Bank.

MURA-ZALA BASIN AQUIFER

| Hungary | Slovenia |



MURA-ZALA BASIN AQUIFER

| Hungary | Slovenia |

Central European states have been cooperating about water resources for over 150 years, starting with the 1856 Treaty of Paris. Since then, numerous, regional and sub-regional agreements and projects have enhanced political and economic cooperation as well as cooperative management of water resources. More recently, with the formalization of the International Commission for the Protection of the Danube River (ICPDR) and the implementation of the European Water Framework Directive (EU WFD), more attention has been given to the benefits of jointly managing groundwater. Hungary and Slovenia established the Permanent Bilateral Slovenian – Hungarian Water Management Commission in 1995 as part of the Agreement between Hungary and Slovakia on Water Management. Although Hungary made a number of formal cooperative agreements with other Danube states dating back several decades, this was the first bilateral agreement between the two countries

Level of Cooperation
4
Catalyst for Cooperation
Contamination of drinking water supply
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms High Institutional Capacity Previous Water Cooperation

The Mura-Zala Groundwater Body underlies Hungary and Slovenia. The groundwater body consists of three stratigraphic layers, the deepest of which yields groundwater warm enough to generate thermal energy. The direct uses for the Mura-Zala Groundwater Body are residential and commercial heating, air conditioning, heating greenhouses and balneology (Nádor & Lapanje 2010). While individual and small scale uses of the aquifer have been ongoing for more than 100 years, it was only within the last five years that efforts were made to upscale uses for geothermal energy in the region. This change was motivated by the implementation of the integrated climate change and energy policy (i.e. the Renewable Energy Roadmap) and the European Union Directive on renewable energy. These policies spurred Austria, Hungary, Slovakia and Slovenia to consider co-managing their underlying thermal groundwater resources (Transenergy n.d.; European Commission 2007) and to begin two projects: a project specifically for the Mura-Zala basin and sub-regional project called “Transenergy” (Transenergy n.d.)

While cooperation over shared water resources had begun nearly a decade before, cooperation for the Mura-Zala only began with the delineation of groundwater bodies under the EU Water Framework Directive. In 2009, as a result of EU Directive on renewable energy, the “Thermal Joint Aquifer Management: Screening of geothermal utilization, evaluation of thermal groundwater bodies and preparation of joint aquifer management plan in the Mura- Zala basin” project (T-JAM) began. The purpose of T-JAM was to identify and delineate the transboundary groundwater body and determine potential the risks and advantages of exploiting its geothermal potential. T-JAM was initiated under the Slovenia-Hungary Cross-Border Operational Programme 2007-2013 (European Commission 2008). At the time the project began, the Mura-Zala had not been officially delineated and there were no common resource management practices between the countries (Nádor & Lapanje 2010).

As a result of the project, a common but unofficial delineation for the groundwater body was agreed upon. Further, existing data collected from nearly 1,200 boreholes in both countries were aggregated into a private database and used to model its geothermal capabilities. The most representative data gathered from the boreholes was then made publicly available (T-JAM Project n.d.). It was found that a majority of thermal water use occurs in Hungary (Prestor et al. 2011). As part of the project, the countries also generated a report on “Cross-border management recommendations,” which were specifically tailored for the Permanent Bilateral Slovenian – Hungarian Water Management Commission. In particular, the recommendations addressed potential for increased demands due to agriculture and tourism. They also recommended methods for information exchange and establishing a common monitoring system (Prestor et al. 2011). Overall, cooperation in the Mura-Zala groundwater body is just beginning but is likely to continue due to increased demands on the transboundary resource.

References:

- European Commission, 2007. *Renewable Energy Roadmap*, Brussels, Belgium.
- European Commission, 2008. *Slovenia-Hungary Cross-border Operational Program*.
- Nádor, A. & Lapanje, A., 2010. Transboundary geothermal resources of the Mura-Zala basin. *Eur Geol*, 29, pp.24–27.
- Prestor, J. et al., 2011. *Cross-border management recommendations*, Ljubljana, Slovenia and Budapest, Hungary: T-JAM Project.
- T-JAM Project, *Introduction and brief summary of available reports*.
- Transenergy, Transenergy – Transboundary Geothermal Energy Resources of Slovenia, Austria, Hungary and Slovakia Web Page. Available at: <http://transenergy-eu.geologie.ac.at/> [Accessed September 8, 2014].

NORTHWEST SAHARA AQUIFER SYSTEM

| Algeria | Libya | Tunisia |



NORTHWEST SAHARA AQUIFER SYSTEM

| Algeria | Libya | Tunisia |

The implementation of various scientific projects on the Northwestern Sahara Aquifer System (in French referred to as the Système Aquifère du Sahara Septentrional [SASS]) pre-dated any political interactions regarding groundwater. Prior to 1980, there was very little development of the SASS Aquifer. Nevertheless, between 1968 and 1971, UNESCO in conjunction with Algeria and Tunisia, began a modeling project for the SASS (Sahara Sahel Observatory 2008). In 1982, Algeria and Tunisia began pumping groundwater heavily (Governments of Tunisia Algeria & Libya n.d.). Consequently, the project was continued from 1982-1983 with funding from the United Nations Development Programme (UNDP). Simultaneously, Libya had generated two of its own groundwater models for the SASS. Over the next two decades, bilateral cooperative initiatives were established between the aquifer states. However, it was not until 1998 that all three were cooperating over the SASS (Sahara Sahel Observatory 2008).

Level of Cooperation
4
Catalyst for Cooperation
Third-party investigation
Enabling Factors
Existing Regional Institutions Funding Mechanisms Strong Political Will Third-Party Involvement

Beginning in 1998, the SASS was the subject of a three-phase project aimed at increasing the scientific understanding and management capacity for the aquifer system. In the first phase of the project, the Observatoire du Sahara et du Sahel (Sahara and Sahel Observatory - OSS) obtained funding from the Swiss Agency for Development and Cooperation (SDC), the International Fund for Agricultural Development, and the Food and Agriculture Organization. This phase was completed in 2002 and focused on understanding the hydrogeology of the aquifer, establishing an information system, generating a mathematical module, and creating a consultative mechanism for the aquifer states. The second phase of the project ran from 2003 to 2006 and the Global Environment Facility (GEF), SDC, and the French Global Environment Facility (FGEF) provided funding. In addition to expanding the work completed in Phase I, the focus for Phase II was enhancing cooperation and pursuing an institutionalized consultative mechanism. Phase III of the project is focused on improving understanding of the socio-economic and environmental aspects of developing the SASS. In this phase, GEF and FGEF continue to provide funding along with the African Water Facility (Sahara Sahel Observatory 2008).

The major project outcome, with respect to cooperation between the aquifer states, was the establishment of the SASS consultative structure. A preliminary consultative mechanism was negotiated by the three countries in 2002. It included a Steering Committee, a Coordination Committee, and an Ad Hoc Scientific Committee. The aquifer states, with the support of the OSS, developed the permanent Mechanism for Concerted Action over the next 5 years. In 2007, SASS coordination unit was established and funded equally by all three aquifer states (Sahara Sahel Observatory 2008). At the conclusion of the Phase III of the GEF Project a Strategic Action Programme (SAP) for the SASS was established for the continued monitoring, modeling and management of the aquifer system.

For nearly 45 years, the individual aquifer states of the SASS have been collaborating with each other, as well as with various international institutions, to improve scientific understanding of the aquifer. As knowledge increased, so did development of the aquifer. However, it seems the countries strived to have management practices keep pace with groundwater use. The combination of strong political will, access to funding, and support from regional institutions facilitated the creation of the Mechanism for Concerted Action. Through the execution of the SAP, it appears that cooperation over the SASS will continue to grow.

References:

Governments of Tunisia Algeria & Libya, *Protection of the North West Sahara Aquifer and related humid zones Project Brief*.

Sahara Sahel Observatory, 2008. *The North-western Sahara Aquifer System – Concerted Management of a Transboundary Water Basin Synthesis*.

NUBIAN SANDSTONE AQUIFER SYSTEM

| Chad | Egypt | Libya | Sudan |



NUBIAN SANDSTONE AQUIFER SYSTEM

| Chad | Egypt | Libya | Sudan |

The Nubian Sandstone Aquifer System (NSAS) is the largest known freshwater reservoir in the world. The NSAS is also a non-recharging aquifer system and considered a non-renewable resource (International Atomic Energy Agency 2010). Two of the aquifer states, Egypt and Sudan, are part of the Nile River Basin. Consequently, these countries have a long history of interaction about transboundary water resources management. With respect to the Nile this includes a flux between cooperation and conflict. However, for the NSAS, a spirit of cooperation prevails.

The International Fund for Agriculture Development began initiatives and baseline management activities for the NSAS under the auspices of the Centre for Environment and Development for the Arab Region and Europe (CEDARE) in the 1970's. These activities stemmed from Egypt's desire to understand the potential impacts of the Libya's Great Man Made River Project, which would pump up to 6,500,000 m³ of groundwater from the aquifer and convey it to major Libyan cities. Additionally, these activities spurred consultation between Egypt and Libya about forming a joint management authority for the NSAS. In 1992, the Joint Authority for the Study of the Development of the Nubian Sandstone Aquifer Waters (Joint Authority) was formalized in a constitution between Egypt and Libya (International Atomic Energy Agency 2012). In 1996 Sudan signed the constitution, followed by Chad in 1999. Then in 2000, the aquifer states became party to the Programme for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System (Republic of Chad et al. 2000). The Programme consists of two legally binding agreements concerning the NSAS: one for the monitoring and exchange of groundwater information and the other for monitoring and data sharing.

Subsequently, the Joint Authority facilitated a number of initiatives and partnerships with regional and international institutions; contributed significantly to the technical knowledge of the NSAS; and assessed how governance of the aquifer interacts with political, economic, environmental and humanitarian issues in the region. The International Atomic Energy Agency/United Nations Development Programme/Global Environmental Facility Medium Sized Project titled The Regional Formulation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer was critical to increasing the level of cooperation on the aquifer. The objective of the project was to develop a framework for the sustainable management and use of the Nubian Sandstone Aquifer System (International Atomic Energy Agency 2010). A major outcome was the negotiation of the 2012 Regional Strategic Action Program for the NSAS (SAP). The SAP provides guidance regarding future actions and legal agreements for the management of the NSAS (International Atomic Energy Agency 2012).

In total, there are three active and binding legal agreements for the NSAS - the 1992 Constitution of the Joint Authority and the two agreements that compose the Programme for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System. However, the level to which these agreements are being implemented is debatable. Capacity of regional institutions as well as country governments, third-party intervention, scientific knowledge and available funding were clear factors that lead to a high level of cooperation. There is still opportunity for the aquifer states to increase their level of cooperation given that none of the legal agreements constitute a holistic management mechanism for the NSAS. Nevertheless, they form a strong foundation for any future management agreement, which may developed as part of planned projects under the SAP.

Level of Cooperation
6
Catalyst for Cooperation
Third-party involvement
Enabling Factors
Existing Regional Institutions Funding Mechanisms Scientific Research Third-Party Involvement

References:

- International Atomic Energy Agency, 2010. *Draft Regional Shared Aquifer Diagnostic Analysis for The Nubian Sandstone Aquifer System*.
- International Atomic Energy Agency, 2012. *Regional Strategic Action Program for the Nubian Sandstone Aquifer System*.
- Republic of Chad et al., 2000. *Programme for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System – Terms of Reference for the Monitoring and Exchange of Groundwater Information of the Nubian Sandstone Aquifer System*.

ORANGE-SENQU RIVER BASIN AQUIFERS

INCLUDING THE STAMPRIET-SOUTHEASTERN KALAHARI KAROO AQUIFER SYSTEM

| Botswana | Namibia | South Africa |



ORANGE-SENQU RIVER BASIN AQUIFERS

INCLUDING THE STAMPRIET-SOUTHEASTERN KALAHARI KAROO AQUIFER SYSTEM

| Botswana | Namibia | South Africa |

Formal cooperation in the Southern Africa region dates back to 1980, when the Southern African Development Coordination Conference (SADCC) was established. The purpose of SADCC was to foster national political liberation in the region and reduce dependence on the South African apartheid regime. In 1992, after several years of consultation, the SADCC became the Southern Africa Development Community (SADC) (Southern African Development Community n.d.). Cooperation for the management of water resources in Southern Africa also dates back to the late 1980's. At that time, Botswana was independent but Namibia was still under colonial rule and the apartheid regime was present in South Africa. Nevertheless, three bilateral agreements were forged between Namibia and South Africa (two occurred after Namibian independence) (Governments of Botswana, Lesotho, Namibia, and South Africa 2009). Now SADC plays a critical role in regional water resources management. The Revised Protocol on Shared Watercourses in SADC lays the foundation for regional cooperation on water resources. More specifically it emphasized the equitable and reasonable use of water resources and the adaptation of Integrated Water Resources Management (IWRM) principles (Southern African Development Community n.d.).

Level of Cooperation
4
Catalyst for Cooperation
Localized pollution and third-party involvement
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms Previous Water Cooperation Third-Party Involvement

In an effort to have the IWRM model permeate throughout the region, several international River Basin Management Organizations (RBOs) were established, one of which is the Orange-Senqu River Basin Commission (Orange-Senqu RBC). The Stampriet Artesian Basin Aquifer and the Molopo Aquifer are transboundary resources that are hydrologically connected to the surface waters of the basin. However, the attention given to groundwater in the Orange-Senqu RBC is limited to assessment of risks and stress indicators. In certain parts of the catchment, groundwater plays a critical role in reducing stress on surface water resources. Yet, there is only one known instance of transboundary groundwater impacts - industrial contamination in the Molopo aquifer (Governments of Botswana, Lesotho, Namibia, and South Africa 2009). Consequently, the governments of Botswana and South Africa have set up a groundwater monitoring network for the Molopo (Governments of Botswana Lesotho Namibia and South Africa 2009). However, asymmetric groundwater use by Namibia is of growing concern for the Stampriet aquifer states (Alker 2008).

Groundwater began to receive more attention when the Orange-Senqu RBO began a project in conjunction with the Global Environmental Facility (GEF) and United Nations Development Program (UNDP) for the Development and Adoption of a Strategic Action Program for Balancing Water Uses and Sustainable Natural Resource Management. The project began in 2008 and is currently in its second phase. Outcomes specific to groundwater management include a transboundary assessment of groundwater resources and the creation of the Transboundary Aquifer Initiative, which is a task force within the Orange-Senqu RBC. In the next phase of the project, particular attention will be given to groundwater resources as well.

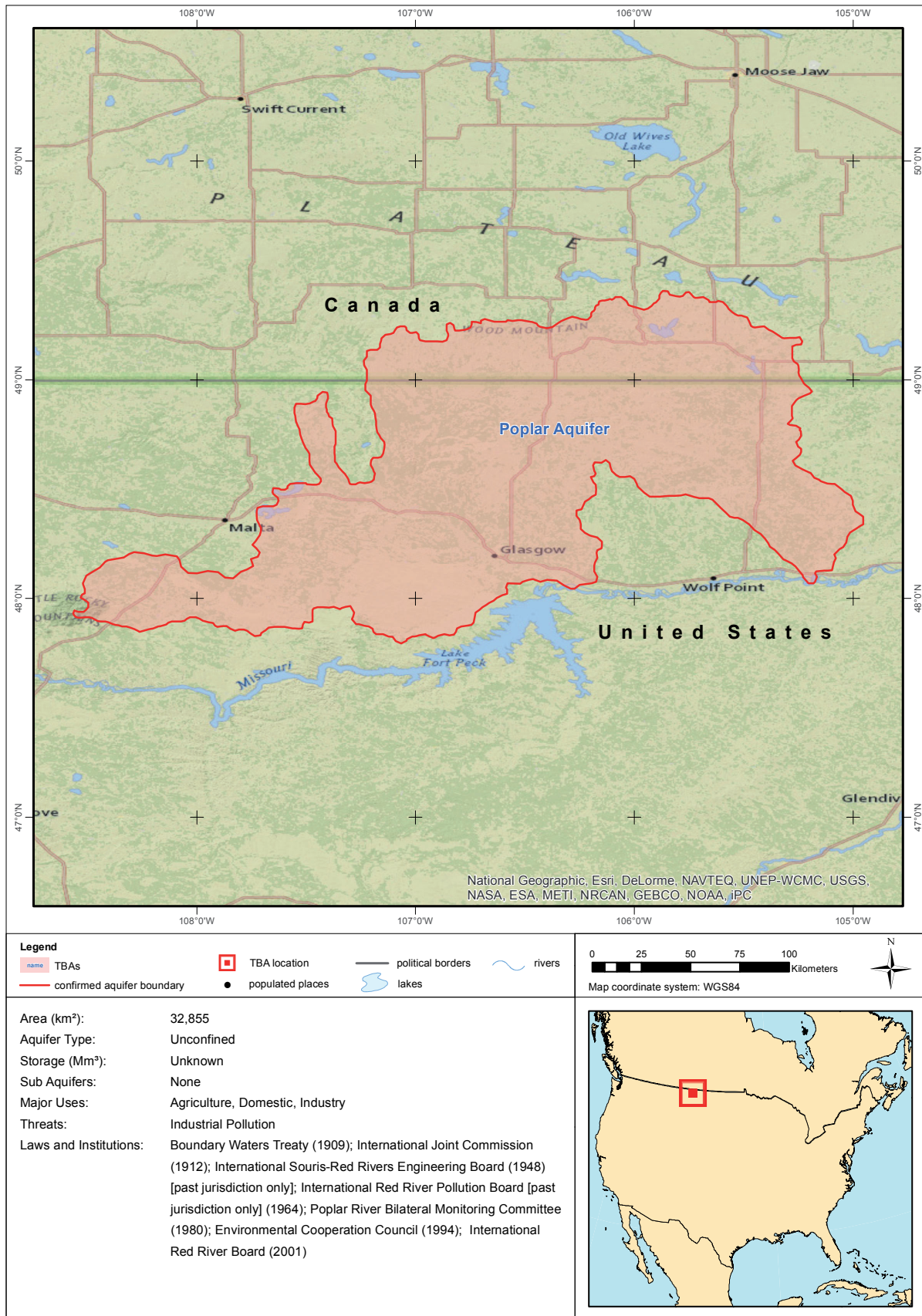
High-capacity regional institutions as well as a history of previous water cooperation were clear Enabling Factors for cooperation on transboundary aquifers in the Orange-Senqu RBO. Though there is not a general threat to groundwater sustainability in the region, implementation of the GEF-UNDP Project was also a clear driver for recently increased cooperation over groundwater resources. Additionally, a project with the Swiss Agency for Development and Cooperation on the Stampriet Aquifer is underway. With the continuance of these projects there is potential for the level of cooperation to increase.

References:

- Alker, M., 2008. The Stampriet Artesian Aquifer Basin A case study for the research project "Transboundary groundwater management in Africa". In W. Scheumann & E. Herrfahrdt-Pähle, eds. *Conceptualizing Cooperation on Africa's Transboundary Groundwater Resources*. Bonn, Germany: German Development Institute.
- Governments of Botswana Lesotho Namibia and South Africa, 2009. *Development and adoption of a Strategic Action Programme for balancing water uses and sustainable natural resource management in the Orange-Senqu River transboundary basin*, United Nations Development Programme.
- Southern African Development Community, History and Treaty. Available at: <http://www.sadc.int/about-sadc/overview/history-and-treaty/> [Accessed September 8, 2014a].
- Southern African Development Community, Water webpage. Available at: <http://www.sadc.int/themes/natural-resources/water/> [Accessed September 8, 2014b].

POPLAR AQUIFER

| Canada | United States of America |



POPLAR AQUIFER

| Canada | United States of America |

The Poplar Aquifer is one of the 17 aquifers shared by Canada and the United States. The aquifer is split between the province of Saskatchewan and the state of Montana. It is hydrologically linked to the Poplar River, which is tributary to the Red River (International Red River Board 2008). There is very little data available regarding the hydrogeological features and extractive uses of the aquifer. However, because of its link to Poplar River it has been subject to various monitoring protocols and data sharing efforts for more than 25 years.

In 1975, the Saskatchewan Power Corporation put forth a proposal for a thermal power station. At that time, Environment Canada and the United States Geological Survey began collecting monthly water quality samples. The International Joint Committee (IJC) instructed the International Souris-Red Rivers Engineering Board to research equitable apportionment alternatives on the East Branch of the River and subsequently recommended an apportionment formula to the Canadian and American governments.

Recommendations for water quality objectives were also put forth (International Red River Board 2008). Shortly thereafter, the Poplar River Bilateral Monitoring Committee was established in 1980. It is composed of government representatives from Canada and the US as well as one civilian from each state. The Committee's mandate includes quality and quantity monitoring for both surface water and groundwater resources as well as air quality data. The Committee has submitted reports on these issues to the Canadian and United States government since 1982.

Despite the Committee's clear mandate to include groundwater resources in the cooperation, there is very little information available about the aquifer as a whole. This particular instance of transboundary cooperation is limited to preventing impacts from the thermal power plant. There was no apparent intension on the part of the IJC to manage the aquifer comprehensively. Given the clear limitations of the cooperation, this is not necessarily a case of holistic transboundary groundwater governance, but one of pollution prevention and control. Nevertheless, the Poplar Aquifer can serve as a good example of how cooperation for surface water can, and should, include groundwater resources.

The Poplar case shows that creation of bi-national law will not necessarily lead to broad cooperation. Although, there was a clear mandate for the International Red River Board to 'prevent and resolve' disputes regarding transboundary aquifers, the scope of actions required to meet this mandate was limited to monitoring at the border and data sharing (International Red River Board 2011). The monitoring and data sharing mandates have been met successfully, thus far. Consequently, the extent transboundary cooperation is actually being scaled back, with monitoring points being removed and the potential sun-setting of the Bilateral Committee (Poplar River Bilateral Monitoring Committee 2010).

Level of Cooperation

4

Catalyst for Cooperation

Infrastructure project

Enabling Factors

Existing Legal Mechanisms
Existing Regional Institutions
High Institutional Capacity
Previous Water Cooperation
Scientific Research

References:

International Red River Board, 2011. Mandate webpage. Available at: http://www.ijc.org/en/_irrb/Mandate [Accessed September 8, 2014].

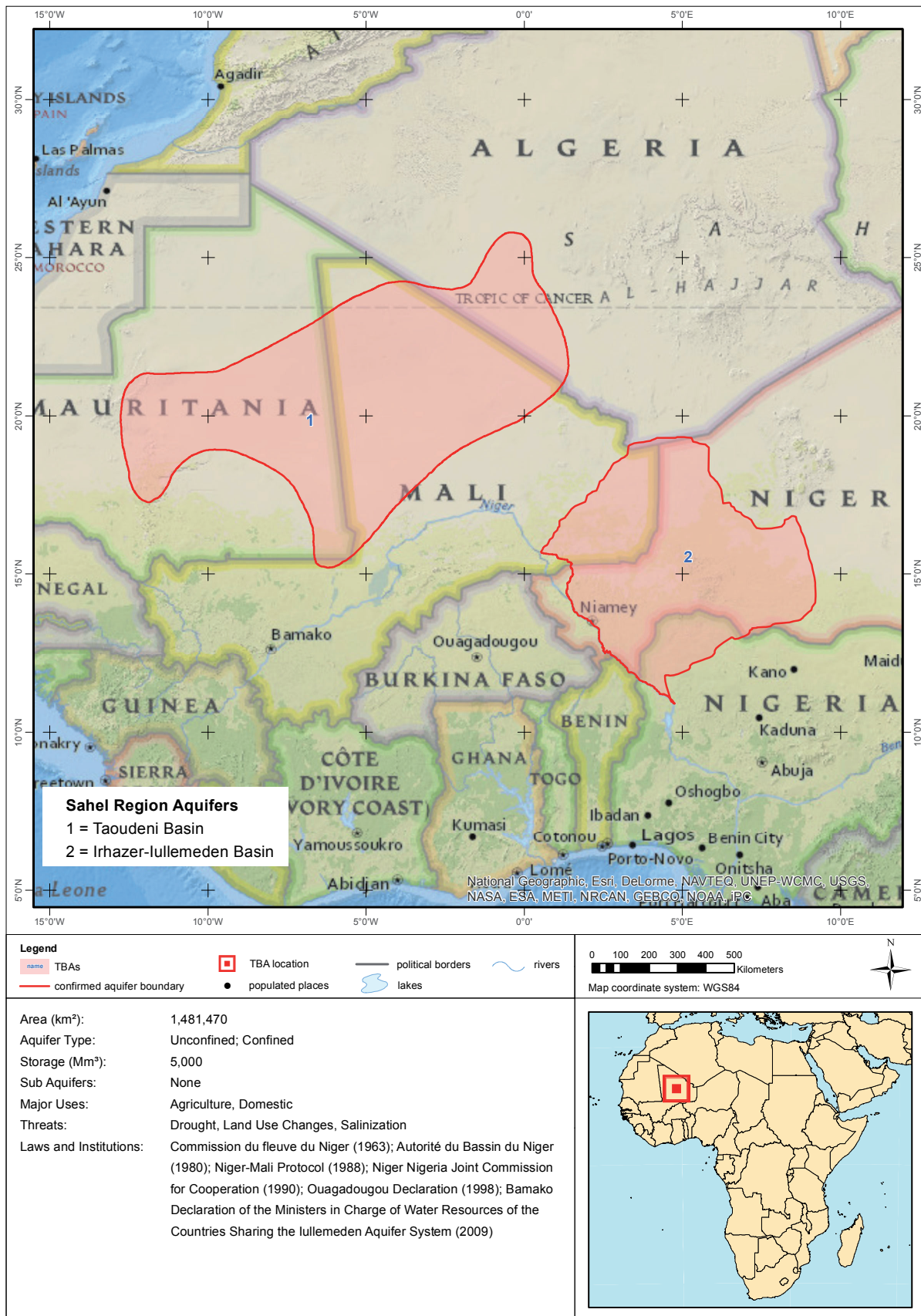
International Red River Board, 2008. *Ninth Annual Progress Report*.

Poplar River Bilateral Monitoring Committee, 2010. *2009 Annual Report to the Governments of Canada, United States, Saskatchewan, and Montana*.

SAHEL REGION AQUIFERS

INCLUDING THE IULLEMEDEN AQUIFER SYSTEM

| Algeria | Benin | Mali | Mauritania | Niger | Nigeria |



SAHEL REGION AQUIFERS

INCLUDING THE IULLEMENDEN AQUIFER SYSTEM

| Algeria | Benin | Mali | Mauritania | Niger | Nigeria |

Bilateral cooperation on water resources in the Sahel region began in the late 1980's. In 1988, Mali and Niger established the Protocol on Cooperation of the Utilization of the Niger River. Then, Niger and Nigeria established a Joint Commission for Cooperation on equitable sharing for development, conservation and utilization of the common water resources in 1990. The Sahel is the highest priority area under the Convention to Combat Desertification and Drought. In 1992, the Observatoire du Sahara et du Sahel (Sahara and Sahel Observatory - OSS) was founded under the auspices of United Nations Education, Scientific and Cultural Organization with the purpose of combatting the effects of desertification and drought in the Sahara and Sahel region. In 2000, OSS became independent of UNESCO. In the meantime, OSS developed a program to facilitate scientific cooperation on aquifers called the 'Aquifers of the Major Basins' Program. Through this program the aquifer states began communicating about transboundary issues facing the Iullemeden.

Between 1992 and 2002, three of the Iullemeden aquifer states adjusted their national water policies to prioritize transboundary cooperation on issues such as land use changes, 'inappropriate and uncontrolled' water uses, reduced precipitation and impacts due to climate change (Governments of Mali Niger and Nigeria 2003). Simultaneously, in 1999, a regional seminar led to future meetings among officials from Mali, Niger, and Nigeria in which they formulated a project proposal for a Global Environmental Facility (GEF) Medium Sized Project. In 2003, three of the aquifer states submitted a proposal to GEF to establish a joint project entitled 'Managing Hydrogeological Risk in the Iullemeden Aquifer System.'

The project was active from 2003-2007 with the objectives of (1) establishing joint mechanisms to identify transboundary risks; (2) establishing mechanisms to formulate management policies; and (3) establishing a legal and institutional cooperative framework. As a result of the GEF project, a common GIS database now aggregates data provided by the aquifer states. The participating countries also produced a Transboundary Diagnostic Analysis and negotiated a Strategic Action Program, increasing technical knowledge about the aquifer and generating a strategy for comprehensive management, respectively. One of the major outcomes included the creation of the Bamako Declaration of the Ministers in Charge of Water Resources of the Countries Sharing the Iullemeden Aquifer System in 2009. This declaration establishes a consultative mechanism for the joint management of groundwater (Governments of Tunisia, Algeria, & Libya 2009). Now the GEF project is being expanded under the Strategic Action Program to include scientific investigations of the Taoudeni-Tanerouft and River Niger Aquifers (Sahara Sahel Observatory & Global Environmental Facility 2008).

The trajectory of the cooperation over the Iullemeden Aquifer System began over 20 years ago. Since that time, various cooperative mechanisms for water have moved three of the five aquifer states towards high-level cooperation. Consequently, a history of cooperation over water, the expansion of regional institutions for water management, paired with financing mechanisms and political will, created the circumstances necessary for the Bamako Declaration to come forth. Further, this has spurred a desire for cooperation on other aquifers in the region.

Level of Cooperation
4
Catalyst for Cooperation
Rapid environmental change
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms Previous Water Cooperation Scientific Research Strong Political Will Third-Party Involvement

References:

- Governments of Mali Niger and Nigeria, 2003. *Managing Hydrogeological Risk in the Iullemeden Aquifer System Project, Project Brief.*
- Governments of Tunisia Algeria & Libya, 2009. *Bamako Declaration Bamako Declaration of the Ministers in Charge of Water Resources of the Countries Sharing the Iullemeden Aquifer System*, Bamako, Mali.
- Sahara Sahel Observatory & Global Environmental Facility, 2008. *Management of Hydrologic Risks of the Iullemeden Aquifer System Scientific Report.*

AQUIFERS OF THE SAVA RIVER BASIN

| Bosnia & Herzegovina | Croatia | Slovenia |



AQUIFERS OF THE SAVA RIVER BASIN

| Bosnia & Herzegovina | Croatia | Slovenia |

The Sava River is the third largest tributary to the Danube River. As a result of the dissolution of the Socialist Federal Republic of Yugoslavia in 1992, the Sava River was converted from a river of national importance to a river of international importance. The Stability Pact for South Eastern Europe provided a basis for regional cooperation to emerge in the form of the Sava River Basin Initiative (International Sava River Basin Commission n.d.). After that time, the level of cooperation increased until the Framework Agreement for the Sava River Basin was signed in 2002 and entered into force in 2004. At that time, an interim Sava River Basin Commission was created. The official commission began work in 2006. The Framework Agreement for the Sava River Basin includes a 'General Obligation to Cooperate' as well as clauses on dispute resolution in its articles (Bosnia and Herzegovina et al. 2002). To date, there are 18 multilateral treaties relevant to the Sava River Basin with the oldest dating back to 1948. There are also eight bi-national agreements among the basin countries related to water management. Further, there is a high level of coordination between the Sava River Basin Commission and the Danube River Basin Commission on the issues of flooding and navigation.

Level of Cooperation
4
Catalyst for Cooperation
Significant political event
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions High Institutional Capacity Previous Water Cooperation

The Sava River Basin Commission has delineated 41 groundwater bodies of basin-wide importance (20 of which are transboundary groundwater bodies) according to the guidance of the EU Water Framework Directive (International Sava River Basin Commission 2011a). They have also recommended chemical quality objectives for the groundwater bodies. The countries are currently completing a proposal for a Water Framework Directive compliant groundwater monitoring system for the entire group of aquifers (International Sava River Basin Commission 2011a). The Commission facilitates the individual states' development of laws and policies to assess the qualitative and quantitative status of groundwater resources.

According to the Strategy on Implementation of Framework Agreement on the Sava River Basin Management Plan, there is further commitment to increase attention to groundwater resources (International Sava River Basin Commission 2011b). However, there is a low level of confidence regarding groundwater information in the Basin and a need for capacity building in this area. The Southeastern Europe (SEE) region is also an area of increasing activity for surface water and groundwater cooperation. In addition to the cooperation occurring in the Sava River Basin, there is an ongoing initiative for the Dinaric Karst Aquifers. The Dinaric Karst Aquifers lie within several of the same aquifer states as the Sava River Basin. For the most part, the Sava Framework focuses on alluvial aquifers that are hydrologically connected to the river, while Karst formations are the focus of the other aquifer group.

The case of the Sava River Basin Aquifers shows how events outside of the realm of water management can be significant catalysts for water cooperation. The dissolution of the Former Yugoslavia and the subsequent creation of the Stability Pact created a climate for cooperation as well as the institutional capacity to deal with many water management issues in a complex regional hydrologic system. Within the context of the European Union, the aquifer states are complying with the requirements of the Water Framework Directive and the UN Economic Commission for Europe Water Convention in order to comply with their status as member countries or in order to move towards accession. These legal requirements are also major drivers of cooperation in the Sava River Basin aquifers and for coordination with the Danube River Basin Commission. Bi-lateral commissions established as part of the eight bi-lateral treaties within the Basin are also key mechanisms for cooperation and policy harmonization.

References:

Bosnia and Herzegovina et al., 2002. *Framework Agreement on the Sava River Basin*, Kranjska Gora: 3 December 2002, entered into force 29 December 2004.

International Sava River Basin Commission, 2011a. *Draft Sava River Basin Management Plan*.

International Sava River Basin Commission, History webpage. Available at: <http://www.savacommission.org/history> [Accessed September 8, 2014].

International Sava River Basin Commission, 2011b. *Strategy on Implementation of the Framework Agreement on the Sava River Basin*.

UPPER RHINE VALLEY AQUIFER

[PLIOCÈNE DE HAGUENAU ET NAPPE D'ALSACE AQUIFER]

| France | Germany | Switzerland |



UPPER RHINE VALLEY AQUIFER

[PLIOCÈNE DE HAGUENAU ET NAPPE D'ALSACE AQUIFER]

| France | Germany | Switzerland |

Approximately, 80% of residents in the Upper Rhine Valley Aquifer area use the groundwater for their drinking water supply (Region Alsace n.d.). Most of the groundwater is used by industry (68%). The second largest use is drinking water supply (20%) and the remaining water is used for agriculture (12%). The accumulation of industrial pollution especially pharmaceuticals and nitrates, motivated the aquifer states to pursue collective action to protect the aquifer (Huggenberger et al. 2010). Consequently, the primary goal for cooperation over Upper Rhine Valley water resources is to provide drinking water without treatment, for present and future generations at a low cost (Region Alsace n.d.).

Formal cooperation in the Upper Rhine region began in 1975, when the governments of France, Germany and Switzerland signed the Bonn Accord. The Bonn Accord was designed to form a commission for the investigation and resolution of neighborly issues on the Upper Rhine. In 2000, the Bonn Accord was superseded by the Agreement between the Swiss Federal Council, the Government of the Federal Republic of Germany and the Government of the French Republic on Cross-border Co-operation in the Upper Rhine Region (Upper Rhine Agreement) (Metropolregion Rhein-Neckar n.d.). As part of the implementation of the Bonn Accord and now the Upper Rhine Agreement, two key mechanisms were established. The first is the Upper Rhine Conference, which functions as the implementation body for the agreement. The Conference currently has 12 topical working groups, including an environment working group, which names groundwater as one of the priority areas (Region Alsace n.d.). The second is the Tripartite Congress that was formed in 1988 and meets biannually to discuss a topic of importance in the region. The Congress' first meeting on the environment occurred in 1991. This meeting marked the beginning of cooperative efforts focused on groundwater quality.

In 1996, the Environmental Programme of Europe initiated hydrodynamic modeling and hydrologic mapping of the region. Then in 2000, an inventory of regional groundwater quality was conducted (Deutsch-Französisch-Schweizerische Oberrheinkonferenz n.d.). Subsequently, the European INTERREG funding mechanism co-financed three groundwater projects for the Upper Rhine Valley Aquifer. The projects' foci ranged from monitoring and modeling to public education (Deutsch-Französisch-Schweizerische Oberrheinkonferenz n.d.). One major project was INTERREG III A, which occurred between 2003 and 2006. The broad objectives of the projects were to protect and restore groundwater quality (Gudera 2007). A second iteration of the project, INTERREG IV A is ongoing.

Additionally, INTERREG IVB launched the Transnational Organization for Groundwater Protection at the Rhine (Länderübergreifende Organisation für Grundwasserschutz am Rhein [LOGAR]) programme, which establishes an expert network and continues data monitoring and forecasting to ensure that withdrawals do not exceed recharge. A comprehensive water quality diagnostic is also completed every six years in compliance with the EU Water Framework Directive.

Cooperation on the Upper Rhine Valley Aquifer stems from a robust regional cooperative framework. As groundwater contamination became problematic, the aquifer states were able to establish specific institutional mechanisms for its management and to access funding mechanisms to enhance technical knowledge. Therefore, there is strong cooperation on groundwater management and a well-established monitoring program for the aquifer.

Level of Cooperation
4
Catalyst for Cooperation
Contamination of drinking water supply
Enabling Factors
Existing Legal Mechanisms Existing Regional Institutions Funding Mechanisms High Institutional Capacity Previous Water Cooperation

References:

- Deutsch-Französisch-Schweizerische Oberrheinkonferenz, Environment at Oberrhein – Projects webpage. Available at: <http://www.oberrheinkonferenz.org/de/umwelt/projekte1.html> [Accessed September 8, 2014].
- Gudera, T., 2007. Transboundary Groundwater Resources of the Upper Rhine Valley. In *International Roundtable Integrated Management of Shared Groundwater in South Eastern Europe*. Brdo pri Kranju, Slovenia.
- Metropolregion Rhein-Neckar, Upper Rhine Conference Webpage. Available at: <http://www.m-r-n.com/en/home/regional-planning-and-development/institutions/rhine-neckar-regional-association/co-operations/upper-rhine-conference.html> [Accessed September 8, 2014].
- Huggenberger, P. et al., 2010. Concepts for transboundary groundwater management in a region of extensive groundwater use and numerous contaminated sites. In *International Conference "Transboundary Aquifers: Challenges and New Directions."* Internationally Shared Aquifer Resources Management Programme.
- Region Alsace, Rhine Groundwater and Groundwater Quality Webpage. Available at: <http://www.region-alsace.eu/article/nappe-phreatique-rhenane-et-qualite-des-eaux-souterraines> [Accessed September 8, 2014].

No.	Aquifer [Group/ System] Name	Aquifer States	Aquifer Type(s)	Storage Volume (Mm ³)	Area (km ²)	Major Uses	Threats/Risks	Select Laws and Institutions
1	Abbotsford-Sumas Aquifer	Canada United States of America	Unconfined	3,700	200	Domestic Agricultural	Localized overexploitation Agricultural pollution	International Joint Commission NAFTA Commission for Environmental Cooperation Environmental Cooperation Council Boundary Waters Treaty MoU between the Province of British Columbia and the State of Washington
2	Bolsón del Hueco-Valle de Juárez Aquifer	Mexico United States of America	Unconfined	23,683	8,000	Domestic Industrial Military Irrigation	Pollution Overexploitation Salinization from irrigation	International Boundary and Water Commission Convention between Mexico and the United State on the Equitable Distribution of Waters of the Rio Grande Rio Grande Compact North American Free Trade Agreement MoU between City of Juarez, Mexico Utilities and the El Paso Water Utilities Public Services Board of the City of El Paso, Texas US-Mexico Transboundary Aquifer Assessment Act
3	Carboniferous Aquifer	Belgium France	Karst, semi-confined	Unknown	4,500	Domestic Industrial Agricultural	Sanitary, industrial, and agricultural pollution Overexploitation	Contribute to a better quality of surface and groundwater bodies in the Scheldt International River Basin District (ScaldWIN) European Union Water Framework Directive Ghent Agreement International Commission for the Protection of the Scheldt United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes Transhennuyère Agreement Treaty for the Protection of the Scheldt
4	Châteauguay Aquifer	Canada United States of America	Semi-confined	1,287.5	2,500	Domestic Agricultural Bottled water production Industrial	Agricultural and industrial pollution Overexploitation	International Joint Commission Environmental Cooperation Council Boundary Waters Treaty Great Lakes Water Quality Agreement The Great Lakes Charter The Great Lakes St. Lawrence River Basin Sustainable Water Resources Agreement and Compact

No.	Aquifer [Group/ System] Name	Aquifer States	Aquifer Type(s)	Storage Volume (Mm ³)	Area (km ²)	Major Uses	Threats/Risks	Select Laws and Institutions
5	Danube River Basin Aquifers	Austria Bosnia & Herzegovina Bulgaria Croatia Czech Republic Germany Hungary Moldova Montenegro Romania Serbia Slovakia Slovenia Ukraine	Karst, semi- confined Confined	Unknown	100,082	Domestic Agriculture Industry Balneology Caloric energy	Agricultural, industrial, and sanitary pollution Localized overexploitation	Convention on Cooperation for the Protection and Sustainable Use of the Danube River European Union Water Framework Directive International Commission for the Protection of the Danube River United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes
6	Dinaric Karst Aquifers	Albania Bosnia & Herzegovina Croatia Italy Macedonia Montenegro Greece Serbia	Karst, unconfined	Unknown	19,700	Livestock Fishing Domestic Agriculture Industry	Reduced spring flow Solid waste and sanitary pollution Saline intrusion Ecosystem degradation	Athens Declaration concerning Shared Water, Shared Future and Shared Knowledge European Union Water Framework Directive Petersberg Process on Transboundary Cooperation and Water Management in South Eastern Europe UNESCO-UNEP Mediterranean Partnership United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes
7	Franco-Swiss Genevois Aquifer	France Switzerland	Unconfined	74	19	Domestic	Overexploitation	Convention on the Protection, Utilization, Recharge and Monitoring of the Franco-Swiss Genevois Aquifer European Union Water Framework Directive European Outline Convention on Transfrontier Co- operation Between Territorial Communities or Authorities United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes
8	Guaraní Aquifer System	Argentina Brazil Paraguay Uruguay	Confined	40,000,000	1,200,000	Domestic Industrial Geothermal energy	Localized overexploitation Localized pollution	Organization of American States La Plata Basin Treaty Common Market of the South (MERCOSUR) Guaraní Aquifer Agreement

No.	Aquifer [Group/ System] Name	Aquifer States	Aquifer Type(s)	Storage Volume (Mm ³)	Area (km ²)	Major Uses	Threats/Risks	Select Laws and Institutions
9	Hispaniola Island Aquifers	Dominican Republic Haiti	Unconfined	Unknown	16,660	Domestic Agricultural Industrial Power generation	Saline intrusion Desertification Deforestation	Peace, Perpetual Friendship, and Arbitration Treaty Organization of American States GEF/UNEP/OAS/UNESCO Reducing Conflicting Water Uses in the Artibonite River Basin through Development and Adoption of a Multi-focal Area Strategic Action Programme Project Agreed vision for shared management
10	Kilimanjaro Aquifer	Kenya Tanzania	Unconfined	Unknown	15,000	Domestic Agricultural	Reduced base flow to lakes and rivers Reduced recharge due to deforestation	Treaty for the Establishment of the East African Community East African Community Protocol on Environment and Natural Resources Management Lake Victoria Basin Commission Nile Basin Initiative Greater Pangani Basin Cross Border Dialogue
11	Lake Chad Aquifer System	Cameroon Chad Central African Republic Niger Nigeria	Unconfined Confined Confined, non-recharging	170,000-360,000	1,917,000	Domestic Agriculture	Drought Desertification	Lake Chad Basin Commission Niger Basin Authority Mondou Agreement GEF/UNDP/UNOPS Project 'Reversal of Land and Water Degradation Trends In the Lake Chad Basin Ecosystem: Establishment of Mechanisms for Land and Water Management Niger-Nigeria Joint Commission
12	Mekong River Plain Aquifers	Cambodia Laos Thailand Vietnam	Unconfined	Unknown	369,124	Domestic Irrigation Aquaculture	Agricultural and sanitary Pollution Localized overexploitation	Mekong River Commission
13	Mura Zala	Hungary Slovenia	Unconfined	Unknown	4,974	Balneology Geothermal Energy	Overexploitation	Convention on Cooperation for the Protection and Sustainable Use of the Danube River European Union Water Framework Directive European Union Directive on the promotion of the use of energy from renewable sources International Commission for the Protection of the Danube River Permanent Bilateral Slovenian – Hungarian Water Management Commission Slovenia-Hungary Cross-Border Operational Programme 2007-2013 United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes

No.	Aquifer [Group/System] Name	Aquifer States	Aquifer Type(s)	Storage Volume (Mm³)	Area (km²)	Major Uses	Threats/Risks	Select Laws and Institutions
14	Northwest Sahara Aquifer System	Algeria Libya Tunisia	Unconfined Confined, non-recharging	Unknown	1,019,000	Domestic Agricultural	Overexploitation Salinization Loss of artesian flow Reduced discharge Transboundary conflict	Protection of the Northwest Sahara Aquifer System and related humid zones and ecosystems Northwest Sahara Aquifer System Mechanism for Concerted Action
15	Nubian Sandstone Aquifer System	Chad Egypt Libya Sudan	Confined, non-recharging Unconfined	375,000,000	2,199,000	Domestic Industrial Mining Agriculture	Increasing abstraction Hyper salinity (Northern portion only) Loss of ecosystems	Centre for Environment and Development for the Arab Region and Europe (CEDARE) Joint Authority for the Study of the Development of the Nubian Sandstone Aquifer Waters Nile River Basin Initiative Programme for the Development of a Regional Strategy for the Utilisation of the Nubian Sandstone Aquifer System Regional Formulation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer
16	Orange-Senqu River Basin Aquifers	Botswana Namibia South Africa	Unconfined	Unknown	Unknown	Domestic Livestock Mining	Contamination due to diffuse pollution Drought Diminished recharge due to surface water diversion	Agreement between the Government of the Republic of South Africa and the Government of the Republic of Namibia on the Establishment of a Permanent Water Commission Orange-Senqu River Basin Commission Revised Protocol on Shared Watercourse in the Southern African Development Community Project for the Development and Adoption of a Strategic Action Program for Balancing Water Uses and Sustainable Natural Resource Management Southern Africa Development Community Declaration and Treaty
17	Poplar Aquifer	Canada United States of America	Unconfined	Unknown	10,000	Domestic Agricultural	Industrial pollution	International Joint Commission Environmental Cooperation Council Boundary Waters Treaty International Red River Board Poplar River Bilateral Monitoring Committee
18	Sahel Region Aquifers	Algeria Benin Mali Niger Nigeria Mauritania	Unconfined Confined	5,000,000	1,000,000	Domestic Agricultural	Land use changes Drought Salinization	European Union Water Framework Directive Framework Agreement on the Sava River Basin International Commission for the Protection of the Danube River International Sava River Basin Commission United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes

No.	Aquifer [Group/ System] Name	Aquifer States	Aquifer Type(s)	Storage Volume (Mm ³)	Area (km ²)	Major Uses	Threats/Risks	Select Laws and Institutions
19	Sava River Basin Aquifers	Croatia Slovenia Bosnia & Herzegovina	Unconfined	Unknown	20,518	Domestic	Agricultural, industrial and sanitary Pollution	Danube River Protection Commission International Sava River Basin Commission Framework Agreement on the Sava River Basin International Commission for the Protection of the Danube UNECE Water Convention
20	Upper Rhine Aquifer	France Germany Switzerland	Unconfined	80,000	13,693	Domestic Industrial Agricultural	Agricultural and industrial pollution Reduced recharge due to urbanization	Agreement between the Swiss Federal Council, the Government of the Federal Republic of Germany and the Government of the French Republic on Cross-border Co-operation in the Upper Rhine Region Association for the Protection of Groundwater in the Plain of Alsace Bonn Accord European Union Water Framework Directive Franco-German-Swiss Conference of the Upper Rhine INTERREG III A INTERREG IV A Tripartite Congress United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes

APPENDIX B: REFERENCES

-
- Buzan, B., Wæver, O. & De Wilde, J., 1998. *Security: a new framework for analysis*, Boulder, Colorado: Lynne Rienner Publishers.
- Canelas de Castro, P., 2002. Prospects of the Future of International Water Law: the View Projected by the Epistemic Communities. In The International Bureau of the Permanent Court of Arbitration, ed. *Resolution of International Water Disputes*. The Hague, Netherlands.
- Conti, K.I., 2013. Cooperation over transboundary aquifers: lessons learned from 10 years of experience. In *Free Flow - Reaching Water Security through Cooperation*. Paris, France: United Nations Educational, Scientific and Cultural Organization - World Water Assessment Programme, pp. 40–44.
- Craig, J.G., 1993. *The nature of co-operation*, Montreal, Canada: Black Rose Books.
- Dellapenna, J., 2011. The customary law applicable to internationally shared groundwater. *Water International*, 36(5), pp.584–594.
- Döll, P. & Hoffmann-Dobrev, H., 2012. Impact of water withdrawals from groundwater and surface water on continental water storage variations. *Journal of Geodynamics*, 59-60, pp.143–156.
- Domenico, P.A. & Schwartz, F.W., 1998. *Physical and chemical hydrogeology*, Wiley New York.
- Eckstein, G.E., 2007. Commentary on the UN International Law Commission's draft articles on the law of transboundary aquifers. *Colo. J. Int'l Envtl. L. & Pol'y*, 1.
- Eckstein, G.E. & Sindico, F., 2014. The Law of Transboundary Aquifers: Many Ways of Going Forward, but Only One Way of Standing Still. *Review of European, Comparative & International Environmental Law*, 23(1), pp.32–42.
- Eckstein, Y. & Eckstein, G.E., 2005. Transboundary aquifers: Conceptual models for development of international law. *Groundwater*, 43(5), pp.679–90.
- Falkenmark, M. & Allard, B., 1991. Water quality genesis and disturbances of natural freshwaters. In O. Hutzinger, ed. *The handbook of environmental chemistry 5, part A: WaterWater Pollution*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 45–78.
- Feitelson, E., 2005. Impediments to the management of shared aquifers: A political economy perspective. *Hydrogeology Journal*, 14(3), pp.319–329.
- Feitelson, E., 2003. When and how would shared aquifers be managed? *Water International*, 28(2), pp.145–153.
- Fitts, C.R., 2002. *Groundwater science*, Academic Press.

Gleick, P.H., 1993. Water and Conflict: Fresh Water Resources and International Security. *International Security*, 18(1), p.79.

Government of the State of Israel & The Palestine Liberation Organization, 1995. *Israeli-Palestinian Interim Agreement on the West Bank and Gaza Strip*, 28 September, 1995.

Hernance, J.F., 1999. *A Mathematical Primer on Groundwater Flow*, Prentice Hall.

International Groundwater Resources Assessment Centre, 2014. Transboundary Aquifers of the World 2014. Available at: <http://tbamap.un-igrac.org>.

International Law Association, 2004. Berlin Rules on Water Resources. In *Fourth Report of the Berlin Conference on Water Resources*. Berlin, Germany: Berlin Conference on Water Resources Law.

International Law Association, 1966. *Helsinki Rules on the Uses of the Water of International Rivers* 52nd Confe., Helsinki, Finland: reprinted in Bogdanovic, S. (2001).

International Law Association, 1986. *Seoul Rules on International Groundwaters* 62nd Confe., Seoul, Korea: Report of the Sixty-Second Conference Held at Seoul.

International Law Commission, 2008. *Draft Articles on the Law of Transboundary Aquifers*,

Jarvis, T. et al., 2011. International borders, ground water flow, and hydroschizophrenia. *Ground water*, 43(5), pp.764–70.

Konikow, L.F., 2011. Contribution of global groundwater depletion since 1900 to sea-level rise. *Geophysical Research Letters*, 38(17), p.L17401.

Lautze, J. et al., 2011. Putting the cart before the horse: Water governance and IWRM. *Natural Resources Forum*, 35(1), pp.1–8.

Linton, J. & Brooks, D., 2011. Governance of transboundary aquifers: New challenges and new opportunities. *Water International*, 36(5), pp.606–618.

Llamas, M.R. & Martínez-Santos, P., 2005. Intensive groundwater use: a silent revolution that cannot be ignored. *Water science and technology : a journal of the International Association on Water Pollution Research*, 51(8), pp.167–174.

Machard de Gramont, H. et al., 2011. *Towards a Joint Management of Transboundary Aquifer Systems*,

Margat, J. & van der Gun, J., 2013. *Groundwater around the world: a geographic synopsis*, CRC Press.

McCaffrey, S.C., 2011. The International Law Commission's flawed Draft Articles on the Law of Transboundary Aquifers: the way forward. *Water International*, 36(5), pp.566–572.

-
- McIntyre, O., 2011. International Water Resources Law and the International Law Commission Draft Articles on Transboundary Aquifers: A Missed Opportunity for Cross-Fertilisation? *International Community Law Review*, 13(3), pp.237–254.
- Mirumachi, N. & Allan, J.A., 2007. CAIWA International Conference on Adaptive and Integrated Management: Coping with Scarcity. In *Revisiting Transboundary Water Governance: Power, Conflict, Cooperation and the Political Economy*. Basel, Switzerland.
- Ohlsson, L., 2000. Water conflicts and social resource scarcity. *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere*, 25(3), pp.213–220.
- Oregon State University, 2014. International Water Event Database: 1950-2008. Available at: <http://www.transboundarywaters.orst.edu/database/interwatereventdata.html> [Accessed September 5, 2014].
- Puri, S. et al., 2001. *Internationally Shared (Transboundary) Aquifer Resources Management: their significance and sustainable management. A framework document*, Paris, France: UNESCO.
- Rogers, P. & Hall, A.W., 2013. *Effective Water Governance Background*., Global Water Partnership Technical Committee (TEC).
- Sadoff, C.W. & Grey, D., 2002. Beyond the river: The benefits of cooperation on international rivers. *Water Policy*, 4(5), pp.389–403.
- Sálamé, L. & van der Zaag, P., 2010. Enhanced knowledge and education systems for strengthening the capacity of transboundary water management. In A. Earle, A. Jägerskog, & J. Öjendal, eds. *Transboundary Water Management, Principles and Practices*. London, UK: Earthscan.
- Scheumann, W., 2008. Conceptualizing cooperation on Africa's transboundary groundwater resources. In W. Scheumann & E. Herrfahrdt-Pähle, eds. *Conceptualizing Cooperation on Africa's Transboundary Groundwater Resources*. Bonn, Germany: German Development Institute.
- Schrodt, P., 1995. Event data in foreign policy analysis. In L. Neack, J. A. Hey, & P. J. Haney, eds. *Foreign policy analysis: continuity and change in its second generation*. Englewood Cliffs, NJ: Prentice Hall.
- Shiva, V., 2002. *Water Wars: Privatization, Pollution and Profit*, Cambridge, MA: South End Press.
- Siebert, S. et al., 2010. Groundwater use for irrigation – a global inventory. *Hydrology and Earth System Sciences Discussions*, 7(3), pp.3977–4021.

-
- Sindico, F., 2011. The Guarani Aquifer System and the International Law of Transboundary Aquifers. *International Community Law Review*, 13(3), pp.255–272.
- Solomon, H. & Turton, A., 2000. *Water wars: Enduring myth or impending reality* 2nd ed., Pretoria, South Africa: ACCORD - Africa Dialogue Monograph.
- Stefano, L. De et al., 2010. Tracking cooperation and conflict in international basins: historic and recent trends. *Water Policy*, 12(6), p.871.
- Stefano, L. De et al., 2009. *Updating the International Water Events Database (Revised)*, Paris, France.
- Stephan, R., 2011. The Draft Articles on the law of Transboundary Aquifers: the process at the UN ILC. *International Community Law Review*, 13(3), pp.223–235.
- Struckmeier, W., Rubin, Y. & Jones, J., 2005. Groundwater—Reservoir for a Thirsty planet? *Earth Sciences for Society Foundation*, Leiden, Netherlands.
- Tanzi, A., 2010. Reducing the gap between international water law and human rights law: the UNECE Protocol on Water and Health. *International Community Law Review*, 12(3), pp.267–285.
- UNESCO, 2012. *Facts and Figures from the World Water Development Report 4 – Managing Water under Uncertainty and Risk*, United Nations Educational, Scientific and Cultural Organization - World Water Assessment Programme.
- UNESCO - World Water Assessment Programme, 2006. *Water, a Shared Responsibility*, Paris, France: United Nations Educational, Scientific and Cultural Organization - World Water Assessment Programme.
- United Nations Conference on Environment and Development, 1992. Declaration of the United Nations Conference on Environment and Development. In *Report of the United Nations Conference on Environment and Development*. Rio de Janeiro, Brazil: Annex 1, UN Doc A/Conf. 151/26 (Vol. I), p. reprinted in 31 ILM 876 (1992).
- United Nations Economic Commission for Europe, 2003. *Amendments to Articles 25 and 26 of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes*,
- United Nations Economic Commission for Europe, 1998. *Convention on Public Participation in Decision-making and Access to Justice in Environmental Matters*, Aarhus, Denmark: 25 June 1998, entered into force 30 October 2001.
- United Nations Economic Commission for Europe, 1992. *United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes*, (17 March 1992, entered into force 6 October 1996) 1936 UNTS 269.

United Nations General Assembly, 1997. *United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses*, reprinted in 36 ILM 700.

UN-Water, 2008. *Transboundary Waters: Sharing Benefits, Sharing Responsibilities*,

Varady, R.G. et al., 2013. *Thematic Paper No. 5: Groundwater Policy and Governance*,

Water Authority of the State of Israel, 2009. The Issue of Water between Israel and the Palestinians. Available at: <http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/IsraelWaterAuthorityresponse.pdf> [Accessed September 5, 2014].

Wijnen, M. et al., 2012. Managing the Invisible: *Understanding and Improving Groundwater Governance*, Washington, D.C.

Wolf, A., 2008. Healing the enlightenment rift: Rationality, spirituality and shared waters. *Journal of International Affairs*, 61(2), pp.51–73.

Wolf, A., Yoffe, S. & Giordano, M., 2003. International waters: Identifying basins at risk. *Water policy*, 5(1), pp.29–60.

Yamada, C., 2011. Codification of the Law of Transboundary Aquifers (Groundwaters) by the United Nations. *Water International*, 36(5), pp.557–565.

Yoffe, S. et al., 2004. Geography of international water conflict and cooperation: Data sets and applications. *Water Resources Research*, 40(5), p.W05W04.

Yoffe, S. & Larson, K., 2002. Basins at Risk: *Water Event Database Methodology*. Oregon State University.

Zeitoun, M. & Mirumachi, N., 2008. Transboundary water interaction I: Reconsidering conflict and cooperation. *International Environmental Agreements: Politics, Law and Economics*, 8(4), pp.297–316.

Zeitoun, M., Mirumachi, N. & Warner, J., 2010. Transboundary water interaction II: the influence of “soft” power. *International Environmental Agreements: Politics, Law and Economics*, 11(2), pp.159–178.

Zeitoun, M. & Warner, J., 2006. Hydro-hegemony – a framework for analysis of trans-boundary water conflicts. *Water Policy*, 8(5), p.435.

Zektser, I. & Everett, L., 2004. Groundwater resources of the world: and their use. *IhP Series on groundwater*.

APPENDIX C: LIST OF INTERVIEWEES

