UNDERSTANDING THE ROLE OF RISK PERCEPTION AND TRUST IN TRANSBOUNDARY WATER SHARING: A STUDY ON CONFLICT AND COOPERATION

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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December 2018

Major Subject: Ecosystem Science and Management

ABSTRACT

Along the Texas-Mexico border, different management regimes, property rights, and uses for groundwater are overlapping or conflicting, which has led to unilateral takings on both sides of the border and severe aquifer degradation. In the face of surface water scarcity and increased reliance on groundwater resources, improved water security requires decision-makers to behave in cooperative ways. Within this polycentric governance setting, it is difficult to obtain policy integration and cooperation. A questionnaire was developed to survey water decision-makers on the Texas-side of the Texas-Mexico border to determine how perceptions of risk and levels of trust impact willingness to cooperate or engage in conflict over internationally-shared, transboundary water resources.

This research provides insight into how trust and perception of risk influences cooperation over shared transboundary water resources. Trust in social and political institutions has proven to be a central tenant of social capital and a necessary condition for achieving cooperative behavior. This study measures how risks are perceived by different stakeholder groups, what role binational cooperation plays in building trust, and how risk perception and trust impact willingness to cooperate or engage in conflict over transboundary water sharing, with a focus on groundwater.

Results from this project support the hypothesis that perceptions of risk and levels of trust do influence willingness to cooperate or engage in conflict. Results show that as trust increases, perceptions of risk decrease and willingness to cooperate increases. As participation in binational stakeholder engagement efforts increase, levels of trust also increase. Perceptions of risk are impacted by experience, knowledge, and frequency of engagement with binational partners.

Perceptions and levels of trust vary by tier of governance; those at the local-level have the highest perceptions of risk and lowest levels of trust, while federal-level actors have the highest level of trust and lowest levels of risk perception over shared transboundary water. Results also provide a proven framework and template for use in other global transboundary water sharing settings.

DEDICATION

This dissertation is dedicated to my loving husband, Dr. Garett Sansom. I never would have survived the journey and made it to the finish line without the love, patient support, and constant encouragement from my partner in life.

CONTRIBUTORS AND FUNDING SOURCES

This work was supported by a dissertation committee consisting of Dr. Kent Portney, my advisor, of the Department of Public Service and Administration at Texas A&M University, Dr. Forrest Fleischman, my co-advisor, of the Department of Forest Resources at University of Minnesota, Dr. Gabriel Eckstein of the Texas A&M School of Law, and Dr. Michael Campana of the Department of Geosciences at Oregon State University.

The funding for data collection for this study was provided by Dr. Kent Portney and the Institute for Science, Technology and Public Policy at the Bush School of Government and Public Service.

All other work conducted for the dissertation was completed by the student independently.

NOMENCLATURE

(BECC) Border Environment Cooperation Commission

(CILA) Comision Internacional de Limites y Aguas

(CEC) Commission on Environment Cooperation

(CI) Confidence Interval

(CNA) National Water Commission of Mexico (aka CONAGUA)

(CPR) Common Pool Resource

(DACA) Deferred Action for Childhood Arrivals

(DFC) Desired Future Condition

(EPA) Environmental Protection Agency

(EPWU) El Paso Water

(GCD) Groundwater Conservation District

(GDP) Gross Domestic Product

(GIS) Geographic Information System

(GMAs) Groundwater Management Areas

(GNEB) Good Neighbor Environmental Board

(GWP) Global Water Partnership

(IAD) Institutional Analysis and Development

(IBWC) International Boundary and Water Commission

(IIL) International Institute of Law

(ILA) International Law Association

(ILC) UN International Law Commission

(IPCC) Intergovernmental Panel on Climate Change

(IR) International Relations

(IRB) Institutional Review Board

(ISTPP) Institute of Science, Technology and Public Policy

(ISRAM) International Shared Aquifer Resources Management

(IWRM) Integrated Water Resource Management

(MCWE) Meadows Center for Water and the Environment

(MUD) Municipal Utility District

(NADB) North American Development Bank

(NAFTA) North American Free Trade Agreement

(NM-TX-CHI) New Mexico – Texas – Chihuahua Regional Workgroup

(NPS) National Parks Service

(OR) Odds Ratio

(PGMA) Priority Groundwater Management Area

(SEDUE) Secretaria de Desarrollo Urbano y Ecologia

(SEMERNAT) Secretaria de Medio Ambiente y Recursos Naturales

(SES) Socio-Ecological System

(SWCD) Soil and Water Conservation District

(TAAA) Transboundary Aquifer Assessment Act

(TAAP) Transboundary Aquifer Assessment Program

(TCEQ) Texas Commission on Environmental Quality

(TPWD) Texas Parks and Wildlife Department

(TWDB) Texas Water Development Board

(TWRI) Texas Water Resources Institute

(TX-COAH-TAMP-NL) Texas - Coahuila - Nuevo Leon – Tamaulipas Regional Workgroup

(UNWC) UN Watercourses Convention

(USACE) U.S. Army Corps of Engineers

(USBR) Bureau of Reclamation

(USFWS) U.S. Fish and Wildlife Service

(USGS) U.S Geological Survey

(VIF) Variance Inflation Factor

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CHAPTER I

EVOLUTION OF TRANSBOUNDARY WATER SHARING: AN INTRODUCTION TO PROBLEMS AND SOLUTIONS

The purpose of this dissertation is to explore how individual characteristics, such as peoples' perceptions of risk and level of trust, can be aggregated at the institutional level to understand what conditions influence willingness to engage in conflict or cooperation over shared transboundary water resources. Transboundary water provides an ideal setting to test these concepts because politicians and water managers operating within their respective countries must come together to make decisions about shared waters. The resulting interactions are either cooperative or conflictual and it is valuable to understand how and why individuals, within institutional settings, make decisions over shared waters. This chapter introduces the common pool resource problems associated with sharing surface water and groundwater across international borders, how those challenges have been addressed or not addressed globally, and the role that institutions play in shaping or constraining nation-state interactions over shared water use and management.

This chapter will discuss broadly how transboundary water sharing has evolved to protect common pool resources for surface water versus groundwater, and the interplay between what happens at the nation-state level and at the supranational level of governance, by exploring the evolution of customary international water law principles and the widely-advocated Integrated Water Resource Management, or IWRM, paradigm. Within IWRM concepts, a new focus has begun to be placed on the importance of water security, specifically in understanding the drivers of cooperation and conflict, in order to better promote cooperation and limit conflict over shared resources. By highlighting the roles that institutions play in cooperation and conflict, this chapter will begin to explore potential characteristics of cooperative or conflictual decision-making behavior. Concepts of risk perception and trust will be introduced as potential drivers of cooperative or conflictual decision-making at the individual level, particularly over shared groundwater resources.

Finally, this chapter will outline the conceptual and theoretical framework for analysis, as well as briefly summarize the particular case study used, which looks at individuals' willingness to engage in cooperation and/or conflict between Texas and Mexico. In order to set the stage for this study, the reader must first understand the problems of modern transboundary water sharing, the role that institutions play in addressing these challenges, as well as the evolution of solutions to these challenges, from the development of customary international water law principles to changing international water discourse.

Modern Challenges of Transboundary water sharing

Water is arguably the most important natural resource and is necessary for sustaining life, growing economies, and maintaining healthy ecosystems. The old adage, without water there is no life, cannot be overstated. As humans, we require water for drinking and sanitation, agriculture, generating energy and growing industry, recreation, navigation, and keeping the ecosystems we rely upon healthy. Literally, nearly every single human need comes back to the necessity of clean, accessible potable water.

Despite the fact that we live on a blue planet that is over 70 percent water, not all of it is usable or economically accessible. Global water sources are found in a variety of physical states and places that may or may not be readily available for use: "96.4 percent of the water on earth is in the oceans. Of the freshwater, 69 percent is in solid form in glaciers and 30 percent is in groundwater; only one percent is in surface water bodies” (Dingman, 2015, p. 55). The one percent of surface water occurring in rivers, lakes, and wetlands is threatened by pollution, degradation, over allocation, ecosystem disruption, and general mismanagement (Gleick et al., 2014).

Furthermore, human populations across the world continue to increase in number and with this population growth, there is also a strong rural to urban trend occurring globally, as people from all walks of life try to attain ever higher standards of living and economic growth. The result is increased pressure on surface and groundwater resources, leading to water scarcity or water stress, where demand for water outstrips supply. According to the 2018 Global Risks Report, generated by the World Economic Forum, water crises are listed as number five in the top ten risks in terms of impact (World Economic Forum 2018).

As demand for water increases with population and standard of living, global water supplies are further stressed by socioeconomic drivers of growth and resulting anthropogenic climate change. While modern feats of engineering, increased understanding of natural system dynamics, and more efficient management of water have allowed us to grow more with less water, as humans we are still outpacing nature’s capacity for sustainable water resource use. Additionally, modern engineering has allowed us as a species to move massive amounts of physical water and virtual water (water embedded in material or agricultural commodities) all over the globe, causing disruption to natural systems. In many places, we have started to realize the ramifications of this disruption, and as Winston Churchill famously said, “where there is great power there is great responsibility, where there is less power there is less responsibility, and where there is no power there can, I think, be no responsibility.” The more power humanity has gained over the flows and distributions of natural water systems, the more responsibility we have had to take for the successes, failures, and unintended consequences of our management decisions. Scientists, water users, and policy makers are all starting to realize that "we humans have become the principal driver of environmental change" (Cosgrove and Loucks, 2015, p.4823). This new dominion over Earth's natural systems has, on one hand, granted us the ability to grow exponentially and meet ever higher standards of living by adapting our environment to meet our needs, and on the other hand, the obligation to address the degradation of the complex, interdependent natural systems upon which we all rely.

Many problems associated with modern transboundary water resources are the result of their common pool resource nature, which is an important distinction because common pool resources require a different approach to management than many other types of goods, such as public or private goods. As defined by Elinor Ostrom (1990), a common pool resource is "a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use" (p.30). In the 1960s, Garrett Hardin published his famous essay on the "tragedy of the commons," in which he argued that nature of common pool resources would likely lead resource users to overuse and exhaust the resource in a race to the bottom (Hardin, 1968; Ostrom, 1990; Poteete, Janssen, and Ostrom, 2010). The nature of common pool resources is often described as a resource system where it is difficult or costly to exclude resource users (excludability) and where use of the resource subtracts from the amount available to other users (subtractability). To address institutional problems of managing these types of goods, the concept of collective action was identified and, as described by Mancur Olson in the 1960s, collective action by all resource users was necessary to achieve sustainable management of the resource (Olson, 1965; Ostrom, 1990). However, Olson argued that users of common pool resources would always act within their own self-interest to maximize individual benefit, regardless of negative consequences to the community as a whole, making the idea of collective action seem unlikely (Olson, 1965; Ostrom, 1990). Many scholars at the time that in order to avoid the “tragedy of the commons,” either a centralized government needed to have total control of managing these resources through the exercise of regulatory authority (Ophuls, 1973; Heilbroner, 1974; Ehrenfeld, 1972; Hardin 1978; Carruthers and Stoner 1981) or all common pool resources needed to transferred into private ownership (Demetz, 1967; Johnson, 1972; Smith, 1981; Welch, 1983). However, in her seminal work, Elinor Ostrom described alternative forms of management, where collective action choices were more likely to adequately address the sustainable management of common pool resources, thus avoiding the tragedy of the commons. These alternative forms of management will be discussed further in Chapter 2.

Management of transboundary surface water evolved very differently from that of transboundary groundwater. Appropriate collective choice rules were instituted iteratively in surface water systems and largely ignored in groundwater systems. Transboundary surface waters have traditionally been regulated within and across borders to help address potential issues of overuse on these commonly held resources. The institutions and laws governing transboundary surface waters have evolved over time to incorporate values and beliefs into rule structures to prevent or mitigate over allocation, degradation, or other sources of water scarcity. This evolution of rules and institutions has helped generate appropriate collective action to prevent, or at least mitigate, the “tragedy of the commons” (Ostrom, 2011).

Institutions and rules have not evolved in the same way for groundwater as they have for surface water and, as a result, groundwater resources tend to suffer more from the “tragedy of the commons,” where the incentive for resource users is to use as much as possible until the resource is exhausted. Consequently, transboundary groundwater is an iconic representation of a common pool resource dilemma because transboundary aquifers lack excludability, are characterized by subtractibility, are mobile across borders, are not easily divisible, and often lack the appropriate rules in use to prevent overexploitation of the resource (Schlager, Bloomquist, and Tang, 1994; Gardner, Moore, and Walker, 1997; Poteete, Janssen, and Ostrom, 2010; Lopez-Gunn, 2012; Skurray, 2015; Cody et al., 2015). Despite the differing nature of surface water versus groundwater, these resources are often hydrologically connected. While extensive institutionalization of transboundary surface waters has occurred all over the world, transboundary groundwater has been left behind. In the face of surface water scarcity, heavier reliance has been placed on groundwater. As a result, in places where there is a strong surface-groundwater connection, surface water is being negatively impacted by groundwater use. This problem is occurring all across the globe at different geographic and political scales.

With our increased command over water resources, we as a species, have developed complicated systems of agricultural, societal, and economic growth that all rely upon steady, reliable access to water. To manage the ever-complicated needs of modern society, each country, state, and municipality has had to develop rigorous institutional structures, or appropriate laws, rules, and organizations responsible for interpreting and administering those policies and procedures, in order to govern the use of water resources. Transboundary water issues, which can include problems associated with lack of coordination, lack of appropriate institutional structures, and lack of international agreements or problems with monitoring, enforcement, and sectioning associated with those agreements, have started to occur more frequently around the world for a variety of reasons, including water scarcity, population growth, climate change, environmental degradation, and mismanagement across borders resulting from complex, polycentric governance systems. The challenges associated with modern transboundary water management can be summed up as follows: water is a necessary element for human survival and economic growth; there is limited supply, which is exacerbated by increased demand; management decisions about use, allocation, and distribution are made by different institutions at different scales, which impacts availability. The following sections will provide a more in-depth discussion of the complexity of each issue.

Water Scarcity

Water scarcity is a problem that occurs all over the world and is increasingly becoming a more prevalent issue as population growth rises, climate change increases uncertainty in planning, and pollution decreases usable water. "Water scarcity occurs when water demand nears (or exceeds) the available water supply" (Gleick et al., 2014, p.2). Water scarcity can occur for a variety of reasons. Scarcity in some parts of the world may be due primarily to a physical lack of precipitation or extreme drought. However, water scarcity can also occur in regions that seem to have plenty of water, but the quality is so poor that it is unusable. A lack of access to clean water, which could be caused by poor management, failing infrastructure, or issues of affordability, can also lead to water stress or scarcity. It is estimated that two-thirds of the global population experiences some type of water stress or scarcity at least one month out of every year (Mekonnen and Hoekstra, 2016). Globally, there is currently enough freshwater available to meet all human needs; however, those resources are not allocated evenly- either spatially or temporally (Gleick et al., 2014). As a result, water is often scarce when and where needs are highest, which leads to competition between users. Regardless of whether those users are local agencies within the same municipality or several nations that rely upon the same river, the result is often the same: a race to the bottom resulting in a 'tragedy of the commons.' Sharing scarce water resources across a large international border only adds to issues of competition, particularly for groundwater, where there are not always sufficient rules in place to govern allocation or use. For instance, “regions with moderate to severe water scarcity during more than half of the year include northern Mexico and parts of the western United States” (Mekonnen and Hoekstra, 2016, p. 6).

Population Growth

As the earth becomes more crowded, natural resources are becoming increasingly scarce, creating opportunities for both conflict and cooperation. As of 2018, the global population has hit the 7.6 billion mark and continues to climb (U.S. Census Bureau, 2018). Not only is the earth becoming more crowded overall, but there is a strong rural to urban migration trend that is happening all over the world as people move to cities to seek better lives. Unfortunately, most people live in arid to semi-arid areas, and it is estimated that 76 percent of all people live in regions that are water-stressed (Delli Priscoli, and Wolf, 2009). Additionally, as quality of life improves for people all over the world, demand for clean water is rising faster than our capacity or supply. “In recent decades the percentage increase in water use on a global scale has exceeded twice that of population growth” (Cosgrove and Loucks, 2015, p.4824). As population density in urban areas increases and the proportion of agricultural land that is irrigated increases to meet the demands of a growing population, demand for water will only continue to rise. However, as previously mentioned, water is not always where it needs to be temporally or geographically, which can exacerbate issues of water scarcity, particularly for internationally-shared resources.

Climate change

All over the globe subtle (or not so subtle) shifts are taking place and those changes are adding up to an increasingly dramatic alteration in climactic trends that have dangerous implications for life on Earth. The impacts of climate change will be felt primarily through the medium of water. Climate change, both natural and anthropogenic, adds to the uncertainty of planning for water managers. Scientists worldwide recognize that the world is heating up and it is leading to more drastic extreme weather events, such as droughts and flooding (IPCC 2014). While local climate change projections are still weak, scientists are starting to have stronger indications of how a changing climate will impact large regional areas (IPCC 2014). As an example, the El Nino Southern Oscillation (or ENSO), weather events have always had an effect on the American southwest, owing to its geographic location; however, the IPCC Fifth Assessment Report (AR5) projects that this natural weather phenomenon will increase in severity, and already has to some point (IPCC 2014). An increase in ENSO and other extreme weather events can lead to an increase in flooding (Vergara, 2005). ENSO also has the ability to cause droughts, due to an increase in temperature and decreases in summer precipitation. While this may seem contradictory, the El Nino weather events lead to temperature increases and more extreme storm surges, when storms do appear, so ENSO can cause both flooding and drought, at different spatial-temporal scales. This adds a large degree of uncertainty to institutions responsible for water resource planning.

Environmental degradation

The economically available water, or water that is economically feasible to invest in extraction, has decreased drastically over the last several decades because of increased pollution and environmental degradation (Gleick et al., 2014). Both point source and nonpoint source pollution are exacerbated by human socio-economic drivers. Point source pollution occurs at a known point (e.g. factory or industrial waste) and nonpoint source pollution occurs across watersheds and is washed into water systems (e.g. fertilizers). Some pollution is naturally occurring in the environment, such as heavy metals, like arsenic and waste from wildlife. However, the vast majority of modern pollution and environmental degradation comes from anthropogenic sources (Vörösmarty et al. 2010). Socio-economic drivers of economic development include agriculture (livestock and crops), industrial growth, energy demands, navigation, and most importantly, water supply for drinking and sanitation. From initial industrialization efforts to current globalization, humans have utilized natural resources to fuel short-term growth and development, often ignoring the negative long-term environmental outcomes. In international border regions, there is often increased pollution resulting from trade, migration, and mismatched governance structures managing environmental quality.

Governance Challenges

To address societal, economic, and environmental changes over time, humans have devised governance structures, such as laws, policies, and the institutions necessary to develop, manage, and enforce constraints. The creation of governance structures, laws, policies, and institutions is an inherently political process. The political processes have varied from place to place, and has yielded different approaches at different geographic scales, oftentimes leading to a mismatch in governance (e.g. overlaps in jurisdiction, gaps in management, etc.). Laws and policies are developed to deal with local, state, federal, and international issues and are carried out and enforced at different tiers of governance. Water is one of the most important and complicated management issues owing to the wide variety of uses within modern society and the natural complexity of hydrological systems. However, for the most part, natural hydrological boundaries do not fall within political boundary delineations and so governance structures and management approaches are often very different once you cross political jurisdictions, especially international boundaries. Mismatches in governance occur frequently with water management precisely because of its flowing nature across political jurisdictions. Surface water and groundwater resources cross political boundaries all the time, which creates immense challenges for peaceful and efficient management. There are 263 transboundary rivers and lake basins worldwide, which comprises slightly less than half of the Earth's land surface, and when you add in approximately 608 transboundary aquifers into the mix, it is easy to understand that management across these water sources often generates complex, wicked problems (UN Water, 2018; Wolf et al., 2005; Conti, 2014). The sheer number of competing water uses can make it difficult just to manage water flows from one city to the next, particularly in places where water is managed by multiple institutions without coordination. Management of water that crosses international boundaries presents a much more complicated challenge, which requires careful balance of issues related to national sovereignty, equity, and accountability among other things. While there are challenges associated with sharing scarce resources across borders, there is also an opportunity for cooperation to generate shared benefits and increased regional security, where cooperation can lead to more safe and secure regions by ensuring that both sides of the border are accommodating their needs to generate growth and stability.

The following sections will discuss the role of institutions in managing transboundary water, the evolution of international water law principles and water management paradigms to address transboundary water management, and the nature of conflict and cooperation over shared water.

The Role of Institutions: Fostering collective action

Institutions shape, enforce, and monitor rules and procedures that are necessary for managing a variety of public goods or common pool resources. Keohane defines institutions as "persistent and connected sets of rules (formal or informal) that prescribe behavioral rules, constrain activity, and shape expectations" (Keohane, 1989, p.3). Traditional approaches to managing transnational surface waters have relied heavily upon the notion of a state-centered institutional model, where principles of absolute sovereignty reigned supreme and management of shared waters either fell under formal international water sharing agreements or were subject to unilateral takings by politically, economically, or militarily powerful "hegemon" nations. The governance of large-scale natural resources, such as a transboundary water basin, is a relatively new endeavor in public policy, with serious efforts toward building appropriate institutions for management beginning in the 1970s. By the late 1960s and early 1970s, there was a clear connection between human economic development activities and increasingly negative human health outcomes from the result of environmental degradation (e.g. air and water pollution). To address these issues associated with the "tragedy of the commons," institutions needed to adopt ways to overcome challenges of collective action. Initially, the response was a command-and control, top-down approach, where the state was seen as the appropriate institution for management of common pool resources (Ophuls, 1973; Heilbroner, 1974; Ehrenfeld, 1972; Hardin, 1978; Carruthers and Stoner, 1981). Others during the same time argued that converting common pool resources into private property would address the problems of the collective action dilemma (Demetz, 1967; Johnson, 1972; Smith, 1981; Welch, 1983). Since the 1990s, Ostrom's Common Pool Resource (CPR) theories have argued that neither the state only nor privatization only was an appropriate approach; instead, a nested set of institutions could more appropriately address collective action challenges at different scales. Given the number of successful common pool resource management examples that have been supported by Ostrom's CPR theories, there is a strong call for more collaborative, polycentric governance approach, which highlights the interdependent relationships between nested institutions (Ostrom, 1990; Lubell, 2003).

Large-scale environmental systems provide compelling and challenging spatial templates for institutional management. Institutional approaches to management of common pool resources have had to evolve to address issues of large-scale natural resources and the increasing interconnected nature of international actors. The global impact of human development, resource extraction, and consumption has begun to be felt across the world (ozone layer depletion, connection between greenhouse gases and climate change, and global fish stocks). Large surface water systems have the potential to cross multiple countries and be managed by countless institutions. Groundwater also covers large swaths of territory, is complicated to measure, and is generally less regulated. Additionally, groundwater-surface water connections are heterogeneous and complicated, in terms of calculating/modelling flow and especially in terms of governance structures. The natural complexity of the hydrological systems, competing socio-economic needs, and political boundaries makes the role of institutions vital to improving management outcomes. Take a large, international river basin system such as the Rio Grande for example, which crosses two U.S. States (Colorado, New Mexico) and forms the international border between Texas and four Mexican States (Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas). The spatial context of this international river basin crosses multiple jurisdictions (international, federal, state, and local), is governed by vastly different rules for resource extraction (ranging from surface water only to conjunctive use, where surface water and groundwater are managed as one resource), has a wide range of rights (private property, common property, open access, and public property), and faces pressure from a diverse set of uses (agricultural, municipal, industrial, recreational etc.). This polycentric system creates a unique challenge based on a highly heterogeneous social, cultural, economic, and political landscape, where over-allocation and resource degradation is problematic and cooperation is costly. Within a context such as this, one must understand the diversity of institutions present within the system in order to begin to address potential cooperation or conflict over resource management across boundaries and in the face of conflicting development agendas. According to leading experts in the field, “the likelihood and intensity of dispute rises as the rate of change within a basin exceeds the institutional capacity to absorb that change” (Wolf, Yoffe, and Giordano, 2003, p. 53). Thus, in order to understand where and why conflict over water does occur, decision-makers must understand not only the physical system, but also the institutional context as well.

Development of water governance institutions has increased dramatically in the past several decades. This is partially because of an evolution in global discourse on the role institutions should play in water resource management. Global discourse also included an attempt to answer major questions on what scales management should occur at, and what principles of management should be included within institutional procedures to improve transboundary water sustainability outcomes (Bernado and Gerlak, 2012; Cook and Bakker, 2012). This conversation and promulgation of ideas on international water management ideals has occurred primarily at the global-level, led by water experts and leaders from all over the world. The expression of these ideals has been primarily through the development of international water law principles and the development of a global water management paradigm, which have attempted to guide the development of institutional roles and structures. “Institutions play important roles in mitigating conflict and promoting cooperation by allowing resource users to handle rapidly changing physical or political constraints” (Berardo and Gerlak, 2012, p.101). The following sections identify how collective action solutions to the complex challenges of transboundary water management have evolved within the international arena. First, a brief introduction into how international water law principles have evolved will be provided, followed by a discussion of IWRM as a dominant water management paradigm. To summarize, the section will end on new conversations in global water management discourse by highlighting the emergent concept of water security as an overarching goal.

Evolution of Solutions: International water law principles and changing global water management paradigms

The development of institutions, particularly at the nation-state level, has been heavily influenced by concepts generated within the international arena, such as customary international law principles and global water management paradigms. Managing international waters has always been a challenge. Internationally-shared waters have traditionally been managed from a strongly state-centered institutional model, where the nation-state is seen as an actor that must act within its best interests. Owing to the diverse and often competing demands for water (for economic growth and development, for urban population consumption, for food and agricultural production, etc.), transboundary waters have historically been an important piece of the puzzle for maintaining state sovereignty, regional stability, and security. According to Subramanian, Brown, and Wolf (2012), “the cause of international waters has developed through three interweaving streams of influence—the legal, environmental, and Integrated Water Resource Management (IWRM) streams” (p.62). The following will provide a brief explanation of the evolution of customary international water law principles within the context of the environmental movement and the emergence of IWRM, with a focus on emerging trends for transboundary groundwater governance.

Notions of sovereignty and the development of international water law principles

Historically, nation-states relied upon traditional notions of absolute sovereignty for transboundary surface water. Deeply held views on how transboundary rivers ought to be managed depended on your location, particularly whether you were an upstream riparian or a downstream riparian. Riparian just refers to the area located near the bank of a river. Upstream riparian countries tended to focus on the *theory of absolute territorial sovereignty.* The most famous assertion of this was in 1895, when U.S. Attorney General, Judson Harmon, proclaimed the right of the U.S. to utilize or divert the Rio Grande to meet any development needs that the U.S. might have without consideration for downstream conditions (Eckstein, 2002; Rahaman, 2009; Subramanian, Brown, and Wolf, 2012). In contrast, downstream riparians preferred the *theory of absolute territorial integrity*, whereby downstream riparians had the right to an unimpeded, natural flowing river (Eckstein, 2002). Fortunately, neither one of these theories hold sway within modern international surface water governance regimes because absolute sovereignty in a modern world of globalization could lead very rapidly to intense conflict over perceived inequities over water usage. Instead, the *theory of limited territorial sovereignty* is the most widely accepted approach to transboundary water sharing. Under this approach, upstream and downstream riparians are free to use the river as long as that use doesn't preclude use by the other riparians (Rahaman, 2009). This limited approach allows countries to manage transboundary resources harmoniously, for the most part, with less intense conflict because each country has agreed to limit their sovereignty to achieve improved cross-border resource allocation and sharing.

Recently, there has been significant movement on the development and acceptance of customary international law principles for transboundary water management. Customary international laws are sub principles of the broader theory of limited territorial sovereignty and help to offer guidance on best practices under limited territorial sovereignty. "Customary international law consists of the practices of states undertaken out of a sense that the practice is required by law" (Dellapenna, 2011, p.586). This is not referring to actual international treaties, but rather to the principles that have emerged as globally-acceptable international law principles that can be codified into bilateral or multilateral treaties for shared waters. However, codification, ratification, and implementation of an internationally-acceptable set of law principles has been slow and halting, at best. Governance of transboundary groundwater has proven to be even more challenging. Historically, groundwater has been excluded from the conversation of international law principles and management. Development of customary international law principles for groundwater governance is in a nascent state and has traditionally been ignored and left up for sovereign takings.

International water law principles have been shaped and influenced primarily by three different organizations: the UN International Law Commission (ILC), the International Institute of Law (IIL), and the International Law Association (ILA). The latter two organizations are scholarly in intent; thus, the end products are seen mostly as potential guidelines or references (Eckstein, 2002). Formal international water cooperation began initially over the navigational-uses of waterways, with early focus on navigation (Rahaman, 2009). However, as development continued and populations grew, countries began to face difficulties regarding the non-navigational uses of transboundary water. In 1911, the International Regulations Regarding the Use of the International Watercourses for the Purpose other than Navigation, also known as the Madrid Declaration, was issued by the IIL (Subramanian, Brown, and Wolf, 2012). This is seen as one of the earliest attempts at addressing the legality of non-navigational use of transboundary rivers and was followed up with several statements and resolutions adopted by the ILA. By the 1960s, it became increasingly clear that a more comprehensive document was needed to help with the broader codification of international water law principles. In 1966, the ILA adopted the

Helsinki Rules on the Non-Navigational Uses of International Watercourses (known as "Helsinki Rules"), which created a more cohesive document that brought together the emergent principles in customary international law; most notably, principles of equitable and reasonable use, and no significant harm, which are specific sub principles of limited territorial sovereignty.

Integrated Water Resource Management (IWRM) and its influence on customary international law principles

Customary international law principles and IWRM evolved concurrently and, as a result, have heavily influenced one another. Essentially, customary international water law principles and IWRM are two sides of the same coin. Both are concerned with providing guidance on how institutions develop to manage water. Customary international water law principles provide guidance on potential treaty language to include to achieve best transboundary water management practices. On the other hand, IWRM provides a technical toolbox for water managers to implement to achieve improved water management efficiency.

To provide some background, concurrently in the 1960s and 70s, environmental concerns began to top both national and international political agendas. This culminated in 1972 at the UN Conference on the Human Environment, held in Stockholm, where emphasis on the negative impact of humans on the environment began to take center stage. The nebulous concept of sustainable development became a driving force in the global arena. This was followed by the UN Conference in Mar del Plata, Argentina, where IWRM began to emerge as new paradigm for the management of water (Conca, 2006).

Conceptually, IWRM is the most widely utilized water management paradigm across the world. IWRM has existed as formalized, codified language in a number of places, ranging from recommendations in the 1992 Dublin Principles, to inclusion in the 2002 UN World Summit on

Sustainable Development in Johannesburg, and a more recent reaffirmation at the seventh World Water Forum in Daegu-Gyeongbuk in 2015. The concept of IWRM has been highly utilized and encouraged by international entities, such as the Global Water Partnership (GWP) and the United Nations Development Program. The primary tenants of the integrated water resources management system places a focus on water as a cross-sectoral resource that is necessary and intricately related to human survival. According to the GWP, an IWRM approach encourages three key objectives; (1) to balance the 3 Es, social equity, economic efficiency, and environmental sustainability, (2) to encourage cross sectoral and multi-level governance cooperation and coordination, and (3) to promote the development of a long-term water management strategy. The major methods to accomplish these objectives include the following; increased stakeholder participation, promotion of efficient use and conservation, adjustment of pricing to reflect 'true cost,' promoting public-private partnerships, and ensuring the integrated, cross-sectoral management of water resources, as well as the multi-level governance coordination (Global Water Partnership, 2010). This holistic method of water resources management places importance on wide stakeholder involvement, decentralized and highly integrated cooperation, education and the sustainable use of water. The use of IWRM couples economic, social and environmental concerns in order to highlight the fact of interdependency that is inherent in the use of water. The model calls for improved efficiency of infrastructure and water usage as well as the efficiency of governing institutions and water resource policy, particularly in the face of traditionally siloed water management sectors. "All the combined dysfunctions of the water sector have given rise to the concept of Integrated Water Resources Management (IWRM) that emphasizes integration of the management of land and water resources, of surface water and groundwater, of upstream and downstream uses, of sectoral approaches, of economic production and environmental sustainability, and of the state and non-state stakeholders" (Molle, Mollinga, and Meinzen-Dick, 2008, p.3).

The IWRM paradigm is now recognized as the guiding force for water resource management. However, much like the concept of sustainable development, IWRM has become a term that, with its vague and commendable goals, can be interpreted differently depending on the stakeholders concerned. In the 1970s and 80s, international water law principles and broader environmental law became heavily influenced by IWRM and the concept of sustainable development, whereby countries were promised a technical toolbox that could help them achieve greater integration, efficiency, and ultimately development, without the hefty price tag of pollution (Beaumont, 2000). By the 1990s, the global paradigm of IWRM began to find application, not only in practical, on-the-ground projects, but also in water law principles. This essentially is echoed in the principle of equitable and reasonable use, the principle of no significant harm, and the duty to cooperate.

Within this political backdrop, the UN's International Law Commission had been working for nearly three decades to negotiate and draft a politically-feasible codification of the IRA's 1966 Helsinki Rules (Conca, 2006) and in 1997 the UN Watercourses Convention (UNWC) was finally adopted. The UNWC is often considered to be a codification of customary international law for the non-navigational uses for freshwater. Not only are the principles highlighted by the UNWC broadly accepted within the international community, they have also been used in several international treaties and by the ICJ for the sustainable management of transboundary watercourses. The UNWC codifies the following principles of customary international law for transboundary watercourses: the principle of equitable and reasonable utilization; the obligation not to cause significant harm; protection of ecosystems; the principles of notification, consultation, and negotiation; the principles of cooperation and information exchange; and the peaceful settlement of disputes (Rahaman, 2009; Litke and Rieu-Clarke, 2015). These principles evolved over a long time period (starting as early as the 1911 Madrid Declaration), with ample time for adaptation, application, and implementation. Thus, the UNWC really was a codification of existing and broadly accepted customary international laws on transboundary watercourses (McCaffrey and Sinjela, 1998). However, the UNWC only gained enough signatories to be ratified in 2014 (Eckstein, 2014). Part of the reason for the long process of development and ratification has to do with how the UNWC defines a watercourse. In the UNWC, a watercourse is defined as “a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus” (UNWC, Art 2a). This legal connection between surface water and the physically connected groundwater has caused tension, disagreement, and conflict. For instance, the U.S. and Mexico have not ratified this document, partially based on this definition.

Even considering the broad acceptance of the principles as customary international law, it took over 25 years to draft and adopt the convention, and another 16 years to garner enough signatories to enter into force, with many countries still refusing to ratify (Eckstein, 2002; Eckstein and Sindico, 2014; Salman, 2015). Furthermore, according to some scholars, despite the entering into force of the UNWC and the broad acceptance of the principles as customary international law, there are not that many treaties on transboundary watercourses that specifically reference the language of the principles (Giordano and Wolf, 2003; Wolf, 1999) This is an ideal example of how slow and challenging it can be to generate a set of internationally-accepted norms for natural resource management. According to Ken Conca, “it may be that building a global regime for international rivers is a bottom-up process of aggregation and lateral diffusion rather than a top-down process of norm dissemination" (Conca, 2006, p.104).

While serious strides have been made in the development of customary international water law for surface water, groundwater management and regulation has lagged behind and is still considered to be in a budding stage of development. Groundwater is often still seen as being strongly within the purview of the state, as in the case of the U.S. and Mexico. There are several reasons for the nascent state of international groundwater law: the technical understanding of transboundary aquifers is still limited in many places; aquifers present a much more complicated management challenge, due to their highly heterogeneous nature; and there are still relatively few international treaties that incorporate groundwater. The 2008 Draft Articles on the Law of Transboundary Aquifers are an attempt by the ILC to create a more comprehensive approach to groundwater management but are modelled after the principles found in the UNWC (Eckstein and Sindico, 2014). However, in contrast to the 25+ year development of the UNWC, the Draft Articles were put together at a furious pace, especially by international standards. Many countries are still not familiar or comfortable with the principles located in the Draft Articles (Eckstein and Sindico 2014). Furthermore, there is little evidence within the broader legal context of emerging customary international laws for transboundary aquifers. "Only five particular transboundary agreements count on a legal mechanism concerted among their aquifer states" (Movilla Pateiro, 2016, p.854). Out of the five transboundary agreements, all tend to take an ad hoc approach to crafting their agreements, with little consensus from case to case (Eckstein 2017). In the ILC's Draft Articles, there are several principles that overlap with the UNWC, including the principle of equitable and reasonable utilization, obligation not to cause significant harm, obligation to cooperate, regular exchange of data and information, and the protection and preservation of ecosystems (Draft Treaty, 2008). However, it differs in a few very important and controversial ways. Most notable, Article 3 asserts that States have sovereignty over the aquifers underlying their lands. Many scholars argue that this is a step backward in the development of international water law (McCaffrey, 2011; McIntyre, 2013). However, some see it as necessary in order to move forward (Sindico, 2011). The ILC's Draft Articles also place special rules in place for groundwater specific needs, such as the acknowledgement of recharge and discharge zones (Art. 11) and especially the focus on the need for establishing bilateral and regional agreements and arrangements (Art. 9).

The slow and halting process for the UNWC stands in stark contrast to the ILC's 2008 Draft Articles on the Law of Transboundary Aquifers, which were developed for the UN in only six years (Eckstein and Sindico, 2014). After the adoption of the UNWC in 1997, it became apparent that the definition of 'watercourses' excluded groundwater that was not connected to surface water, such as 'fossil aquifers' (McCaffrey, 2011). In an attempt to rectify this oversight, the ILC began working in earnest to draft a set of articles that would be more comprehensive for the management of transboundary aquifers. However, despite extensive work at the international level to promote common international water law principles, very few principles have been stated clearly within international treaties.

International Principles: Equitable and Reasonable Use

While international water law principles are helpful in designing treaties, rarely are they explicitly applied within treaty language. An ideal example of this is the principle of equitable and reasonable use, which is one of the primary principles recognized within customary international law. This principle has historical roots within the original riparian rights system that was used in England and Wales (Beaumont, 2000). Emerging in the ILA's Dubrovnik Statement in 1956, the principle of equitable and reasonable use started out as merely a suggestion for upstream riparians to consider their impact on downstream riparians (Beaumont, 2000). This concept was reiterated again by the ILA in New York in 1958, while the notion of equitable and reasonable use was refined to imply beneficial use (Subramanian, Brown, and Wolf, 2012). In 1966, with the adoption of the Helsinki Rules and the later codification in the UNWC in 1997, the principle of equitable and reasonable use was officially codified and has been used in enough international agreements to be widely considered as one of the primary tenets of customary international water law. However, many scholars argue that the principle itself is too vague to provide clear interpretation (McIntyre, 2013).

The UNWC doesn't provide clear guidance on how the principle should be applied (Giordano and Wolf 2002). Many argue that the language was designed to be intentionally vague so as to be flexible enough to be adapted to the varied landscape of transboundary water management (Eckstein, 2002; Wouters, 2000; Beaumont, 2000). Furthermore, "equitable and reasonable utilization rests on a foundation of shared sovereignty, equality of rights and it does not necessarily mean equal share of water" (Rahaman, 2009, p.210). The intentional vagueness of the language used to describe what is considered 'equitable and reasonable use' has been cause for considerable debate for the purposes of application (Giordano and Wolf, 2002; Eckstein, 2002; McIntyre, 2013). In practice, there are very few treaties that refer explicitly to the UNWC or the principle of equitable and reasonable use; the Mekong Agreement (1995) is one example (Giordano and Wolf, 2002). McCaffrey argues that the UNWC and the principles that are codified within, acts primarily as a guidance document, particularly in the absence of an existing treaty or in the face of conflict (McCaffrey, 2011). Aaron Wolf (1998, 1999) has repeatedly argued that the UNWC codifies customary international water law principles, but it is often ignored in the actual negotiation of treaties, with countries preferring to set out their own custom-designed specific rules, rights, and obligations. The results of these treaties may represent customary international water law principles in practice, but do not explicitly refer to the language used in the UNWC (Wolf, 1999).

However, there is evidence within the international community of a shift towards acknowledging and engaging a broader concept of stakeholders (Islam and Susskind, 2013), rather than relying only on the nation-state as an actor; of the importance of "soft power" rather than just formal power (Zeitoun, Mirumachi, and Warner, 2011); of managing rivers at the basin scale, rather than being constrained by political jurisdictions (Huffman, 2009; Nava and Solis, 2014; Trevin and Day, 1990); and of multilateral cooperation as a way to promote peace and security, rather than unilateralism as the guiding force (Young, 2011; Young et al., 2006; Young, 1989). The underlying and uniting theme in these paradigm shifts is to promote cooperation as the primary tool to limit international conflict. The following section will outline how the global water management discourse has changed over time and will highlight the growing importance of the concept of water security for achieving improved transboundary water management.

From IWRM to Water Security: Exploring changes in global discursive frameworks on transboundary water management

In the previous section, we explored a whirlwind history of how international water law principles have evolved to help guide the development of institutions responsible for shared water resources and we touched briefly upon IWRM as "the discursive framework of international water policy" (Conca, 2006, p. 126). This section will delve more in depth into IWRM and how is has developed over time, given relative successes and failures of implementation worldwide. This section will also discuss the emergence of water security as a new way of thinking and framing water management issues. Many scholars argue that the two frameworks are compatible and can strengthen one another in terms of achieving improved water outcomes (Cook and Bakker 2012; Gerlak and Mukhtarov 2015; Hailu, Tolossa, and Alemu 2018) Water security places a strong focus on improving cooperation and reducing conflict over transboundary water and proponents of IWRM have also begun to hone-in on this focus as well. The final part of this section will discuss the importance of understanding drivers of conflict and cooperation for improving transboundary water sharing and, ultimately, regional water security.

Conceptually, IWRM supports water sustainability, the integration of management across diverse sectors, highlights the need to balance economic, social and environmental concerns regarding water usage, and calls for a large variety of stakeholder involvement. The IWRM model primarily operates from a top-down and bottom-up approach and encourages “hard” and “soft” methods, through governmental institutions, policy making and increased infrastructure efficiency. In theory, when IWRM methods are implemented correctly and completely, it should offer a fairly strong planned adaptation mechanism for planning across sectors and borders.

However, the transition from theory to practice can be problematic and within the literature multiple problems of implementing the conceptual framework have been identified, including that it is difficult and time consuming for developing countries to institutionalize this method. Countries with a long tradition of highly centralized governmental structure, such as Mexico, will encounter difficult roadblocks in trying to fully integrate water resources management into the institutional structure. “The IWRM arena has been marked by struggles over public versus private authority, conflict over market versus non-market bases for resource valuation and allocation, and tensions between the territorially fixed character of the state and the transnationally fluid character of contemporary global capitalism” (Conca, 2006, p.128). Another problem that can emerge from utilizing the IWRM model in a poor, developing country is the issue of privatization. There is a fine balance that must be maintained regarding the price of water, as privatization can exacerbate social inequalities. While IWRM has received extensive praise at the international level, enjoying widespread inclusion in international agreements presented by the United Nations (UN), there are a growing number of dissenting voices emerging within the broader scholarly literature (Allan, 2006; Biswas, 2008; Molle, 2008; Giordano and Shah, 2014).

After decades of riding the IWRM train to implementation, it has become evident that there are problems with the practical application of IWRM. In fact, a newer trend has started emerging in the literature, particularly in the last fifteen or so years, which shifts the ultimate goal from IWRM to the achievement of water security (Bakker, 2012). Global water experts, while still convinced of the conceptual merit of IWRM, are now focusing their attention on IWRM as a path to achieving broader water security, with water security being the ultimate goal (Gerlak and Mukhtarov, 2015).

Water Security: a new global discourse?

Water security is a term that has gained massive traction within the past two decades. It initially emerged out of a post- cold war era conception of regional and national security, which highlighted the need to include environmental or natural resource issues into the conversation (Fischhendler, 2015; Gerlak and Muhtarov, 2015). "Environmental change and resource scarcities can lead to economic decline, social turmoil, disputes, or forced migration, which may in turn lead to instability, violence, and even armed conflict" (Dinar, 2002, p. 232). The concept of water security emerged as a way to highlight that water is a basic human need and that pre-existing power asymmetries between countries often lead to inequities and insecurities in weaker countries. In particular, in the 1990s, there was increased focus on the potential for water stress or scarcity to spark “water wars” or lead to regional instability (Pielou, Gleick, and Hillel 1999; Homer-Dixon, 1995; Butts, 1997). Since the 90s, it has been determined that volatile conflicts over water are unlikely and are only found in systems where there is not sufficient institutional capacity to absorb rapid changes in the physical or institutional system (Wolf, Yoffe, and Giordano, 2003; Wolf, 2004; Zeitoun and Mirumachi, 2008; Cook and Bakker, 2012).

A focus on water security has sought to limit potential for conflict by encouraging cooperation via the incorporation of customary international law principles, an increase in development of institutions to handle cooperative efforts, and a change is discursive framing of water scarcity issues (Berardo and Gerlak, 2012; Cook and Bakker, 2012; Petersen-Perlman and Wolf, 2015). While multiple definitions have been suggested, water security is often defined as “an acceptable level of water-related risks to humans and ecosystems, coupled with the availability of water of sufficient quantity and quality to support livelihoods, national security, human health, and ecosystem services” (Bakker, 2012, p.914). This definition highlights the coupled nature of human societies and our reliance on complex, natural systems. Within this definition, we can already see that there is a stronger focus on using a systems-thinking approach, where the complicated socio-ecological interdependencies are emphasized and risks to these interdependent systems are highlighted as potential risks to national or regional water security, where water is seen as a basic human right (Bakker and Morinville, 2013).

Water security is a new discursive framework for trans-border water management. In contrast to IWRM, water security highlights the need of “good governance- namely transparency, accountability, public participation, legitimate policy processes, equity and effectiveness- and aiming at sustainable development” (Gupta, Dellapena, and van den Heuvel, 2016, p.120). Water security and IWRM are similar, in that they both highlight the multi-scalar interlinkages within the natural system and the many, often conflicting, uses of water for both human development and ecological stability; however, water security places more emphasis on the need for adaptive governance in response to risks in dynamic systems and highlights the nature of water as a basic human need (Berado and Gerlak, 2012; Cook and Bakker, 2012; Bakker and Morinville, 2013; Gerlak and Mukhtarov, 2015).

Traditional IWRM places the focus on creating a comprehensive management structure to streamline management, using natural hydrological boundaries -such as river basins or watersheds- as the management unit. It has been argued that the IWRM approach doesn't adequately consider all the difficulties of managing water across international borders, and, in particular, ignores concepts of social power or issues hydro-hegemony, focusing instead on using technocratic approaches to balance social, economic, and environmental needs (Jensen, 2013; Giordano and Shah, 2013; Gerlak and Mukhtarov, 2015). However, many international organizations (e.g. United Nations Environmental Programme; Global Water Partnership; and United Nations Educational, Scientific, and Cultural Organization) have started to integrate water security into the global discourse by asserting that water security is the goal for management and IWRM is a prescriptive path towards achieving that goal (Bakker and Morinville, 2013; Gerlak and Mukhtarov, 2015).

Cooperation and Conflict: drivers of water security

The role of cooperation and conflict is vital in securing water at local, state, national, and international scales. "Cooperation is defined as the process by which states take coordination to a level where they work together to achieve a common purpose that produces mutual benefits that would not be available to them with unilateral action alone" (Leb, 2015, p.22). Regional water security is increased when nations cooperate to manage resource use, but also to generate shared benefits from the use of transboundary waters (Alam, Dione, and Jeffrey, 2009). “Conflict can be regarded as existing when an actor attempts to exert power over another actor to overcome that actor's perceived blockage of the first actor's goals and faces significant resistance” (Frey, 1993, p.66). While fear over ‘water wars’ and conflict induced by water scarcity has been found to be the exception and not the rule (Wolf, 2005; Petersen-Perlman and Wolf, 2015), issues of conflict do arise between nation-states ranging from low-level, non-politicized types of conflict to violized, or high-level conflicts (Zeitoun and Warner, 2006; Zeitoun and Mirumachi, 2008). By studying cooperation and conflict, academics and world leaders can gain a deeper understanding of what system characteristics can lead to effective water security. There have been a large number of studies looking at what drives cooperation and conflict, but the vast majority of studies look at the institutional context: these include characteristics such as examining laws or policies in place to limit use or enforce limits; exploring treaty mechanisms, which serve as international laws between two countries; identifying how hydro-hegemony or power structures impact cooperation or conflict; and outlining how polycentric, or nested, institutional structures function to limit conflict and/or encourage cooperation.

Individual decisions-makers: how individuals can drive cooperative or conflictual behavior within institutional settings

An undertheorized component of transboundary water sharing is what role individuals play in influencing cooperation or conflict. As we have already seen in previous sections, institutions are made up of laws, policies, rules, and procedures. Institutions are constrained by scope and authority. However, it is important to note that institutions are also run by people. Human decision-makers within institutional settings can influence changes in how rules are interpreted and enforced. Institutions are comprised of individuals, arranged in a decision-making hierarchy, with different responsibilities and level of authority, who are given responsibility to carry out the mission of the institution, enforce the rules and procedures associated with that mission, and shape how future decisions should be made. It has been understood for a long time, particularly within studies of common pool resource management that individuals can act as champions or catalysts within an institution to bring about change in either procedure, rules, or even overarching missions. To ignore the potential drivers of individual decision-making within institutional contexts for transboundary water management is to ignore the most capricious characteristic.

There are several different theories that make assumptions about how humans make complex decisions. These theories include the rational choice theory, expected utility theory, and bounded rationality theory, which will be further explored and explained in Chapter 2. These theories can be nested within other theories and used as models to generate conceptual understanding of human decision-making.

Drivers of Cooperation and Conflict: How individual Perceptions of Risk and levels of Trust impact willingness to engage in conflict or cooperation

Cooperation and conflict are not just the results of decisions made at the institutional level. Leaders within institutions are the primary interpreters of laws, rules, procedures, and overall institutional authority and mission. Individuals can champion specific causes or write to policy-makers to influence changes or interpretations of laws or policies at the state and federal-level, which naturally has an impact on international water treaties between nations. A deeper understanding of the human component of institutional decision-making is necessary to generate a deeper understanding of when cooperation is promoted at different scales or when conflict is embraced. There are strong theoretical underpinnings for studying individual decision-making; however, these have not been applied to transboundary water settings.

The study of how humans use risk perceptions to make decisions has been primarily applied within hazards research (Slovic, 1987). This is a well-studied body of literature that uses the psychometric paradigm, developed by Paul Slovic and others, to measure which specific factors or characteristics of a specified hazard or risk influence how a person perceives that risk and, in turn, what type of decisions a person will make to mitigate that risk (e.g. evacuate during floods). However, while this approach has been utilized for water hazards like flooding or drought, it has never been applied to deepen the understanding of how leaders or decision-makers within transboundary water sharing settings make decisions regarding more intangible risks, such as a risk to sovereignty. This concept of intangible and political types of risk, as proposed by Subramanian, Brown, and Wolf (2012, 2014), is necessary to understand how policy makers and leaders make decisions regarding cooperative or conflictual behaviors over shared transboundary resources at different tiers of governance; local, state, and federal. These intangible risks include risks to 1) sovereignty and autonomy, 2) equity and access, 3) stability and support, 4) capacity and knowledge, and 5) accountability and voice (Subramanian, Brown, and Wolf 2012, 2014). These categories of perceived risk will be more thoroughly explained in Chapter 2.

Another well-supported concept that has been used to identify when and where humans are willing to make certain decisions is the concept of trust, which has been explored from a variety of theoretical backgrounds. From a social capital perspective, trust is one of the central tenets in generating willingness to cooperate. This has been studied extensively within the context of common pool resource management but has not been measured in a transboundary water sharing setting. Additionally, within the context of risk perception, trust has been seen to be a modifying factor, with the potential to reduce perceptions of risk and level of trust increase (Earle 2010). There are a variety of aspects of trust that have been measured by previous studies, but for the purpose of understanding how trust impacts willingness to cooperate or engage in conflict, this study uses five different types of trust; general trust, dispositional trust, affinitive trust, rational trust, and procedural trust, which will be further outlined and explored in Chapter 2 and Chapter 4.

The following section will identify the proposed conceptual framework for filling this gap within the literature, by placing a focus on how individual perceptions can be aggregated at the institutional scale to better understand drivers of cooperation and conflict.

Conceptual Foundations: understanding individual drivers of cooperation and conflict within institutional contexts

This chapter started with a discussion of modern transboundary water sharing challenges; water scarcity, population growth, climate change, environmental degradation, and challenges associated with complex, polycentric governance structures. The chapter then explored the importance of the role of institutions in managing these collective action challenges, the evolution of solutions at the supranational level (development of customary international law principles for water and the emergence of IWRM as a global paradigm), and the importance of understanding cooperation and conflict as drivers of water security over shared transboundary resources. This section will highlight the purpose of this research, the theoretical and conceptual frameworks that are utilized, and a brief description of the chosen case study and how it highlights characteristic problems of transboundary water sharing across the world.

While transboundary water sharing has a long history, rooted in international relations literature, little is known on the driving factors for individual decision-makers (nested within institutional settings) to engage in cooperation or conflict over international transboundary water issues. Substantial efforts have gone into conceptualizing key metrics of successful cooperation over internationally-shared water resources; however, most do not have a strong empirical approach or rigorous empirically-grounded theoretical underpinnings and most only focus on how institutions can encourage cooperation or conflict, ignoring the role of individuals within the institution. Additionally, most of the literature is focused on surface water sharing. Drivers of cooperation or conflict over transboundary groundwater resources are poorly understood, partially due to the complicated nature of the hydrological system and partially due to the complex historical progression of laws governing water.

The purpose of this research is threefold: (1) to provide a deeper understanding of the historical evolution of cooperation and conflict over transboundary water sharing; (2) to understand individual drivers of cooperation and conflict, in particular, how levels of trust and perception of risk impacts formal and informal cooperative and conflictual behavior; and (3) to gain insight into the relationship between perceptions of risk and levels of trust over transboundary water resources, using the relationship between Texas and Mexico as a case study. Understanding how individual actions within the policy arena add up into broader societal impacts is a difficult process that requires a clear conceptual framework and analytical process for describing the working parts of nested complex systems. The Social-Ecological Systems (SES) framework offers an ideal outline for conceptualizing the relationship and feedback mechanisms between individuals, their natural environment, and the institutions they create to manage that environment (Poteete, Janssen, and Ostrom 2010). Within the SES framework, there are nested concepts of interactions that link the extraction of resources to the resource users within the broader context of the governance and biophysical systems (Ostrom 2009). This framework is ideal for use in understanding overarching water security issues because it serves to illustrate how the interactions between resource users or actors within the broader system add up to larger societal outcomes. The SES framework can offer researchers and policy makers a clear way to understand the complex feedback mechanisms that exist between individuals, the institutions they create, the biophysical system, and the outcomes of those interactions. This framework offers a clear process to lay out the components of the larger system structures and to understand how individual actions can add up to larger societal changes in public policy.

A systems-thinking approach will help accomplish these goals because it is necessary to understand an entire system in order to be able to fully dissect and understand a smaller portion. In order to provide a deep understanding of the entire system, this study will utilize the SES Framework to help clarify and categorize each system component.

The theoretical components will be incorporated into the larger SES Framework by combining multiple theories to understand different aspects of the system. Results will provide readers with a deeper understanding of mechanisms and characteristics of each aspect of the system**.** Within academic traditions of international relations, there are methods of analysis that focus on how institutions shape economic and political behavior. International relations researchers have tried to understand large-scale governance and cooperation, particularly across international boundaries by focusing on the role of bilateral or multilateral treaty formation and the impact of power asymmetries on the negotiation of those treaties or agreements (Zeitoun and Warner 2006). CPR theory has placed focus on polycentric or multi-level governance structures to shed light on the nature of institutions by focusing on how institutions function within nested systems and how those systems can constrain or shape the role of institutions in managing water resources. Using common pool resource theories about polycentric governance structures will help us to understand how institutions function within larger, nested political hierarchies.

While theoretical concepts about polycentric governance and power asymmetries are useful for understanding evolution of institutions, these approaches often don't consider the role of individuals within institutions. In studying how institutions are created, it is important to understand the models of individual decision-making, the collective role of individuals in forming institutions, and underlying social constructs that drive the form of those institutions. To explore the role of individuals, we must look to social psychology for answers. Theories about human decision-making have gone from assuming that humans always make rational decisions, based on perfect understandings to a more realistic theory of bounded rationality, which states that humans are bounded in their ability to make rational decisions because of imperfect information and constraints on processing time. To understand how humans make decisions over resources, CPR theory will be utilized to support a deeper understanding of how trust and social capital contribute to willingness to make certain decisions regarding cooperative or conflictual behavior over shared resources. This theory is useful for understanding how individuals make decisions within the constraints or absence of constraints provided by institutional structures, however, it doesn't tell the whole story. Theories on risk perception are potentially very useful for filling this gap because it helps us to understand how and why individuals make decisions in the face of tangible and intangible risks.

This study applies this conceptual framework and theoretical approach to understand cooperation and conflict between the U.S. and Mexico, specifically by looking at Texas - Mexico as a case study. In order to measure these concepts, a questionnaire was developed and appropriate decision-makers were identified within different institutions and at different tiers of governance in Texas. Texas served as an ideal geographic location to test these concepts because it covers the largest stretch of the U.S. - Mexico border, has a long institutional history of both cooperation and conflict, and has generally been successful in generating more cooperative behaviors for transboundary water management than other case studies that have been analyzed within the broader literature.

To answer these questions, the dissertation will be structured in the following way. Chapter 2 will outline the theoretical and conceptual studies that have explored transboundary water sharing between countries and will identify both strengths and weaknesses of each approach or theory that has been previously used. Chapter 2 will offer an explanation of how different theories will be combined within the SES framework, in order to answer questions regarding how perceptions of risk and levels of trust influence decisions regarding willingness to cooperate or engage in conflict over binational, shared water resources. This chapter will also provide an in-depth explanation of the hypotheses and objectives of this study. Chapter 3 will offer a comprehensive exploration of the study location to be explored by using the SES Framework to outline the different components that are important for contextual understanding of the case study. This chapter will focus on the natural system (both surface water of the Rio Grande Basin and groundwater occurring along the U.S.-Mexico border), the governance system (outlining treaties and other informal agreements), and the system actors (managing institutions, resource users, and major decision-makers). Chapter 4 will then provide a detailed explanation of what metrics were used within the development of the study, how and why those metrics were chosen, an explanation of questionnaire development and distribution, along with specific analytical tools chosen. Finally, Chapter 5 will provide the results of this study, along with an exhaustive analysis of what those results mean in theory and practice, how the results can be applied in other transboundary water settings, and potential implications for future studies.

CHAPTER II

RISK PERCEPTION, TRUST, AND WILLINGNESS TO COOPERATE: A CONCEPTUAL FOUNDATION

This chapter serves as a literature review and an introduction to the development of broad hypotheses regarding transboundary water sharing across international borders, how institutions constrain and shape those interactions, and the role that risk perception and trust plays in individual decisions to engage in cooperation or conflict at different tiers of governance. Multiple bodies of literature have explored these topics, including literature on institutions (institutional analysis, common pool resource (CPR) theory, international relations, water security, and conflict and cooperation) and literature on individuals (risk perception as it relates most directly to cooperation and conflict over international waters; and different types of trust and the role trust plays in building reciprocity). Focus is placed on exploring how all these bodies of literature can be used to develop a better theoretical framework for analysis of cooperation and conflict over shared transboundary waters, by highlighting risk perception and trust as drivers of decision-making over shared water management. Special emphasis is placed on how an improved understanding of transboundary water management decisions can be gained by looking at both institutional characteristics and how individuals within institutions develop attitudes and behaviors, given institutional constraints or missions. Risk perception and trust are explored as potential drivers of willingness to cooperate or engage in conflict, but these variables are also explored within a polycentric or multi-level governance environment in order to identify how individuals operate within their organizational or institutional constraints. At the end of this chapter broad hypotheses and objectives are discussed, along with how they fit within the current conceptual frameworks and contribute to deeper theoretical underpinnings of cooperation and conflict.

Introduction

Understanding the key factors that lead to equitable and sustainable international water-sharing has long been a goal for water managers, policy-makers, and academics alike. As such, one of the core roots of academic literature is found in international relations and international law, especially water security. However, analogous issues have also been addressed from many other perspectives, including socio-ecological systems, coupled-natural-human systems, resilience, common pool resources, environmental, resources and ecological economics, environmental anthropology, psychology and sociology, political ecology, and geography and land-use, among others (Cox et al., 2016). The sheer depth and breadth of the knowledge generated within these diverse disciplines is impressive.

Despite extensive literature from a variety of disciplines and perspectives, transboundary water governance is a rapidly evolving field that still lacks rigorous, empirically-tested theory. While there is an abundance of literature exploring conceptual models applied to transboundary water management, the field lacks generalizable theories that help understand decision-making and cooperation at various levels and types of governance across international boundaries, and has been limited by the largely individual case study-basis of empirical work. Efforts to conduct more rigorous comparisons have either found few patterns to explain cross-national cooperation (Delli Priscoli and Wolf, 2008), or have focused on environmental cooperation broadly, providing few inferences that can be applied specifically to transboundary water cooperation (Mitchell, 2006).

This research provides insight by combining distinctively different academic traditions rooted in political science, international relations, cognitive psychology, and sociology. Each of these approaches have weaknesses and cannot fully explain or predict cooperative behavior amongst the typically large and diverse set of stakeholders found in international water sharing settings. International relations and water security theories tend to focus on the importance of country-level actors and institutions (Lankford et al., 2013; Islam and Susskind, 2013; Delli Priscoli and Wolf, 2008; Mitchell, 2006; Conca, 2006; 2015), while the sociological and psychological literatures on trust and risk perception focus on individual-level traits and tend to downplay or ignore the importance of institutions and nation-to-nation relations (Slovic, 1987; McDaniels et al., 1997; Willis et al., 2004; Earle and Siegrist, 2008; Dobbie and Brown, 2014). The CPR theory is helpful because it does look at both institutions and individuals to examine how institutional structures and rules shape or constrain individual decisions to consume resources (Ostrom, 1990, 2008, 2011; Poteete, Janssen, and Ostrom, 2010). However, CPR theory lacks a clear understanding of the role that power dynamics play within and between institutions, it has traditionally been applied to small to medium sized resources, and it does not address clearly how individuals within institutions use perceptions to make decisions (Clement, 2010; Schlager and Cox, 2018; Fleischman et al., 2014; Cox et al., 2016).

Within international relations theories on water security and the role of conflict and cooperation, little attention has been given to the nature of transboundary waters as a type of common pool resource. The institutional analysis frameworks developed by Ostrom offer a compelling context for combining CPR theory with water security conceptualizations to understand how power dynamics at the nation-to-nation level can impact or influence the development of appropriate institutions. However, even with the combination of these two strong theories, one component is still undertheorized; the role of the individual within institutional settings to influence the changing dynamic of rules, policies, and laws. Risk perception literature can fill this gap by identifying how individuals use perceptions to make decisions.

There is no existing literature that empirically studies differences in risk perception and trust among transboundary water actors at different levels of government or in different decision-making positions over water governance, although this idea has been addressed more broadly in other areas of governance and policy (Lipsky, 1980; Hill and Hupe, 2009). By utilizing a combination of these approaches – with risk perception, trust, and willingness to cooperate or engage in conflict measured at the individual level, and variations in these measured for individuals within different institutional positions and tiers of governance (Mirumachi and Van Wyk, 2010) -- a deeper understanding is provided for how, why, and when stakeholders (decision-makers and other interested parties) cooperate effectively over shared transboundary water resources.

Frameworks for analysis: Institutional Analysis & Development and Socio-ecological Systems

Frameworks are useful in helping researchers conceptualize different theoretical components for analysis. According to Elinor Ostrom, "Frameworks identify the elements and general relationships among the elements that one needs to consider for institutional analysis and they organize diagnostic and prescriptive inquiry" (Ostrom, 2011, p.8). Institutions are a vital function for the organization of human societies. An institution is defined by Douglass North as "the humanly devised constraints that shape human interaction" (North, 1991, p.97). Since institutions are "humanly devised constraints," it is imperative to understand how humans devise those constraints collectively, how those institutional constraints influence individual attitudes and behavior, and also how different conceptual models of the individual can tell policy makers about how humans solve collective action problems. Collective action problems are challenges that require collective action by a large group of people in order to generate benefits for all and reduce negative externalities associated with self-interested individual action (Olson, 1965; Poteete, Janssen, and Ostrom, 2010). An ideal example of a collective action problem is the "tragedy of the commons," where public goods, such as groundwater, are not adequately protected by property rights or rules-in-use, and as a result there is a negative incentive to race to the bottom, where individuals are acting within their own best interests, while ignoring the negative external costs or externalities associated with their use of the resource (Poteet, Janssen, and Ostrom, 2010).

It is of great interest to academics and policy makers to understand what types of institutional structures or design principles help to facilitate successful collective action to limit inefficiencies within the management of public goods, like common pool resources. In the 1960s, Vincent and Elinor Ostrom began exploring ideas about the various components of an organization and different intergovernmental relationships (Ostrom, V. and Ostrom, E., 1965). This initial research soon exploded into a full-blown effort on how to understand and better describe and analyze how institutions function to manage different types of collective action problems. The conceptual framework of Institutional Analysis and Development (IAD) was initially presented in a 1982 publication by Kiser and Ostrom (Ostrom, 2006). Since then, the IAD Framework has evolved many times and has been used ubiquitously by political scientists, geographers, anthropologists, economists, social psychologists and many other academic disciplines to understand how institutional constraints influence the behavior of actors to address collective action problems (Ostrom, 2006; Poteete, Janssen, and Ostrom, 2010; McGinnis, 2011;

Cox et al., 2016). The IAD Framework is useful because it aids researchers in the identification and categorization of different structural components and relevant explanatory factors necessary for understanding how institutions shape or constrain the development of laws, policies, rules, or procedures, which influences individual attitudes and behaviors regarding collective action problems (Ostrom, 2006, 2011; McGinnis, 2011). The primary components within this framework help researchers by determining how exogenous variables, such as biophysical conditions, attributes of the community, and rules-in-use, impact action situations that lead to interactions and outcomes (Ostrom, 2006, 2009, 2011; McGinnis, 2011).

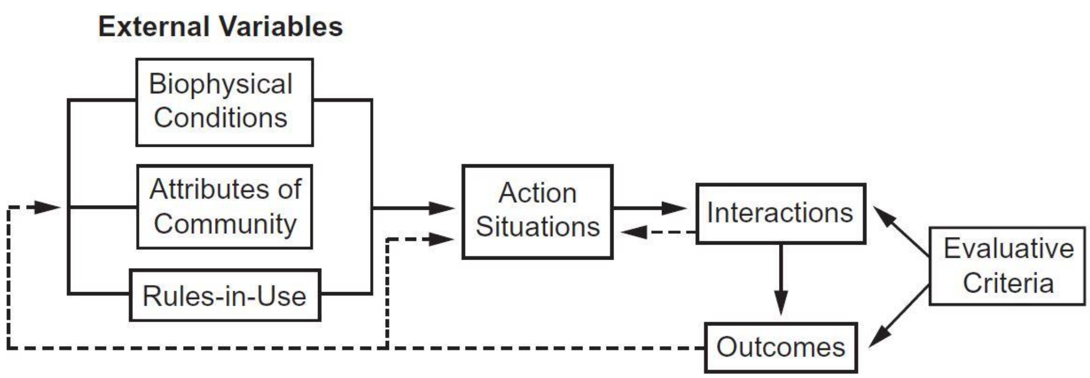

Figure 1: Framework for Institutional Analysis
Reprinted from Ostrom 2005

Within each of these components are nested concepts that analysts can use to fully understand an institutional system. Through an extensive body of literature, IAD Framework has been combined with a variety of theories to study a large variety of collective action problems (Ostrom, 2011). The resounding successful application of the IAD Framework since its initial debut has resulted in evolution over time, not only of concepts and variables, but also of the application to other disciplines.

The Socio-Ecological Systems (SES) Framework emerged directly out of the IAD framework to address complex ecological systems and the socio-economic drivers that impacted those systems (Ostrom, 2007, 2009; McGinnis, 2010). For ecologists the IAD Framework was somewhat limited by the biophysical component, which was not seen as adequate to address complexities of natural ecological system input and outputs (Ostrom, 2011). Within the SES framework, there are nested concepts of interactions that link the extraction of resources to the resource users within the broader context of the governance and biophysical systems (Ostrom, 2009).

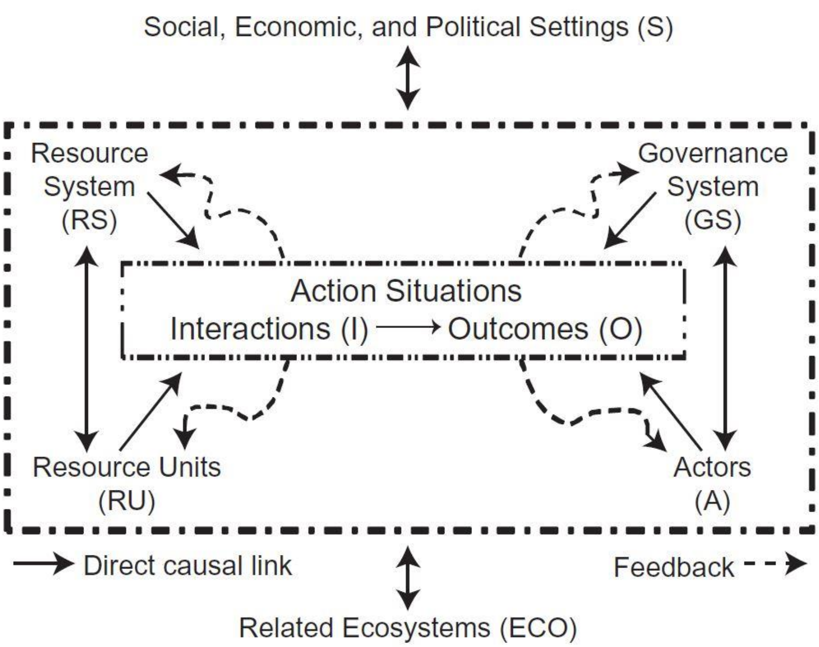

Figure 2: Action Situations Embedded in Broader Social-Ecological Systems
Reprinted from Ostrom, 2007

This illustrates possible linkages or interactions between resource users or actors and the broader system add up to larger societal outcomes. Essentially, the SES framework helps scholars predict how, when, and under what conditions individuals will self-organize to affect the management of resources (Poteete, Janssen, and Ostrom, 2010). Depending on the theoretical approach and underlying assumptions, in addition to the model of individual decision-making, the SES framework provides researchers and policy makers a clear way to understand the complex feedback mechanisms that exist between individuals, the institutions they create, the biophysical system, and the outcomes of those interactions. The complex feedbacks include a recognition between the complicated nature of system components and how a change in one component can drive change in another component because of interlinkages within the system. This framework offers a clear process to understand how individual actions can add up to larger institutional, or societal changes in public policy. It is an ideal framework to use for understanding how individual perceptions of risk and trust can be aggregated within institutional settings to provide a deeper insight into the internal, human dynamic of what drives institutional decision-making for cooperation and conflict.

In comparison with other theories, CPR theory has been consistently considered one of the most compatible theories to use with the IAD or SES framework (Ostrom, 2011). It is a very useful theory for understanding how institutions shape or constrain how resource users or system actors make decisions regarding the use of a resource. It is a theory that has evolved by using components of other theories on institutions and individuals. The following sections are dedicated to looking at relevant theories on institutions and relevant theories on individuals. Since CPR is a theory that looks at both institutions and individuals, it will be discussed throughout the sections on theory.

Understanding Theories: from the role of institutions to the role of individuals

Theoretical constructs are used by researchers to understand individual processes or components identified within a specific framework of analysis. Ostrom states that “theories make assumptions that are necessary for an analyst to diagnose a specific phenomenon, explain its processes, and predict outcomes” (Ostrom, 2011, p.8). It is necessary to have theories that can provide appropriate assumptions or expectations about processes or outcomes; however, sometimes one theory may provide a strong understanding of one component of a system, but cannot predict interactions or feedback mechanisms with other, related components. For instance, there have been a large variety of theories attempting to predict or explain processes of institutional arrangements, efficacy, or change over time. While it is important to understand institutional arrangements, many of these theories do not take into consideration how individual decision-makers, nested within these institutions, influence changes to institutional rules or how institutions shape or constrain individual perceptions or behaviors. Thus, it is necessary to combine theories on institutions and individuals in order to gain insight into how individuals behave within institutional settings to address collective action problems. The following sections will outline some of the most relevant theories that have been used to understand both the behavior of institutions and individual decision-making within the context of transboundary water management.

Theories on the Role of Institutions

This section highlights the development and use of theories that have been applied specifically to analyzing institutions and their role in addressing issues of public policy. In the previous section, the IAD and SES frameworks were briefly introduced and described. This section will focus on theories that either have been used with, or are compatible with, the IAD and SES framework to understand the behavior of institutions in creating rules or procedures to address collective action problems. There are many overlapping concepts within CPR and water security. However, the users of these theories are from distinctly different academic backgrounds and, as a result, there are a number of similar concepts known by different names. This section will discuss the importance of how these divergent academic traditions can be used together to deepen an understanding of institutional arrangements.

Polycentric Governance

Polycentric governance is an important theoretical concept that helps to explain how nested governance structures operate to meet needs for management of different types of systems. It is important to this case study because within water management, especially transboundary water management, multiple governance tiers are responsible for different aspects of water management based on institutional mission, political jurisdiction, and geographic area. Polycentric governance refers to the "nestedness" of a given management structure and helps to theoretically describe how those nested structures should behave. This section will describe the roots of this theoretical concept and its evolution and application to understanding institutional arrangements.

Polycentricity is a concept initially envisaged by Polanyi in 1951 to describe how participants within organizational systems, such as scientific researchers, are given freedom to express differing opinions, while sharing a common ideal (Aligica and Tarko, 2012). Vincent and Elinor Ostrom adapted the concept of polycentricity to describe how public goods could be provided at different scales by nested institutional structures (V. Ostrom, Tiebout, and Warren, 1961; McGinnis and E. Ostrom, 2012; Aligica and Tarko, 2012; Ostrom, 2014). When Vincent Ostrom originally published his ideas of how polycentricity applied to public administration, he highlighted that it was not a state-only or market-only approach, but rather an approach that emphasized the ability of states to interact with markets in order to administer a public good at the most appropriate and efficient scale of governance (V. Ostrom, Tiebout, and Warren, 1961; McGinnis and E. Ostrom, 2012).

Theoretical concepts of polycentricity are utilized by both the IAD Framework and the SES Framework to discuss how collective action rules can be formed within nested, polycentric governance structures in order to address common pool resource problems (Carlisle and Gruby, 2017). Within CPR theories, Ostrom identified eight institutional design principles necessary to sustainably manage common pool resources: 1) clearly defined boundaries, 2) locally-appropriate appropriation or provision rules, 3) actors impacted by operational rules can modify them, 4) monitoring of behavior and resource conditions, 5) graduated sanctions for violation of rules, 6) effective conflict-resolution measures, 7) rights to organize recognized by governmental authorities, and 8) multiple layers of nested institutions (Ostrom, 1990). These design principles have been found to be effective predictors of successful management of common pool resources when at least five of the eight design principles are incorporated into the institutional setting (Cox et al., 2010). Importantly, these design principles are all predicated on the concept of polycentric governance structures, particularly design principle eight, where nested levels or tiers of governance each have the semiautonomous ability to create rules at the most efficient scale for the management of public goods within an interrelated governance system. In subsequent work on CPR theory, Elinor Ostrom emphasized the importance of polycentricity for meeting several of the other design principles. In particular, Ostrom discussed rule-making at multiple tiers of governance: operational rules to manage day-to-day administration; collective choice rules to help manage the formation of operational level rule making; and constitutional-level rules govern the establishment of collective choice rules (Ostrom, 1990). In discussing these different tiers of governance, Ostrom highlighted that it did not have to be a governmental organization, but could be some mix of public and private institutions to collaborate for the formation of rules and procedures at different scales.

International relations (IR) literature also utilizes a version of this concept, however it is more commonly known as multi-level governance within the context of IR literature (McGinnis and Ostrom, 2012). This conceptualization differs slightly from the idea of polycentric governance because it evolved out of an attempt to understand how relationships change between different international organizations (from nation-state to supranational entities), where polycentric governance was initially geared at understanding smaller frames of reference (municipal to state to federal). Despite the differences in language, both concepts of governance identify situations where semiautonomous nodes of decision-making occur at different scales and across different types of organizations to provide for the most efficient management of a variety of public goods. Oran Young spent his career examining how international regimes could form to manage large-scale environmental issues. While this is a distinctly different academic approach, it does share conceptual foundations with the idea of polycentricity, with the main difference being the scale of analysis. As an example of where this concept has been applied, the IWRM paradigm promotes coordinated, multi-level governance as a way to stream-line technical management of water resources across many different sectors, both public and private. Another implicit assumption within this theoretical framework is that of subsidiarity, where management should occur at the lowest level of governance possible to achieve the most efficient outcome.

While traditional IR literature on water security doesn't often include language from IAD/SES frameworks or common pool resource (CPR) theories, there are a few studies that look at the role of polycentric governance structures to understand international transboundary water sharing (Rowland, 2005; Milman and Scott, 2010; Berardo and Gerlak, 2012; Nava and Sandoval Solis, 2014; Fleischman et al., 2014; Villamayor-Tomas et al., 2014; Garrick, Schlager, and Villamayor-Tomas, 2016). Additionally, it has been advocated by E. Ostrom and Keohane (both pioneers in their respective fields) that IR conceptualizations of institutions and IAD conceptualizations of institutions have overlapping concepts and compatible weaknesses, meaning a combined approach can lead to deeper understanding of the role that international institutions play in managing common pool resources (Ostrom and Keohane, 1994). However, as both academic traditions have an unwieldy amount of associated literature, it has been difficult, in practice, for academics to combine these two approaches. Rowland (2005) is one of the first to attempt to tie together concepts of CPR design principles to IR concepts of cooperation and conflict over transboundary water. However, this brief article does not adequately address how this could be applied, nor does it supply a compelling example. In an article by Milman and Scott (2010), an application of institutional analysis is performed by examining the polycentric nature of groundwater management on the U.S. – Mexico border. The authors conclude that, rather than aiding in achieving governance at the most efficient scale, “the gaps, overlaps, and ambiguities that arise from the polycentric and evolving structure of the institutional environment hinder the ability of the U.S. and Mexico to enact formal cooperation over transboundary aquifers” (Milman and Scott, 2010, p.544). Nava and Sandoval Solis came to similar conclusions in their 2014 publication, which looked at the Rio Grande Basin. Berardo and Gerlak (2012) turn their attention to applying design principles of CPR to try and understand what institutional features are most conducive to collective action within international river basins and are more successful in applying a clear institutional analysis approach than Rowland (2005). Studies by Fleischman et al. (2014) and Villamayor-Tomas et al. (2014) both consider the application of the SES Framework and on management of international river basins and look at the effectiveness of CPR design principles in predicting efficient management of a large-scale natural resource.

Water Security: Conflict and Cooperation

Within water security literature, scholars and policy makers all over the world are trying to identify the best approach to reduce conflict and insecurity and the consensus seems to be the promotion of cooperation. However, though the research largely agrees that cooperation is an important tool for reducing potential for conflict, scholars have diverging ideas about how best to achieve said cooperation. Traditionally, a state-centered command and control approach has been advocated, where countries are seen as the central unit of analysis and the national government along with its institutions represent primary actors in transboundary water decision-making. Wolf, Yoffe, and Giordano (2003) assert that water conflict is closely related to the capacity of institutions to absorb rapid changes in either the physical system or the institutional system. This research highlights the role that institutions play in mitigating conflict, which can provide a useful foundation for understanding institutional levels of cooperation. Zeitoun and Warner (2006) shift the discussion from the nation state to the subtler complexities of power and what they call "hydro-hegemony." Hydro-hegemony explores the importance that power and perceptions of power on negotiations and other forms of cooperation. This is particularly important to consider in the U.S. – Mexico case study, as the U.S. has been a strong hydro-hegemon. Grey and Sadoff (2007) recognize that some countries are more water secure than others and focus their analysis on understanding the trade-offs that country decision-makers must make to achieve water security. This research places water sharing in a more complex system, which highlights the tradeoffs that decision-makers face when negotiating water sharing. In response, the concept of benefit-sharing has emerged as an alternative form of cooperation that can reduce the need for difficult tradeoff decisions (Alam, Dione, and Jeffery, 2009). However, even though this research can help understand the institutional or country-level aggregate, these approaches still focus upon the nation-state and its institutions as the primary actors, leaving out the importance of individual behavior within institutional settings.

Newer literature has shifted towards more inclusive, participatory approaches that recognize the complexity of stakeholders in an international river basin. Suhardiman and Giordano (2012) move away from the state-centered model to a process-based analysis of how non-state actors impact negotiations in transboundary water sharing. Berardo and Gerlak (2012) expand the discussion within the water security community by drawing from socio-ecological literature on common pool resources to understand how different institutions (state and non-state) interact to negotiate cooperative behavior over water sharing. This is relevant to the research at hand because it considers an international, transboundary river basin and the institutions necessary to engender appropriate collaboration in a polycentric governance setting. Beck et al. (2014) attempt to take the research a step further by creating a complex model "to generate more precise and nuanced measures of hydro-political dependencies among riparian countries" (p.23). Their research attempts to model the hydrological dependencies between countries and the authors counter to generally-accepted knowledge and assert that upstream-downstream placement doesn't play as large of a role as previously believed. In the U.S.-Mexico case, upstream-downstream dynamics are very interesting because, while the U.S. is upstream for the majority of the border, in parts of Texas the U.S. becomes the downstream user. Regarding cooperative behavior, Petersen-Perlman and Wolf (2015) analyze what factors impact cooperation and how engaging various stakeholder groups impacts cooperative outcomes, which lays the groundwork for identifying variables relevant to cooperation. Robins and Fergusson (2014) highlight the importance of considering the potential for groundwater as a catalyst for conflict. This study contributes to an important and often over-looked element, the impact of ignoring groundwater-surface water interactions (Eckstein, 2012; Eckstein and Eckstein, 2005; Sanchez, Lopez, and Eckstein, 2016).

Several frameworks have been proposed to reduce conflict and encourage cooperation (Rowland, 2005; Zeitoun and Warner, 2006; Zeitoun and Mirumachi, 2008; Berardo and Gerlak, 2012). These frameworks often engage in debates about the proper ways to conceptualize water cooperation and conflict, lack a common conceptual understanding of how to dissect the relationship between cooperation and water security, and even how to operationalize these concepts. Mirumachi (2015) provides a new way of conceptualizing cooperation and conflict. The TWINS matrix places cooperation and conflict on a two-dimensional matrix, which helps researchers to track changes in multilateral water sharing relationships over time (Mirumachi, 2015). This approach can be helpful for contextualizing the importance of historical progression on current power dynamics, which is useful in providing context on relations between the U.S. and Mexico.

In addition to understanding cooperation and conflict, the shift towards participatory stakeholder engagement is opening a new body of research, which focuses more closely on tying together water security from an international relations perspective and the human dimension of decision-making to understand what factors influence cooperative behavior. Analyses by Subramanian, Brown, and Wolf (2014), Bilder (1981), Berardo and Gerlak (2012), and others seek to go more deeply into the inter-personal and cognitive aspects of efforts to achieve greater water cooperation.

Theories on the Role of Individuals

Theories of the individual have been utilized ubiquitously to understand how humans make complex decisions, but this section will focus only on theory development that is relevant for understanding conflict or cooperation over international, transboundary waters. Efforts at understanding individuals' decision-making initially started with efforts to model individuals. Several theories evolved out of this effort: rational choice theory, expected utility theory, and bounded rationality theory are a few that have been applied to water management decisions in the past. These models of the individual can be used within other theories, like CPR, and within nested frameworks, like SES, to better understand both how people can shape institutions but also how institutions shape attitudes and behaviors. Within CPR theory, concepts regarding trust and social capital emerged as important characteristics for engendering collective action decision-making. However, neither IR theories on institutions nor CPR theories on institutions and individuals consider how perceptions of risk impact individual decision-making. Risk perception literature has traditionally been applied to understanding how people make decisions regarding hazard mitigation or adaptation. This approach, when applied to transboundary water management, could provide insight into the role that individuals, nested within institutions, play in influencing changes in constitutional-level, collective action-level, or operational-level rules. This section will outline how these conceptualizations on understanding individuals have evolved from a variety of academic perspectives, from modeling individual decision-making to understanding how perceptions of risk and trust impact decisions to cooperate or engage in conflict.

Modelling the individual

The study of individuals can offer insight into how humans make decisions regarding their natural environment, and the institutions that are created to manage interactions between other users and external factors. Human behavior can be impacted by a variety of variables and humans tend to come together to solve problems. There are several different theories that make assumptions about how humans make complex decisions. A few of the most relevant of these theories include the rational choice theory, expected utility theory, and bounded rationality theory. These theories can be nested within other theories and used as models to generate conceptual understanding of human decision-making.

The rational choice theory assumes that if individuals have perfect information they will maximize their own outcome, even if cooperation with others will achieve a higher outcome for everyone (Simon, 1955; Ostrom, 1997). While this is an oversimplification, the basic idea behind rational choice theory is that individuals acting under perfect information will maximize their own net benefit, even at the expense of the larger community net benefit. However, critics argue that this model is too simplistic and does not account for values, norms, or belief systems, which can contribute to cooperative behavior.

The expected utility theory does not assume perfect information, but instead takes into account the importance of uncertainty and risk aversion in the decision-making process (Grant and Van Zandt, 2007). The expected utility theory was born out of Bernouli' famous equations in 1738, which asserted that "expected value implicitly assumes that the subjective worth of money (utility) is equal to its objective worth" (Lopes, 1994, p.200). After countless mathematical, lab-based, and field-based experiments, it was found that the expected utility theory was not a perfect fit for predicting human behavior (Slovic, Kunreuther, and White, 1974).

Over time, rational choice theory and expected utility theory, have evolved into the more modern and commonly accepted theory of bounded rationality, which incorporates a more dynamic model of human behavior based on attitudes, values, and norms (Slovic, Kunreuther, and White, 1974). The bounded rationality theory asserts that individuals have limited information, limited cognitive ability to process information, limited time to make decisions, and decision-making often results based on a combination of intuition and perception, which is influenced by social values, norms, and beliefs (Kahneman, 2003; Simon, 1955, 1991). This theory is the most appropriate for use within the SES framework and is compatible with CPR theories, water security theories, and theories on perceptions of risk.

Trust and reciprocity: the importance of social capital

Trust is a significant factor in understanding a broad range of human interactions, but especially in explaining cooperative behavior. The concept of trust has been explored from a very diverse set of perspectives across many disciplines. For the purpose of this research, trust will be explored from a social capital perspective. The concept of social capital as a distinctive set of theory is relatively new, and how one defines social capital depends on the discipline and specific application. Social capital is often seen as a necessary component for building cooperative social relationships. Putnam's (1993) definition of social capital as "features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" (p.67). Trust is a key piece to understanding and explaining cooperative behavior, also known as reciprocity, among different groups of people and has been used in CPR theories to explain collaborative decision-making (Ostrom, 1997). It is thought to be vital for binational stakeholders to be able to trust one another in negotiation processes and other stakeholder engagement efforts, such as data sharing (Subramanian, Brown and Wolf 2014).

That is why many concepts within international water law focus on the duty to cooperate and the corollary responsibility to share data and information (Leb, 2015).

Many scholars have used trust and the concept of social capital to understand how and why communities cooperate over things like collective management of natural resources (Pretty, 2003, Leach and Sabatier, 2005, Bouma, Bulte, and van Soest, 2008). Trust factors have been measured qualitatively and quantitatively and has been shown in many studies to be connected to positive social bonding and bridging (Berardo and Lubell, 2016). Leahy and Anderson (2008) measured trust factors within and between several water management agencies (U.S. Army Corp of Engineers and nearby communities) and found that trust was vital to maintaining good communication and cooperation. In another study by Klijn, Edelenbos, and Steijn (2010), trust was found to be a crucial factor in understanding relationships between governance networks. Governance networks are responsible for complex decision-making in potentially high-risk situations and understanding how trust factors into these relationships can shed light on decision-making. Building on work by Elinor Ostrom, López-Gunn (2012) makes an important connection between social capital and collective action or self-governance. This paper is particularly relevant to the research questions at hand because it considers the important of trust and social capital from a network perspective, examining the types of institutions that can improve or constrain the creation of social capital for the management of groundwater resources. All the studies mentioned found positive correlations between trust or, more broadly, social capital and improved cooperation.

Risk perception and willingness to cooperate

Risk perception literature has traditionally been applied to understanding how individuals react to the threat of natural hazards; however, this literature has the capacity to help address an undertheorized component of decision-making in transboundary water management. The idea of measuring perception of risk is potentially very important for understanding how individuals within institutional settings make decisions to cooperate or engage in conflict over shared, transboundary water resources. Measuring risk perception helps researchers to quantify peoples' perception to perceived external threats, which helps predict behavioral response outcomes. Paul Slovic (1987) took the research of measuring risk perception to the next level when he and his colleagues created the psychometric paradigm, which quantifies risk perception utilizing very specific factors, such as controllability of a specific hazard. Perceptions of risk can play a powerful part in an individual's decision to act in one way versus another (Bilder, 1981; Slovic, 1987; Trevin and Day, 1990; Willis et al., 2004). Understanding risk perception can be a useful tool for managing potential risks, especially in the field of natural resource management. For instance, in international water resource management, there are an abundance of physical risks that must be managed (flood, drought, water quality, etc.); in addition to more intangible, political risks, which have never been measured quantifiably.

Risk perception has been applied to managing risks for water in a few key ways, and is still a relatively new application within the broader literature. McDaniels et al. (1997) applied perception of risks to better understand how the public perceived threats from water environments. The study of ecological perceptions of risk is an interesting facet and has been the most widely used approach to understanding risks associated with water management (Willis et al., 2004, Hope et al., 2006, Willis and DeKay, 2007, Dobbie and Brown, 2014). Furthermore, risk perception is often used as a tool to compare lay versus expert communities and their different perceptions to various threats (Larson et al., 2009, Leviston, Browne, and Greenhill, 2013, Mitchell et al., 2012, Dobbie and Brown, 2014).

As one of the first authors to connect risk management with the negotiation of international agreements, Bilder (1981) identified the importance of understanding how policy makers and country-level negotiators perceive potential risks. Trevin and Day (1990) applied risk perception to managing an international river basin, and insights into a historical case study on the Plata River Basin. This case applies the concept of risk perception to an international water-sharing situation and builds on the work by Bilder (1981). Subramanian, Brown, and Wolf (2014) identified five categories of risk specifically for negotiating international transboundary water sharing and laid the foundation for using risk perception on more intangible political risks to understand cooperation in a multilateral setting. In both studies Trevin and Day (1990) and Subramanian, Brown, and Wolf (2014) utilized case studies and did not apply quantitative techniques. However, their work helped lay the foundation for connecting risk perception to international water sharing. In more recent studies by Garrick et al. (2018), researchers use the IAD Framework to consider how risk management factors into decision-making for drought adaptation in the Rio Grande Basin. This study comes the closest to considering how risk management factors into decision-making but does not measure how perceptions of risk influence individual decision-makers within different institutional settings.

None of the studies referenced have used transboundary groundwater sharing as a context for analysis, neither have these studies looked at the differentiated impact of perceived risk on willingness to cooperate formally versus informally. In an international water sharing situation, it is vital to differentiate between formal and informal cooperation. Formal cooperation over water can include treaties, conventions, and other legally-binding governance mechanisms, while informal cooperation can take many forms, including “gentlemen’s agreements, non-binding agreements, de facto agreements, and non-legal agreements” (Aust, 1986, p.787). On an international border, informal cooperation is a more likely outcome, especially since a legally-binding agreement can be seen as a risky endeavor for countries. However, formal cooperation is more likely to lead to laws, policies, and rules that protect against the tragedy of the commons, or a race to the bottom. Despite the inability of informal cooperation to lead to direct changes to laws, informal cooperation is often seen as the first step to a more formalized type of cooperation.

Risk Perception and Trust

Within risk perception literature, there are a number of studies that explore the relationship between trust, risk perception, and cooperation (Earle and Siegrist, 2008; Earle, Siegrist, and Gutscher, 2010; Lopes, 1994; Siegrist, Cvetkovich, and Roth, 2000; and Siegrist, Gutscher, and Earle, 2005). Trust and reciprocity are seen as necessary building blocks for generating cooperative behavior and must be factored into the risk perception equation. The exploration of trust and perception of risk was first explored by Paul Slovic, who asserted that trust in resource managers led to low perceptions of risk, while distrust of resource managers or decision-makers led to high levels of perception of risk (Slovic, 1993). Slovic also suggested the existence of the "asymmetry principle," which asserts that trust can be easily destroyed, but is very difficult to build (Slovic, 2000). While this may seem intuitive, Slovic examines how this principle can be exacerbated by media's desire to report on 'trust-destroying events' rather than those events that increase trust. Since Slovic's initial work on describing the relationship between trust and risk perception, research has expanded rapidly. Most of the literature looks both at the impact that trust in decision-makers has on perceived risk to the resource or hazard in question and the impact that group values has on trust and risk perception (Earle, Siegrist, and Gutscher, 2010; Siegrist, Cvetkovich, and Roth, 2000; and Siegrist, Gutscher, and Earle, 2005).

Early risk perception literature also alluded to the importance of risk communication for reducing distrust, but often found that laypeople distrusted many of the experts producing the risk assessment studies (Earle, 2012). Cvetkovich and Lofstedt's (2013) book, *Social trust and the management of risk*, begins to take a hard look at the connections between managing risk and building trust, particularly in trust deficit communities. Exploring and expanding on the relationship between risk perception and trust in an international setting will add an interesting and previously uncharted element to the literature.

Understanding how individuals operate within institutions to make decisions

Within IAD and SES Frameworks, CPR theory has been used to develop design principles for managing common pool resources. However, CPR has traditionally been used in medium to small settings, often doesn't consider the influence of power dynamics within institutions or resource actors and doesn't consider how actors within institutions use perceptions of risk and trust to make decisions. Within IR literature, a focus has also been placed on identifying guiding principles for improved management. The IAD framework and CPR theories evolved separately from IR literature, but both academic disciplines consider the importance of similar concepts (institutions, property rights, principles for improving cooperation and management, highlighting the need for conflict resolution, monitoring, sanctioning, etc.).

Water security and IR conceptualizations of conflict and cooperation can be placed within the SES framework. While CPR doesn't really consider the importance of power dynamics, IR literature does and IR literature also considers management of larger-scale, multi-level systems. However, neither consider the role of perceptions held by individuals within institutions or how those individuals use perceptions to engage in cooperative or conflictual decision making. Risk perception does consider this approach to understanding how individuals use perceptions to make decisions, but it has never been applied to understand the role of decision-making within an institutional setting. A combination of these approaches can help to understand how individuals within institutions use perceptions of risk and trust to make decisions and shape either collective choice or operational-level rules. By applying this to Texas border water decision-making for surface water and groundwater, insight can be gained into how formal versus informal cooperation is perceived by policy makers within different institutional settings.

Hypothesis and Objectives

Within the broader context of cooperation and conflict, the purpose of this research is to gain insight into how trust and perception of risk impacts individuals, nested within institutional settings, and their decisions to formally or informally cooperate or engage in conflict over transboundary surface or groundwater resources. In CPR theory, trust in social and political institutions has proven to be a pillar of social capital and a necessary condition for achieving cooperative behavior. It is unclear what the relationship is between risk perception and trust across an international border, or how perceptions of risk might be influenced by trust. Additionally, while CPR and IR theories on institutions and individuals do a good job of explaining appropriate institutional design structures, both approaches disregard the importance of individuals, nested within institutional settings, in guiding decisions on willingness to cooperate or engage in conflict. This study will attempt to measure individual perceptions of risk and trust, aggregated at the institutional level, to understand complex attitudes and behaviors on cooperation and conflict over shared international, transboundary resources. The study will also attempt to discern whether trust alone is a sufficient variable to increase cooperation, and how perception of risk among stakeholders, nested within different water governance institutions, seems to impact their willingness to engage in cooperative or conflictual behaviors. The role of individuals, nested within institutions, is seen as an important, undertheorized component because of the way that rules are promulgated at the constitutional, collective choice, and operational levels of rule-making within complex, polycentric governance settings.

The conceptual foundation for this project resides in two alternative explanations of transboundary water cooperation. One explanation focuses on the role of social capital in building trust, and the importance of trust and reciprocity in promoting inter-personal and collective cooperation. The second explanation is rooted in more recently developing literature on risk perceptions suggesting that what underlies inability to achieve cooperation is high perceived risks. Subramanian, Brown, and Wolf (2014) argue that there are five dimensions or categories of perceived risks that come into play to influence international water sharing decisions. These dimensions (capacity and knowledge; accountability and voice; sovereignty and autonomy; equity and access; and stability and support) manifest themselves in the decisions that stakeholders make concerning whether and how water cooperation takes place. These intangible risks perceptions can be manifested in response to a variety of factors. For instance, a perceived risk to sovereignty or autonomy might manifest in the form of unpopular treaty concessions that could infringe on sovereign decision-making rights, such as inclusion of language connecting groundwater to surface water, as seen in the discussion in Chapter 1 on the hesitancy of incorporating international water law principles in to treaty language. For equity and access, perceived risks could be associated with a lack of equitable water allocation or access to water (either spatially or temporally) that is written into water sharing treaties or on the table for renegotiations. Perceived risks to capacity and knowledge are related to whether or not your country has the ability to respond to or adequately manage treaty amendments based on capacity and knowledge (scientific, technical, diplomatic, etc.) A lack of political accountability or the ability for resource users to have a voice in rule making processes can be seen as a perceived risk. Finally, stability and support are related to whether or not your government is stable enough to meet, enforce, and manage water sharing treaties and whether or not those decisions are supported by broader political constituents. Although Subramanian et al. do not measure risk perceptions directly, they do find evidence of these perceptions in efforts to negotiate formal agreements on water sharing.

This research will utilize a SES framework with combined theories on CPR, water security, trust, and perceptions of risk to address the following questions:

1) How does trust across multiple levels of governance vary, and does trust impact the degree of cross-border cooperation (or willingness to cooperate formally or informally) in shared transboundary water resources?
    - H1: Trust will vary based on level and type of governance tier; respondents operating within institutions that are more directly engaged in transboundary water decision-making will have higher levels of trust.
    - H2: Trust will vary based on stakeholder engagement: stakeholders who regularly engage in binational stakeholder engagement efforts are more likely to exhibit high levels of trust than stakeholders who do not regularly engage in binational stakeholder efforts.
    - H3: Trust will be positively correlated with willingness to cooperate.
2) What risk perception factors impact international cooperation over shared transboundary water resources across multiple levels of governance? How do perceptions of risk differ over formal versus informal cooperation for surface water or groundwater resources? Can the complexity of the natural environment impact perceptions of risk over cooperation?

- H1: Stakeholders involved in transboundary water management who exhibit higher perceptions of risk will exhibit lower levels of willingness to cooperate over shared transboundary water resources than those who exhibit lower levels of risk perception.
- H2: Perceptions of risk will be different based on governance tier; those who are part of networks with high-level ties (international, federal, state level) will have perceived risk of formal cooperation higher than those who are part of networks primarily with low-level ties (municipal, non-governmental).
- H3: Perceptions of risk will be higher for formal cooperation over groundwater than surface water and risk perceptions will be lower for informal cooperation over groundwater and surface water, with risk still seen as higher for groundwater cooperation.
- H4: Complexity within the natural system will be positively correlated with higher perceptions of risk over cooperation; as natural, hydrological complexity increases (measured by self-reported reliance on groundwater and knowledge of transboundary nature of groundwater), so will perception of risk.

3) Are trust and risk perception correlated, and can they be used to predict levels of cooperation? Or does high risk perception constrain cooperative behavior despite high levels of trust?

    - H1: Risk perception and trust are correlated; as trust increases, risk perception will decrease.
    - H2: High perceptions of risk and high trust will create conditions conducive to very selective and situation-specific transboundary water cooperation; whereas

high perception of risk and low levels of trust will create conditions more conducive to transboundary water conflict or absence of cooperation.

Conflict and cooperation over international, transboundary water resources change over time, which can impact, or be impacted by, risk perception and trust dynamics. A risk perception approach, combined with a deeper understanding of the role that trust plays, can help to understand both individual and institutional constraints to collective action and effective cooperation in this type of international setting. Results from this project will identify points of contention and disunity between decision-makers of transboundary policy, focusing specifically on how individuals within relevant water managing institutions in Texas perceive water managers in Mexico, which can lay the scientific foundation for strategic interventions to promote cooperation in international, transboundary water settings.

Objectives

Overall, the objective of this study is to serve as a pilot project to test proof of concept for a new measurement tool, furthering the understanding of what characteristics drive cooperation and conflict in shared, international water settings. However, there are several objectives that are important to this study, which are described below. It is seen as important to understand these objectives and the potential future ramifications that they have, not only for the study location, but also for other international, transboundary water sharing situations that occur globally.

- Measure willingness to cooperate over transboundary water issues, the level of trust in the social and political institutions of water governance, and levels and types of interactions within multiple stakeholder networks.
- Empirically examine and verify five categories of risk perceptions (Capacity and Knowledge; Accountability and Voice; Sovereignty and Autonomy; Equity and

Access; and Stability and Support) as described by Subramanian, Brown and Wolf (2014).

- Observe how well new risk perception categories measure decisions to cooperate or engage in conflict, when compared to traditional psychometric paradigm measurements of risk perception.
- Explore the relationship between risk perception and trust in a binational setting.
- Examine how risk perceptions and levels of trust, held by individuals nested within different institutional tiers of governance impact formal versus informal cooperation over shared transboundary water resources across an international border.

This approach will contribute to theoretical understandings of how perceptions of risk or levels of trust, held by individuals within institutional settings, can influence decisions regarding cooperation and conflict. Additionally, this research offers a compelling example of how IR theories on water security and cooperation and conflict can be understood using an institutional analysis approach, provided by the SES framework, and combined with theories on CPR. The addition of risk perception theory deepens theoretical understandings within international transboundary water literature regarding how policy makers or other types of decision-makers within different types of institutional settings make decisions to engage in cooperative or conflictual behaviors. This combined approach offers a clear path towards quantifiably identifying points of contention within other international, transboundary water sharing settings all over the globe, particularly for transboundary groundwater management. Chapter 3 will begin to use the SES Framework to outline the components of the study location.

CHAPTER III

TRANSBOUNDARY WATER SHARING: A CASE STUDY OF RISK PERCEPTION AND TRUST ON THE TEXAS-MEXICO BORDER

This chapter outlines how the theoretical framework and broad hypotheses will be explored through a Texas-Mexico case study and utilizes the Socio-Ecological System (SES) framework to sketch a picture of the broad ecosystems, resource system, actors/users, social, economic, and political settings, and the governance system. A focus is placed on the governance system to provide ample insight into the institutional context between the U.S. and Mexico, generally, and Texas – Mexico, more specifically.

Starting with the broadest concepts, a brief summary of the social, economic, and political settings will be offered. Next, a more in-depth explanation of the resource system will be provided. Focus will be placed on an in-depth exploration of the governance system and associated institutional and political constraints that are currently in place in the border region. For the purpose of brevity within this wide-ranging system, we will only focus on U.S. and Texas actors operating within governmental or quasi-governmental decision-making capacities. Finally, brief explanations of how this study measures interactions and outcomes associated with this focal SES will be offered as a way to summarize.

This pilot study will serve as a first step towards testing a new quantitative approach to understanding international, transboundary water relations. The end of this chapter will discuss the hypotheses and objectives within the context of this particular case study and will identify the potential theoretical and political implications for transboundary waters globally.

Introduction

Transboundary surface water and groundwater along the U.S. – Mexico border is being used under a highly fragmented SES. Different overlapping or conflicting management regimes, property rights, and uses have led to severe resource degradation. In the face of surface water scarcity and increased reliance on groundwater resources, managers from the international level down to the local municipalities must be able to orchestrate communication and agreement across various levels of government. Within this type polycentric governance, it is difficult to obtain policy integration and cooperation, particularly given the number of conflicting water uses. A multidisciplinary approach is necessary to understand and solve the challenges at hand; however, previous analysis efforts in this region haven't been based on theoretical constructs and have failed to deepen the understanding of what dependent variables impact cooperation or conflict over shared transboundary water resources.

Current research asserts that cross border tensions over water represent serious challenges to water security and international diplomacy. The primary U.S.-Mexico institutional framework for dealing with transboundary water issues is the 1944 U.S.-Mexico Water Treaty, which created the International Boundary and Water Commission (IBWC). Since that time, the IBWC has focused much attention on shared surface water, especially the water of the Rio Grande/Rio Bravo. However, in addition to the surface waters of the Rio Grande/Rio Bravo, there are considerable underground water resources (Figure 3).

Along the nearly 2,000-mile border sit approximately 36 potential transboundary aquifers, with only 11 officially recognized as transboundary, and only four designated as priority aquifers for data sharing (Sanchez, Lopez, and Eckstein, 2016). Currently, there is no formal governance mechanism in place to manage these transboundary aquifers.

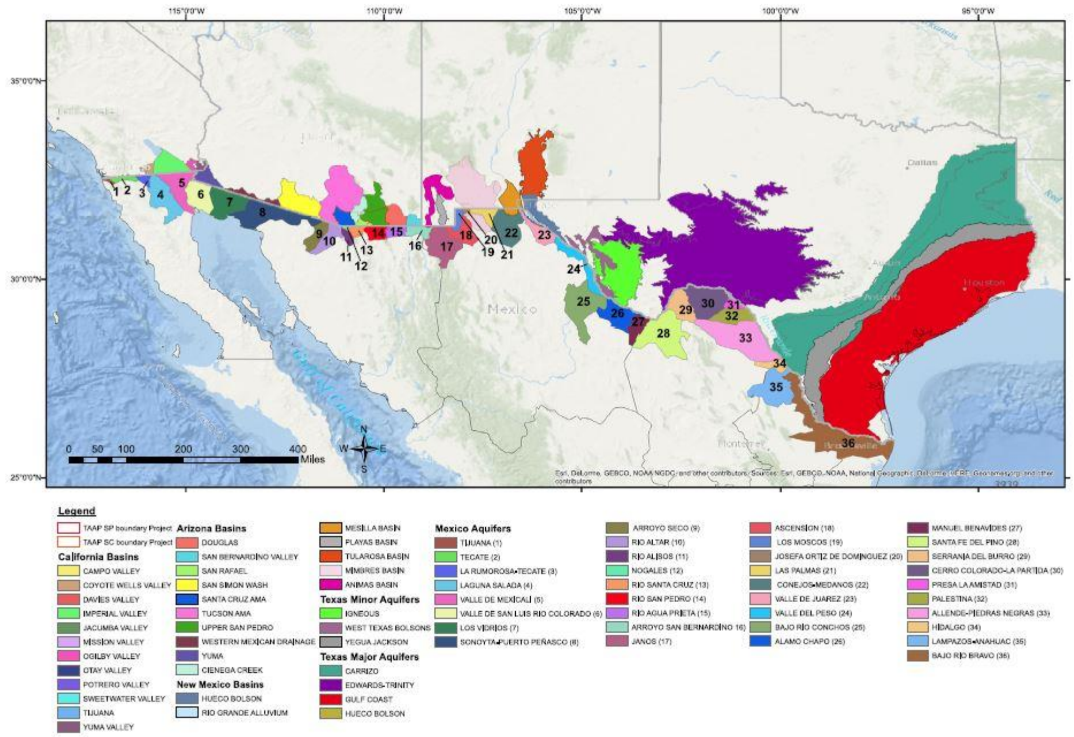

Figure 3: Potential Transboundary Aquifers between the U.S. and Mexico
Reprinted from Sanchez, Lopez, and Eckstein, 2016

To address the challenges associated with managing a complex natural resource within an even more complex polycentric governance system, focus must continue to be placed on subsidiarity, but with the added level of broad, informal collaboration. The U.S.-Mexico water governance involves a myriad of interactions between and among the various governmental entities in each nation. These interactions include formal relations between the two nations including relations between their respective departments of state, federal environmental agencies, and the IBWC. These higher-level relationships are only part of a larger, multi-level and multi-scale set of interactions (Milman and Scott, 2010; Nava and Sandoval Solis, 2014). Moving from the federal level to the state and local levels increasingly shifts the focus from formal relations to informal ones, from explicit water laws and public policies to on-the-ground water management. While Mexico and the U.S. have a long history of promoting cooperation over surface water, arid conditions consistently threaten political-diplomatic relations and there is mounting evidence of tensions bubbling beneath the surface, particularly considering the ever-increasing demand at state and local levels. (Nava and Sandoval Solis, 2014). Furthermore, the relationship between Texas and Mexico is an ideal representation of broader issues occurring on the rest of the border. The following section will discuss the Texas-Mexico case study and will offer insight into how it fits within the larger U.S.-Mexico water governance system.

Texas-Mexico Case Study

As articulated in Chapter 1, transboundary water resources can be considered common pool resources according to the definition commonly found within the literature (Ostrom, 2003; Schlager and Ostrom, 1992; Galik and Jagger, 2015; McKean, 2000). In looking at water resources shared by the U.S. and Mexico, this holds true. The Rio Grande is a source that lacks excludability (it is expensive to monitor and sanction exclusion), it is characterized by subtractability (consumptive use by one user means less is available for the next user), it is mobile (crosses borders), and it is not easily divisible (owing to the flowing nature of water). Similarly, as many as 36 transboundary aquifers have been identified along the U.S. – Mexican border; which are also common pool resources that lack excludability, are subtractible, are mobile (to various degrees), and are not easily divisible (Sanchez, Lopez, and Eckstein, 2016). Both of these resources are shared by a very large, highly heterogeneous group of users, and are over-appropriated or totally unregulated within the formal system for management that is currently in place. These characteristics make the Rio Grande River Basin and the transboundary aquifers along the border an extremely interesting case to study within the context of the SES

Framework. Additionally, not many large-scale systems have been studied within the context of the SES Framework, thus it will help contribute to a growing body of literature (Fleischman et al., 2014; Villamayor-Tomas et al., 2014). The case study specifically measures the perceptions held by decision-makers in Texas who make decisions regarding water management in the Texas-Mexico border region. Texas will serve as a pilot study to test proof of concept. However, because of the polycentric governance structure managing transboundary water along this international border, the entire system will be discussed from a broad, overarching perspective, down to more in-depth details about Texas.

Social, Economic, and Political Settings

Owing to the current situation along the 2,000-mile border, there are numerous diplomatic constraints that serve as a barrier to further development of transboundary water management. The U.S. - Mexico relationship over issues surrounding trade, immigration, and complications from the drug war has changed dramatically over the last two decades, which has influenced perceptions of risk and levels of trust.

Trade Disagreements

Despite the asymmetry of power between the two countries there was a maturing relationship spurred along in the mid-1990s with the North American Free Trade Agreement (NAFTA) designed to allow for easier economic exchange between the U.S., Mexico, and Canada (Villareal and Fergusson, 2017).

Following the implementation of NAFTA, Mexico shifted to an export-oriented economy, comprising nearly 40 percent of their gross domestic product (GDP) in 2016. Despite rhetoric coming from the Trump administration that NAFTA is a bad deal for the U.S., the majority of economist disagree; however, this political rhetoric has still had a negative impact of perceptions held by Americans. In 2017, trade between Texas and Mexico surpassed $187 billion and Mexico is Texas' largest export. In the summer of 2017, the Trump Administration announced that it would be renegotiating NAFTA. In the fall of 2018, an agreement was reached. The new agreement is known as the U.S., Mexico, Canada Agreement or the USMCA. It is still unclear whether or not environmental agreements negotiated under NAFTA will apply under this new agreement and it will take time for policy makers and researchers to sort through the new language. This level of uncertainty influences perceptions regarding the efficacy of environmental cooperation with Mexico.

Immigration Policy

Reforming the U.S. immigration policy, deporting undocumented immigrants, and taking more active measures along the Mexico border has been a central thrust of the Trump administration (Rogers, 2018). A series of executive orders on immigration were signed by President Trump focusing on drastically expanding the border wall and increasing law enforcement along the border. Furthermore, President Trump announced that the Deferred Action for Childhood Arrivals (DACA), a policy that allowed children who were brought illegally into the U.S. to defer deportation and acquire a work permit, is to be phased out. DACAs future is uncertain as a series of lawsuits, both for and against, are underway to decide the fate of the policy.

Recent changes in rhetoric and policies has led to a degradation in relationships between the U.S. and Mexico. Despite the bombastic claims by the Trump administration, more Mexicans having been leaving the U.S. than arriving, and border apprehensions are at a 40-year low (Seelke, 2018). However, there has been a lot of negative press over Trump’s policy to separate families at the border. Tensions over immigration policy reform have been very high on both sides of the border, which impacts how decision-makers in the U.S. and Texas perceive their binational counterparts.

Impacts of Mexico's drug war

The U.S.-Mexico border has been a focal point of the war on drugs since Nixon five decades ago. The border drug war has undergone several reorganizations and strategies over this time, but little progress has been shown. Well-organized, funded, and armed illegal drug cartels formed and operated moving an estimated $19 to $29 billion in drug revenue annually into the U.S. (U.S. Department of Homeland Security, 2010).

In 2007, U.S. President George W. Bush and Mexican President Felipe Calderón enacted a cooperative initiative call the Merida Initiative in order to share in the responsibilities and solutions in curbing narcotics-trafficking. The U.S. Congress pledged up to $1.4 billion in appropriations (U.S. Department of State, 2008). The success of this initiative has been limited; the most violent year on record related to drug cartels occurred in 2017, and the Trump administration is likely to rethink several key provisions of this partnership in the years to come (LaFranchi, 2017).

All of these social, political, and economic issues are at the forefront of the media discussion. As controversy stirs over the immigration reform and trade re-negotiations, water management has taken a political back seat. However, massive media coverage of these issues often has a polarizing impact and has the potential to influence previous held perspectives and levels of trust. Within the broader context of these major issues, water managers on both sides of the border must still come together to address the challenges of transboundary water management.

Resource System: the Rio Grande/Rio Bravo basin and Texas-Mexico aquifers

This section is intended to provide the reader with a clear picture of the transboundary water resources shared between Texas and Mexico. A focus will be placed upon the Rio Grande/Rio Bravo River and on describing the current level of knowledge regarding transboundary aquifers located on the Texas – Mexico border. Descriptions for both surface water and groundwater will be provided on the clarity of the system boundaries, size of the respective resource systems, storage characteristics, major human-constructed facilities, productivity of the system, and general system dynamics.

Surface Water

The mighty Rio Grande/Rio Bravo River flows through Colorado and New Mexico and forms the border between Texas and four different states within Mexico (Chihuahua, Coahuila, Nuevo León, and Tamaulipas). It begins as a mountain stream 12,588 feet above sea-level in the San Juan Mountain Range in Colorado (American Rivers, 2018).

Figure 4: Rio Grande River Basin
Reprinted from The Nature Conservancy, 2018

Prior to human-dominated dams, diversions, channelization efforts, and lined canals, the Rio Grande/Rio Bravo flowed freely, and the meandering length was dynamic and ever-changing. Now, the length of the river is heavily controlled by human feats of engineering. While length estimates of the river have changed over time, it is estimated by the International Boundary and Water Commission (IBWC) that the waters of the Rio Grande flow for about 1,900 miles from the San Juan Mountains in Colorado to the delta in the Gulf of Mexico. From the headwaters in Colorado, it flows south and crosses through the middle of New Mexico. Once the river makes it to Texas, it begins to flow south east and forms the international boundary between the U.S. and Mexico, finally terminating in the Gulf of Mexico. The Texas-Mexico stretch of the river is the longest stretch, covering 1,254 miles (Dunlap, 2006).

The sheer size of this river basin watershed is enormous, covering 355,500 square miles; however, a significant proportion of this river basin is arid to semi-arid and only about half of this area contributes to the flow of the river (Rio Grande International Study Center, 2018). The main water source for the Rio Grande is snowmelt and precipitation from the Rocky Mountains. Once the river leaves Colorado, the rate of recharge drops substantially because precipitation in New Mexico, Texas, and Northern Mexico is relatively low, while evapotranspiration is high. In the U.S., the primary tributaries flowing into the Rio Grande include the Pecos River, Devils River, Rio Chama, and Puerco River. In Mexico, the primary tributaries are the Rio Conchos, Rio Salado, and the San Juan River (Far West Texas Water Planning Group, 2016). The basin is often divided up into the Upper, Middle, and Lower Basin within the broader literature, based on geologic attributes, climate, and hydrologic drivers. The climate ranges from arid to semi-arid, which is why snowmelt provides such a vital contribution to the flow.

Flow along the Rio Grande has been significantly altered by humans through dams, diversions, channelization, and lined sections. There are numerous large dams and smaller diversion dams all along the length of the river that are managed by the U.S. Bureau of Reclamation, the U.S. Army Corps of Engineers, the Middle Rio Grande Conservancy District, or the IBWC (U.S. Fish and Wildlife Services, 2018). The major dams that are internationally-significant for meeting treaties between the U.S. and Mexico are Elephant Butte Dam, Amistad Dam, and Falcon Dam. Each one of these massive dam projects can hold more than a million acre-feet and are vital for storing water and timing water releases for irrigation (U.S. Fish and Wildlife Services, 2018).

The Rio Grande waters all along its length are totally over-allocated, meaning that under normal conditions there is currently not enough water available to meet all of the water rights. Agriculture has been the primary user in every state and in both countries from the headwaters all the way to the delta and according to the IBWC, agriculture accounts for 75 percent of the entire river (IBWC, 2018). In fact, most of the water within the river is used up by the time it gets to the Fort Quitman region, and the stretch between Fort Quitman and Presidio is often referred to as the "forgotten reach" because it essentially slows to a trickle and even dries up in some places until it is renewed by the Rio Conchos tributary out of Mexico (Nava et al., 2016). However, it is projected that water use will begin to shift from agriculture to municipal to account for the massive population growth in the region (Far West Texas Water Planning Group, 2016).

Transboundary Aquifers

There has been debate for several decades regarding the actual number of transboundary aquifers between Texas and Mexico (Mumme, 2000; Dunlap, 2006; Eckstein, 2013; Sanchez, Lopez, and Eckstein, 2016). Up until very recently, there was no clear understanding of the aquifers along the border and the system generally suffered from the "blank map syndrome," where data was left blank once it crossed the international boundary (Sanchez, Lopez, and Eckstein, 2016). This is partially because the nature of transboundary aquifers is much more difficult to assess than surface water resources and partially because it was seen as politically unnecessary to assess the transboundary nature of aquifers. Traditionally, groundwater located along international boundaries has been left up to national sovereignty. The basic nature of aquifers is much different from surface water for a variety of reasons: groundwater is an invisible resource, it is difficult to model, infrastructure is usually held in the private domain, each aquifer is uniquely different, and as a result, aquifers are much more difficult to regulate (Milman and Scott, 2010; Sanchez, Lopez, and Eckstein, 2016; Sanchez and Eckstein, 2017).

Determining the clarity of the system boundaries for transboundary aquifers is hydrologically, politically, and socially complex. According to recent studies, there are potentially 15 transboundary aquifers between Texas and Mexico; five have reasonable data to support the transboundary claim, four have some data, and six have limited data (Sanchez, Lopez, and Eckstein, 2016).

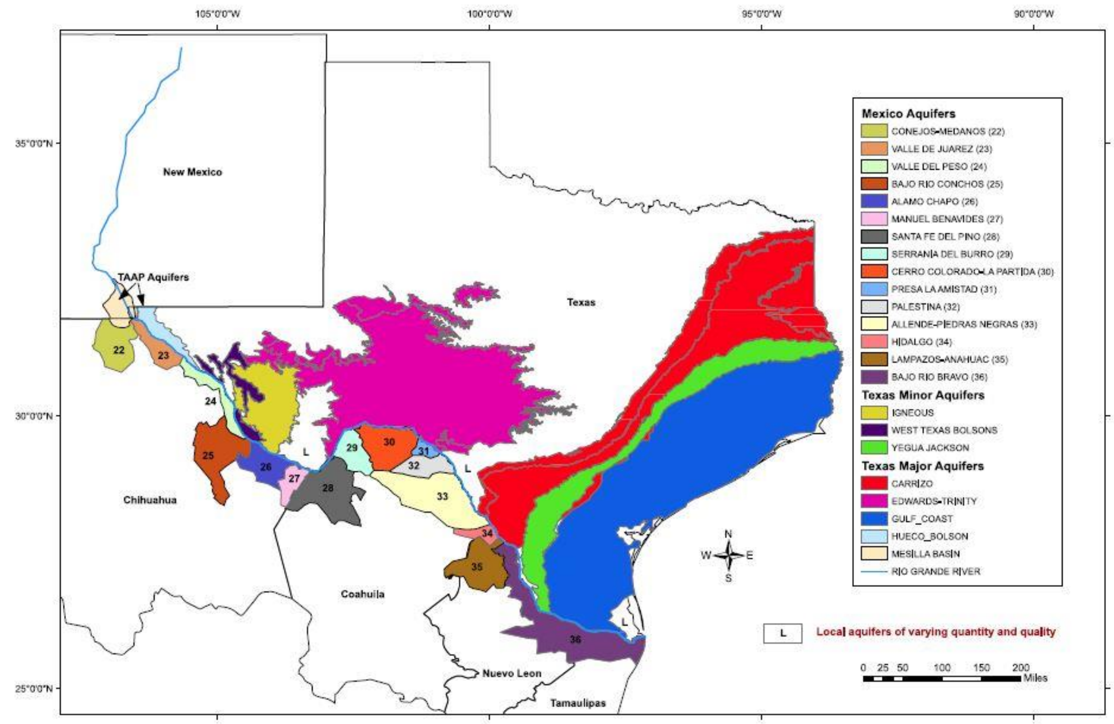

Figure 5: Aquifers along the Texas-Mexico Border
Reprinted from Sanchez and Eckstein, 2017

While these 15 aquifers have been identified as potentially crossing the border between Texas and Mexico, it is argued that designating as aquifer as transboundary requires more than just a physical connection (Sanchez and Eckstein, 2017; Sanchez, Rodriguez, and Tortajada, 2018a; Sanchez, Rodriguez, and Tortajada, 2018b). The transboundary nature of an aquifer should be based on "the extent to which aquifer riparians prioritize a particular aquifer over another and recognize its value in the context of economic, environmental, social, cultural, and legal-institutional criteria" (Sanchez and Eckstein 2017, p. 501). This definition of 'transboundariness' highlights the difficulties in clearly describing the system boundaries and the size of the system. For instance, while one or more international institution may recognize the transboundary nature of an aquifer, other institutions may not. An example given by Sanchez and

Eckstein (2017) is the Allende-Piedras Negras Aquifer, located in the Coahuila-Texas region, which "is not recognized officially by the state of Texas, even though data from the Mexican side and joint technical studies have verified its transboundary linkages" (Sanchez and Eckstein 2017, p. 501). Four other aquifers along the Texas-Mexico border have been recognized as transboundary by the International Shared Aquifer Resources Management (ISARM) Initiative: the Valle de Juarez/Hueco-Tularosa Bolson, the Conejos-Medanos/Mesilla Bolson, the Edwards Aquifer, and the Bajo Rio Bravo/Gulf Coast Aquifer (Sanchez, Rodriguez, and Tortajada, 2018).

Determining the storage characteristics, productivity of the systems, and describing the general system dynamics of transboundary aquifers is also a complex challenge. Aquifers are highly heterogeneous systems that are unique to localized geologic and hydrologic contexts and it is extremely difficult to model flow dynamics for these types of natural resources, particularly in the face of missing data. Modelling system dynamics, calculating storage characteristics, and describing the potential productivity of these systems is increasingly difficult across international boundaries. For instance, in the Texas-Mexico case, scientists on both sides of the border use a different measurement approach to delineate aquifer boundaries (Sanchez, Lopez, and Eckstein, 2016). Only the well-studied aquifers in this region have enough information to describe basic system dynamics. Within the Texas-Mexico border, the Valle de Juarez/Hueco-Tularosa Bolson and the Conejos-Medanos/Mesilla Bolson are considered by both countries as priority transboundary aquifers and are well-studied by scientists. In fact, these aquifers are often considered to be one aquifer, the Hueco-Mesilla Bolsons, though they are technically divided by an aquitard and there is not much groundwater connection between them (Sanchez, Lopez, and Eckstein, 2016).

Calculating the exact number of wells or amount of withdrawal for these aquifers is nearly impossible owing to the lack of data on both sides of the border. In Texas, groundwater wells are considered private property and are not monitored, except for areas where a special district has been created and rules have been adopted to limit pumping (e.g. Harris-Galveston Subsidence District). In Mexico, despite the fact that groundwater is considered a federally-owned resource, there is a lack of monitoring and sanctioning, which results in illegal wells. Groundwater in this region ranges from heavily used aquifers, such as the Valle de Juarez/Hueco-Tularosa Bolson and the Conejos-Medanos/Mesilla Bolson, to areas that have very little groundwater and rely primarily on surface waters (Sanchez, Lopez, and Eckstein, 2016). Uses for groundwater are dependent on the quality of the water and can range from drinking water to water for irrigation. As surface water from the Rio Grande becomes less available, users along both sides of the border will begin to utilize groundwater more, which has the potential to lead to aquifer drawdown and general degradation.

Governance System

This section provides an in-depth description of the multiple tiers of governance where different levels of rule-making occur, from constitutional-level rules, to collective action-level rules, down to operational-level rules. For the constitutional-level rules, a description of the evolution of the international treaties and agreements between the U.S. and Mexico will be provided, along with an analysis of how those rules fit into meta-constitutional structures (e.g. customary international law principles). For both the constitutional level rules and the operational level rules, focus will be placed on U.S. and Texas policies and procedures, with limited descriptions of Mexico policies and procedures.

The river basin is highly fragmented by different management regimes, property rights, and uses. From the international level down to the local municipalities reliant on the Rio Grande, communication and agreement must be orchestrated across various levels of government. This type of integration and cooperation is difficult to obtain, given the number of involved parties. As a result, there are serious gaps in the resulting fragmented policy framework for this transboundary river. Vastly different legal structures in both the U.S. and Mexico make it difficult to manage the river efficiently and the result is an over appropriated resource.

Formal agreements signed by the U.S. and Mexico have been in place for almost two hundred years. In that time, the policies and commissions assigned to manage the waters have changed many times over and molded to the demands of their specific political time period. In addition to the binational treaty, the Rio Grande is also regulated by two interstate compacts: the Rio Grande Compact and the Pecos River Compact. These interstate compacts stipulate allocations from the headwaters to the delta, with each state receiving their negotiated portion.

Evolution of international agreements between the U.S. and Mexico governing surface water and groundwater

The U.S.-Mexico case offers an ideal situation to analyze the difficulties of negotiating formal versus informal cooperative mechanisms on the grounds of international water law principles for several reasons: 1) neither country has signed or ratified the UN Watercourse Convention (UNWC); 2) both countries have a long history of cooperation; and 3) both countries have formal treaties in place for transboundary water sharing. However, the situation is made more complex by the long-held power differences, where the U.S. is a hegemonic leader. Furthermore, the U.S. and Mexico have a very different relationship over surface water sharing when compared against groundwater. This will offer additional insight into the challenges of applying the customary international water law principles to a whole system (surface and groundwater). The following analysis will present background information on the evolution of international treaties between the U.S. and Mexico.

Treaties between the U.S. and Mexico can be traced back to 1848, when the Guadalupe Hidalgo Treaty marked the end of the Mexican-American War, creating the international border (International Boundary and Water Commission, 2018; Donahue and Klaver, 2009). Following the Treaty of Hidalgo, there were several conventions to discuss the water boundary and "different aspects related to the boundary, such as the demarcation of the land and water boundaries" (Sánchez-Mungía, 2011, p.579). At the 1889 convention, the countries founded the International Boundary Commission (later known as the International Boundary and Water Commission or IBWC) as a regulatory body to enforce the rules concerning the Rio Grande and to survey the land.

The first treaty to address international surface water was the Treaty of 1906, also known as the *Convention for the Equitable Distribution of the Waters of the Rio Grande*. The 1906 Treaty stipulated the surface water exchange from the U.S. to Mexico, requiring the U.S. to give 60,000 acre-feet per year from the Elephant Butte Dam located on the American side of the Rio Grande (Dunlap, 2006). The 1906 Treaty referred to the northwest area of the water basin in Texas (near El Paso) and guaranteed Mexico 60,000-acre feet (AF) of water a year. However, while the treaty stipulates that water deliveries are to be made to Mexico from the U.S., the U.S. is not required to make up these payments if dry climate conditions of 'extraordinary drought' are experienced.

Additionally, though the language used within the treaty highlights the concept of 'equitable' sharing, there is not a specific reference to the principle of equitable and reasonable use, nor is ‘equitable’ defined explicitly. This agreement was very limited in scope and was meant to be an initial attempt at the creation of a specific cooperative mechanism for peaceful sharing, as outlined by the Treaty of Hidalgo. By the 1920s, the two countries realized that there was a need for a more comprehensive and specific treaty to regulate the surface water of the internationally shared rivers. While the 1906 Treaty is still currently in place, it is the 1944 Water Treaty that plays a larger role in allocating and managing transboundary surface waters.

The 1944 Water Treaty and Minute 242

By 1944, the U.S. and Mexico acknowledged that further stipulation was required for the peaceful sharing of the international Colorado, Tijuana, and Rio Grande/Rio Bravo Rivers. The *Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande Treaty,* also known as the 1944 Water Treaty, was more robust in scope and was legally-binding in nature. It brought about a clear timetable of delivery for water rights, as designated by the agreement. Under the Treaty, Mexico must deliver 350,000 acre-feet per year from the Rio Conchos tributary while the U.S. must deliver 1.5 million acre-feet per year to Mexico from the Colorado River (Far West Texas Planning Group, 2016).

The 1944 Water Treaty re-envisioned the International Boundary Commission by creating the International Boundary and Water Commission (IBWC), or the Comision Internacional de Limites y Aguas (CILA), in Spanish. The Treaty of 1944 greatly expanded the scope of IBWC/CILA into including solving disputes, monitoring shared waters, and providing rules and minutes (International Boundary and Water Commission, 2018). It has been noted that cooperation is difficult because each section (IBWC in El Paso and CILA in Cd. Juarez) is responsible for protecting the sovereign interests of its corresponding countries. “Naturally, this division of interests has led to an adversarial relationship between the Mexican and American commissioners" (Dunlap 2006, p. 233). However, there is a very clear process in place for disputes and tensions to be negotiated; namely, the joint creation of minutes by IBWC/CILA allows the 1944 Treaty to address problems as they arise, while keeping the Treaty as flexible and adaptable as possible. A successful example of the minute process mitigating conflict can be found in Minute 242, discussed below.

The initial installment of the 1944 Treaty only addressed surface water rights, leaving any other disputes that may arise to be handled through the dispute resolution process by the IBWC/CILA. The escalation of pollution along the border increased rapidly, owing largely to the expanded industry development and population growth from the introduction of the maquiladora program in 1965 (EPA and SEMARNAT, 2011). In the 1960s, a serious salinity crisis arose in the Colorado River and its surrounding basin. In 1973, the contentious issue of water quality finally reached a climax, requiring dispute resolution by the IBWC/CILA (Mumme, 2005; Eckstein, 2012).

Minute 242, finalized in 1983, dictated the appropriate amount of salinity for the water in question; at the same time, the issue of groundwater was also addressed. In an attempt to resolve salinity issues, Resolution 5 allowed for controlled pumping in the Yuma Mesa aquifer along the Arizona- Sonora boundary (Yamada, 2004; Sanchez-Mungia, 2011; Eckstein, 2013). By placing restrictions on groundwater pumping in the Yuma Mesa aquifer, Resolution 5 set precedence for joint transboundary aquifer management and gave the IBWC/CILA the authority to regulate other transboundary aquifers. Currently, this Resolution only applies to the Yuma Mesa aquifer. Additionally, according to Resolution 6 of Minute 242, "with the objective of avoiding future problems, the United States and Mexico shall consult with each other prior to undertaking any new development of either the surface or the groundwater resources, or undertaking substantial modifications of present developments, in its own territory in the border area that might adversely affect the other country" (Minute 242, 1973, Res. 6). It has been argued by scholars and policy makers alike that Minute 242 brought groundwater under the scope of the 1944 Treaty, unfortunately, there has not been enough political backing to move forward in applying this type of policy to other shared transboundary aquifers (Eckstein, 2013).

Minute 242 does afford the IBWC with the authority to monitor transboundary aquifers, which is vital for understanding the complexities of the resource. However, lacking the political momentum to use the restricted pumping framework created by Resolution 5 of Minute 242, there is still no comprehensive management strategy to stipulate limits on groundwater pumping on any of the other shared transboundary aquifers.

The IBWC/CILA has a large degree of control over issues relating to water in the border region, and Minute 242 has arguably brought groundwater pumping regulatory power into the realm of the IBWC/CILA. The IBWC U.S. Section does not have as much political discretion as CILA, because it must answer to the political will of the Border States. Since the Border States make up approximately 23 percent of the congressional House of Representatives, no federal legislation or decision regarding the U.S. – Mexico border would pass without strong Border State support.[1] Thus, while the IBWC/CILA may technically have the power to negotiate an agreement for the joint management of transboundary aquifers, it does not have the political support necessary to initiate such an agreement.

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[1] Arizona, California, Texas and New Mexico have a combined total of 101 seats on the House of Representatives according to the most recent 2010 Census Congressional Apportionment data.

La Paz Agreement of 1983

The 1970s and 1980s brought about a paradigm shift in how policy makers began to think about the environment. The concept of sustainable development was just being formulated in the early 1970s, broadcasted to the world at the UN Conference in Stockholm in 1972 (United Nations, 2002). As policy makers in the international policy arena began to seriously consider how human development impacted the environment, so did the United States and Mexico. The Agreement on *Cooperation for the Protection and Improvement of the Environment in the Border Area*, also known as the La Paz Agreement, was signed in 1983, committing both countries to "cooperate in the field of environmental protection in the border area" (Environmental Cooperation Agreement Between the United States of America and Mexico, 1983). The La Paz Agreement is implemented by an assigned coordinator in each country. In the case of the U.S., the Environmental Protection Agency (EPA) serves this function, while in Mexico; it is the Secretaría de Desarrollo Urbano y Ecología (SEDUE), which functions under the Secretaria de Medio Ambiente y Recursos Naturales (SEMERNAT) (Environmental Cooperation Agreement Between the United States of America and Mexico, 1983). This broad declaration to work together on environmental issues has led to the development of several environmental programs, each addressing multiple levels of border pollution, including issues relating to air, land, and water.

The progression of environmental programs under the La Paz Agreement has slowly evolved to include stronger language on sustainable development, increased public participation, a bottom-up approach to implementation, and specific goals on pollution prevention for land, air, and water (Mumme and Collins, 2014). Additionally, this agreement has helped to address some of the inadequacies within the institutional structure of the IBWC and further validated the authority of the IBWC as the primary agency on water in the border region (Mumme, 2005; Mumme and Collins, 2014).

NAFTA and the North American Commission on Environmental Cooperation

In an attempt to increase the effectiveness of the La Paz Agreement program implementation, NAFTA negotiators focused on establishing a stronger environmental side agreement. With NAFTA ratified in 1994, that side agreement was achieved under Article 13, which created the North America Commission on Environmental Cooperation (CEC). Under the framework of the CEC, NAFTA also established the Border Environment Cooperation Commission (BECC), in addition to the North American Development Bank (NADB) (Hathaway, 2010; Mumme and Collins, 2014).

Upon implementation, the BECC and NADB helped to strengthen the La Paz Agreement, by providing project design and financial assistance for environmental projects in the border region. The connection between the La Paz Agreement and the BECC-NADB partnership is mutually reinforcing. The BECC and NADB directly support the implementation of the La Paz Agreement, despite being a NAFTA creation, by assisting in the development and funding of environmental improvement projects, which was severely lacking in the initial La Paz Agreement (Mumme and Collins, 2014). The BECC and NADB are managed by the EPA and SEMARNAT. While BECC is the organization responsible for designing and certifying environmental projects, it is NADB that funds the development (U.S. Environmental Protection Agency, 2018). In addition to funding projects that relate to conservation and pollution prevention, BECC and NADB also help fund initiatives to gather data on water quality, in support of a transboundary water database (Mumme, 2005). Recently, the BECC was subsumed under NADB in attempt to improve efficiency (North American Development Bank, 2017). It has yet to be seen how this will impact the overall management outcomes or mission. Furthermore, NAFTA was recently renegotiated and is now the United States, Mexico, Canada Agreement (USMCA). It is unclear how the framework of the CEC will be impacted or if will even still be in place. It is too soon to tell what ramifications the new agreement will have on environmental agreements negotiated under the old agreement.

The 2006 Transboundary Aquifer Assessment Act

As the end of 2006 approached, the United States and Mexico signed in the Transboundary Aquifer Assessment Act (TAAA). The purpose of this Act was “to establish a United States- Mexico transboundary aquifer assessment program to systematically assess priority aquifers” (United States-Mexico Transboundary Aquifer Assessment Act, 2006). The participating Border States include Arizona, New Mexico, and Texas. California opted not to be a part of the bilateral agreement because of the political tensions surrounding the All-American Canal disagreement. Priority aquifers identified include the Hueco Bolson, Mesilla Bolson, San Pedro, and Santa Cruz aquifers (Sanchez, Lopez, and Eckstein 2016; Callegary et al., 2016).

The Act established multiple goals including the assessment of transboundary aquifers, the creation of a new Geographic Information System (GIS) database, the evaluation of available data, and the creation of additional data where necessary. The USGS was established as the agency to implement the Transboundary Aquifer Assessment Program (TAAP), and in 2009 the IBWC/CILA signed the Joint Report of the Principal Engineers, a roadmap to enactment.

The purpose of this agreement is to allow the two countries to identify a set of baseline datasets for the politically and environmentally crucial aquifers. Moving forward with any agreement or cooperative management effort, at any level of governance, will require a serious scientific understanding of the resources available. With renewed funding, several studies have already come out of TAAP funding and have involved a variety of stakeholders at the international, federal, state, and local levels (Callegary et al., 2016).

Federal Institutional structures and water rights in the U.S. and Mexico

Mexico: Institutional Structures and Water Rights

The political structure in U.S. is vastly different than that of Mexico. In Mexico, water resources are considered national property, and while private land owners may use as much groundwater as they like (without causing harm to their neighbor), the Mexican government has control over how water is used. Water resource management in Mexico is highly centralized, despite recent efforts towards decentralization. Given the traditions of centralized authority concerning water sector governance in Mexico it is not surprising that the transition towards the more decentralized IWRM system, highlighted by the National Water Plan in 1975, has still not been completely instituted (Nava and Sandoval Solis, 2014). This is partially because governing institutions do not want to weaken their power base.

Institutional Structure

In 1989, CONAGUA, the National Water Commission of Mexico, was established as the sole federal authority to deal with water allocation and was created to essentially implement and oversee the IWRM process (Tortajada, 2002; Nava and Sandoval Solis, 2014). As discussed in Chapter 1, IWRM is a water management paradigm that evolved within the international arena by water experts in order to help countries balance social, economic, and environmental needs to achieve sustainable development. Mexico adopted IWRM principles in order to receive funding from the World Bank, which used funding as a way to leverage implementation of IWRM principles in many developing economies.

CONAGUA, or CNA, is responsible for policy, water rights administration, planning, irrigation and drainage improvement, water supply and sanitation development. Similar to the U.S. EPA, SEMARNAT operates as the Secretaria de Medio Ambiente y Recursos Naturales, and, since 2000, CNA has been housed under SEMARNAT. Currently, CNA directs 13 administrative-hydrological regions based on 25 river basins. The river basin commissions are responsible for "planning, design, coordination and construction of irrigation projects, flood control program and hydropower generation" (Tortajada, 2008, p.2). While this is a clear move toward decentralization compared with historical water resource management, the regional hydrological offices still lack budgetary power and report directly to CNA. Thus, the river basin commissions essentially create the plans and advise CNA on what should be enacted at the local level, and then CNA accepts or rejects the suggestions and provides funding.

The major structural problem with the IWRM paradigm is that the framework was developed by global water experts and not in context with real world attainability, so while the theoretical application sounds ideal, often in the real world the outcome is not. The idea of IWRM "banked heavily and in many cases naively on the conformity of large resource bureaucracies to open themselves to integration" (Scott and Banister, 2008, p.61). This is particularly relevant in Mexico, where the Mexican hydrocracy has been a longstanding centralized power over water resources and control over water has shifted frequently between different ministries. Additionally, with the constant shifting and merging of functional rivals, there is a large degree of interdepartmental conflict and low levels of integration. Furthermore, while it is a problem that CNA has yet to regulate the 2004 water law and disseminate some of its power, it is also true that in many cases the local agencies are not institutionally prepared to manage their own financial and bureaucratic autonomy. River basin councils face challenges owing to a lack of knowledge, expertise, and high employment turnover rates (Tortajada and Contreras-Moreno, 2005).

While the conceptual framework for IWRM has been woven into the federal law, it has not been implemented regionally. Additionally, there is fear that IWRM may be just rhetoric used to support the strengthening of CNA's power structure. According to Rap et al., "IWRM can be used as a guise by the hydrocracy to reaffirm its position as the sole water authority and to frustrate a 'deep' transition from state-directed water management to polycentric and adaptive water governance" (Rap et al., 2009, p.411). The difficulty of IWRM implementation is further compounded by the uneven regional political landscape, where Mexican states have wide ranging, unequal degrees of resources and power. Moreover, challenges arise when water planners that are elected on a short-term basis are required to plan for long term water resource management (Tortajada and Contreras-Moreno, 2005).

Mexico Water Rights

During the Post-Revolutionary Period (1920-1990) the Mexican government issued laws that increased the centralized authority of the federal government. However, starting as early as the 1940s the government of Mexico began the painfully slow shift away from centralized authority. In the 1940s the government created water-centered regional development programs. These programs generated the very first river basin commissions; however, the government gave these commissions limited power with no autonomy and total dependence on the federal authority (Tortajada, 2002; Mumme, 2005; Nava and Sandoval Solis, 2014).

It wasn't until the 1960s and 1970s, when the government began to overhaul its irrigation systems, that a stronger push towards decentralization occurred. In 1975 the National Water Plan called for a new water law, a national water resource authority to manage the new water governance structure, and an IWRM governance structure. The National Water Plan also highlighted the need for more efficiency in the water sector, higher water quality, cross-sectoral coordination between relevant governmental ministries and higher stakeholder involvement (World Bank, 2005). This National Water Plan was the roadmap for the implementation of an IWRM system and the decentralization of water sector governance.

Although this plan was released in 1975 and updated as recently as 2004, the government of Mexico has still not adequately achieved all of the goals put forth by the National Water Plan. One of the reasons that the process of decentralization has taken so long is because of funding issues. While CNA decided to give up some degree of control over regional water management no new revenue sources were directed to the state level. Furthermore, long held traditions of centralized power have also served as an obstacle to the completion of decentralization and this is a problem that Mexico continues to struggle with today. However, the still heavily centralized control over groundwater means that Mexico has a strong platform for negotiation of a binational agreement because there is only one set of laws to negotiate around. While groundwater "ownership is appurtenant to ownership of overlying property, and owners are otherwise free to use the water as they see fit subject to an obligation not to injure other parties, the utilization of groundwater may be legally regulated by the Mexican state" (Mumme, 2005, p.85). Therefore, despite Mexico's attempted shift toward decentralization, in all practicality, groundwater is still largely controlled by the Mexican government.

United States: Institutional Structure and Water Rights

When it comes to water policy, the federal government in the U.S. has rules in place for water quality standards but does not have much authority over water quantity. Each individual state within the nation dictates its own groundwater policy and guards this state sovereignty closely. While there are many pieces of federal legislation regulating certain aspects of water, such as water quality standards, there is no framework currently in place to address groundwater usage. The main legislation on water at the federal level includes the Water Pollution Control Act, the Safe Drinking Water Act, and the National Environmental Protection Act (EPA, 2018). The primary role that the U.S. federal government plays on the border is for international agreement oversight and implementation. While the U.S. federal government has a say in setting water quality standards, it does not have the power to regulate groundwater on a national scale, thus, each State is free to choose its own water law. It is not hard to imagine that, for the most part, each State has chosen a slightly different take on regulating groundwater. In the Border States alone, there are four different regulatory approaches for four different States. Texas employs the rule of capture, New Mexico utilizes the prior appropriation doctrine, and Arizona has a reasonable use approach, while California relies on a correlative rights system. The groundwater use doctrines in New Mexico, California, and Arizona will briefly be examined. More emphasis will be given to Texas groundwater laws in separate section.

New Mexico relies on the prior appropriation doctrine for groundwater, which allocates water rights temporally, giving priority to water users that were the first to utilize the underground resource. For example, "whoever drills into an aquifer first is deemed first in time, and thus, first in right" (Drummond, 2002, p.201). This means that water users in New Mexico establish water rights by utilizing the water on a first come first serve basis, and water rights are given priority based on who used the resource first, provided that the usage was classified as 'beneficial.' Thus, as pumping permits reach the limit established by the State Engineer, water users that hold the oldest water rights are protected, while those with newer permits may be subject to smaller takings. Additionally, in New Mexico, a legal precedence has been set to acknowledge the relationship between surface and groundwater resources and it is the only Border State to do so. This is relevant because of how water rights are established; thus, surface water rights and groundwater right have a connection in which the right to use can be litigated.

In California the use doctrine of correlative rights is in place. Correlative rights, as implied by the title, are correlated directly to the amount of land owned by the water user, a proportionate amount of groundwater is allocated based on property size in relation to other users. Furthermore, “the principle of prior appropriation is used if extracted water is not used in the overlying land” (Mumme, 2005, p.87). Groundwater extracted must be utilized on the overlying land, and if it is not, prior appropriation is enforced. Thus, water users that apply groundwater to overlying land are given legal priority over those that pump the water for off-site usage.

In contrast, Arizona utilizes the rule of reasonable use, which allows landowners to pump groundwater in a manner that is beneficial, reasonable, and does not cause harm to neighboring water users. The nature of what is ‘reasonable’ is determined in part by location and spacing of wells, the amount of water pumped, in addition to the intended usage of the resource (Dunlap 2006). Under this system of rights landowners may “pump unlimited amounts of water, so long as the landowner can show the water was withdrawn for a beneficial and reasonable purpose and does not unreasonably harm neighboring landowners” (Drummond, 2003, p.198). Originally, Arizona required groundwater to be utilized on the overlying land, but now the rules regarding on site versus off site usage are being relaxed.

Texas: Water Rights

While all of the above-mentioned States have some concept of what constitutes ‘reasonable’ usage for groundwater consumption, Texas has the laxest regulatory structure. Through Texas has a strong precedence for regulating groundwater quality, when it comes to groundwater consumption, the rule of capture use doctrine allows private landowners to pump as much water as they like. Also known as the ‘Law of the Big Pump’, the rule of capture allows “*unfettered extraction of* groundwater” (Mumme, 2005, p.87). Therefore, private landowners may pump as much groundwater as they can and may sell it to off-site users even if a neighboring well is negatively affected. There are only three limitations, “(1) that the use for which the groundwater is withdrawn is reasonable, (2) the groundwater withdrawn is used only for the benefit of the overlying land, and (3) uses on the adjacent lands are per se unreasonable” (Drummond, 2002, p.198).

In Texas, where over 94 percent of the land is privately owner, private property rights take priority and politically it is a state that historically resists ‘excess’ government (Dunlap 2006). Texas may be reluctant to regulate aquifer pumping; however, over the last 20 years the Texas Legislature has put in place a framework for voluntary groundwater conservation measures. By dividing up the State into several different hydrologic basins, and then designing appropriately sized Groundwater Management Areas (GMAs) and Priority Groundwater Management Areas (PGMAs), governance of groundwater was placed in the local policy realm.

Additionally, if localities wish to have greater control of aquifer pumping, a region can come together to designate a Groundwater Conservation District (GCD), which are locally-developed areas with the authority to regulate the spacing and production of wells (Texas Groundwater Protection Committee, 2011). GCDs help serve as a statutory limitation on the rule of capture. GCDs are created to help design and carry out regional aquifer management plans. This type of district can be created by a consensus of landowners, by an act of the Texas Legislature, and by a recommendation from the Texas Commission on Environmental Quality (TCEQ). GCDs are comprised of a diverse group of regional stakeholders and allow for more localized control over groundwater resources in locations where groundwater is at risk. While Texas utilizes the rule of capture, a GCD can help regional landowners cooperate to effectively jointly manage local aquifer drawdown. The GCDs have the ability to regulate the number of wells, the appropriate spacing and production of wells, in addition to protecting current water user rights and identifying a long-term aquifer management plan contingent on Desired Future Conditions (DFCs) and other appropriate measurements (Far West Texas Planning Group, 2016). However, only "five GCDs physically touch Texas' border with Mexico, with an additional two GCDs (Culberson and Wintergarden) lying just miles from the border" (Foster, 2018, p.34).

However, not all GMAs or even PGMAs have a GCD designated in their region and even those that do cannot prevent groundwater from being pumped off-site. In the Texas Panhandle, for example, infamous oil tycoon, T. Boone Pickens began buying up land and extensive water rights from the Ogallala aquifer in the 1990s in order to market the water to rapidly growing cities such as San Antonio and Dallas (Berfield, 2008). Despite the rules in place regarding aquifer pumping under the GCD, there was nothing that the authorities could do to prevent Pickens from pumping the water and distributing it clear across the state. While this example is somewhat outdated the problem remains and Texans guard their private property rights closely, so, it is unlikely that there will be any change in the foreseeable future to the current use doctrine.

Constitutional, collective-choice, and operational level rules

Dr. Elinor Ostrom defined three major levels of rule-making or governance: constitutional-level, collective-choice level, and operational-level. Constitutional-level governance doesn't refer to a specific level of government, rather it refers to those within a system that have the power to define rules on which actors are eligible to make collective-choice rules. Within this governance system, the constitutional level rule making occurs at the international level and is dictated by international treaties and agreements signed by the U.S. and Mexico. The 1906 and 1944 Water Treaties are the primary agreements in place that manage the allocation of surface water resources shared between the U.S. and Mexico. However, as seen in the previous sections, the La Paz Agreement, the environmental side agreement under NAFTA, and the TAAA are all important international agreements for generating information regarding the border environment.

The federal actors on both sides of the border are responsible for the collective-choice level of rule-making. The IBWC/CILA is particularly important for implementing the primary water treaties and negotiating any conflict that may arise between the two counties. However, on the U.S. side, the EPA, USBR, USGS, and USACE are the primary federal agencies responsible for implementing the international treaties and agreements. For instance, the EPA helps manage the Border 2020 program that operates as a part of the La Paz Agreement and the NAFTA environmental side agreement. The EPA also facilitates binational working groups such as the New Mexico -Texas - Chihuahua (NM-TX-CHI) Regional Workgroup and the Texas – Coahuila - Nuevo Leon - Tamaulipas (TX-COAH-TAMP-NL) Regional Workgroup.

Operational level rule-making occurs as a mix between federal, state, and local levels of governance and combines a broader approach of public and private partnerships. At the operational level, local actors have very little say in how the rules are made or implemented. Local irrigators work with municipalities and the dam operators, namely USBR and USACE, to find out how much water will be available and to time appropriate surface water releases from the Rio Grande. During times of drought or water stress, local water users turn to local water managers and politicians to express frustration. However, local water managers and policy makers do not have the ability to address these issues or complaints directly. The only outlet that local decision-makers have for expressing their opinions or address potential conflicts is to be involved in binational stakeholder engagement efforts, such as the NM-TX-CHI and TX-COAH-TAMP-NL Regional Workgroups found in the Border 2020 program. Other known binational stakeholder engagement efforts include the Rio Grande Advisory Council, the Paso del Norte Watershed Council and the Desert Landscape Conservation Cooperative. One other forum for local users to participate in operational level activities is the IBWC Citizens' Forum; however, this is only a U.S. forum and does not include interaction with binational partners. It is anticipated that participation in these types of binational stakeholder engagement efforts will influence perceptions of risk and levels of trust to generate increased willingness to cooperate. The following section will delve more deeply into the U.S. and Texas actors responsible for water management efforts along the Texas-Mexico border.

System Actors

There are large cultural differences between the U.S. and Mexico, but there are even cultural differences between the states. With such a large and heterogeneous group of individuals, there is bound to be conflict. In addition to cultural differences and norms, there are also a wide variety of user types, who all hold different use values. For instance, municipal users may place a larger value on water for drinking use than an agricultural user. These types of competing use valuations can cause conflict when drought and over appropriation leads to water scarcity. When these situations arise, it is vital to have institutions in place that can handle the process of mediation. This section will consider the different actors and resource users at the federal, state, and local levels that operate within Texas for managing water resources in the Texas-Mexico border region.

U. S. Federal Actors

When it comes to water, the IBWC/CILA is the primary actor along the U.S. – Mexico border. As described above, IBWC/CILA is the primary institution for the management of the international border and the administrator of the 1906 and 1944 Water Treaties. This institution is composed of federal actors in both the U.S. and Mexico, who meet regularly to discuss management, enforcement, monitoring, and sanctioning of surface waters in the Rio Grande/Rio Bravo. This institution also serves as the primary agent for conflict resolution whenever problems arise in the basin.

The EPA, partnered with Mexico’s SEMARNAT, helps to ensure the creation and implementation of projects under the Border 2020 program, in addition to heading the BECC and NADB. As previously mentioned, the Border 2020 program is required by the La Paz Agreement, under the auspices of joint cooperation on the environment in the border region. Thus, the EPA, in conjunction with SEMARNAT, has a fair amount of power concerning the implementation of pollution prevention and abatement infrastructure projects. Owing to the ‘bottom-up’ structural change outlined in the Border 2020 program, many of the goals and specific projects outlined come from local or regional voices, and the design and funding is provided by the federal government.

In addition to the EPA, the federal government also has the Department of the Interior to oversee efforts by the U.S. Geological Survey (USGS) and the Bureau of Reclamation (USBR). The USGS studies help to provide scientific accuracy regarding the condition of the complex hydrological systems, which in turn, supplies vital information for the joint sharing of transboundary waters. The USBR has the daunting task of distributing waters from the Rio Grande Project, composed of the following: “Elephant Butte and Caballo Dams, 6 diversion dams, 139 miles of canals, 457 miles of laterals, 465 miles of drains, and a hydroelectric power plant” (U.S. Bureau of Reclamation, 2018). Thus, the USBR has the final say over dam water distributions, which is particularly important for New Mexico and Texas, which receive 60 percent and 40 percent respectively of the dam diversions (U.S. Bureau of Reclamation, 2018). As irrigation demand is projected to decline and municipal demand is expected to climb, a decrease in irrigation diversions and an increase in municipal dam diversions may serve as a possible source of alleviation for groundwater reliance in the border region. The U.S. Army Corps of Engineers (USACE) also play an important role in managing navigation, flood protection, water supply, and wetland restoration along the border region (U.S. Army Corps of Engineers, 2018).

Lastly, the Good Neighbor Environmental Board (GNEB) is a presidential advisory board, created in 1992 to help “advise the President and Congress on ‘good neighbor’ environmental and infrastructure practices along the U.S. border with Mexico” (EPA, 2018). This group is essentially comprised of stakeholders from important political entities along the border, including Border State representatives, agricultural and farming agents, tribal group leaders, in addition to other business/industry leaders and scholars. While the group holds no legislative power, the opinions held by the GNEB carry much weight in Congress. Texas alone holds the 2nd largest number of seats in the House of Representatives, at 36 seats (U.S. Census, 2010). Thus, the facts and opinions presented in the annual reports provided by local groups are taken seriously when it comes to developing international environmental policy on the U.S.-Mexico border.

Texas State: Institutional Actors

Water in Texas is a highly volatile topic because there never seems to be enough of it. It is not much of a jump in logic to say that the list of stakeholders is long and the political connections between the various stakeholders is often complex and contentious. However, to understand water policy in Texas it is important to identify the most powerful political players regarding groundwater issues.

Political power over water in Texas is divided between three organizations, the Texas Water Development Board (TWDB), the Texas Commission on Environmental Quality (TCEQ), and the Texas Parks and Wildlife Department (TPWD). TWDB and TCEQ hold the majority of authority, with TPWD serving primarily as a source for natural resource evaluations, in the field of Texas water policy. Additionally, where they exist, regional GCDs play an arguably more important role than all other state agencies because they provide a voice to address local water issues.

The TWDB's mission is "to provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas" (Texas Water Development Board, 2018). TWDB holds a large degree of political influence because it is responsible for collecting and sharing data regarding surface and groundwater resources, providing financial assistance for water planning, offering technical advice for GCDs, in addition to assisting with water planning initiatives across the state. Thus, similar to the international BECC-NADB duo, TWDB has the authority to help cultivate the plans for water, decide where the establishment of GCDs is appropriate, and determine who gets funding for project development.

Regulatory power is held primarily by TCEQ, and where TWDB operates as a planning and funding source, TCEQ holds the power of enforcement. TCEQ provides the regulatory framework for State water resources by enforcing Texas water laws and accomplishes this partially through the adoption and implementation of environmental quality standards. It also functions by monitoring the environmental health of the State's resources (Texas Commission on Environmental Quality and Texas Water Development Board, 2017). Furthermore, TCEQ plays a key role in intra-agency cooperation and coordination, engaging local, state, federal, and international groups in the water resource management process. In effect, TWDB may have a large degree of political clout, but TCEQ has the governmental teeth.

While TPWD has the "primary responsibility for protecting the state's fish and wildlife resources," it does not have any regulatory authority over the State's water resources (Texas Commission on Environmental Quality and Texas Water Development Board, 2017). However, TPWD provides an important role for the protection of water resources by conducting natural resource evaluations for regional PGMAs, orchestrating public outdoor education programs, and by helping private landowners practice water conservation and sustainable land management techniques. In comparison with TWDB and TCEQ, TPWD operates by essentially providing expertise on the sustainable management of the State's precious natural resources, both for state or local agencies and for the public.

In Texas, groundwater management is divided up into GMAs, and if TCEQ determines that a GMA is in danger, it can declare it a PGMA. For instance, El Paso County, overlying the Hueco Bolson, is considered a PGMA. Once an area is classified as a PGMA, state officials conduct further analysis to determine the threats facing the local aquifer. In many cases, TCEQ recommends the formation of a GCD in order to prevent further degradation, and if the local landowners do not form one, TCEQ will step in to establish a GCD (Foster, 2018). However, in the case of the El Paso County PGMA, a GCD was not created. TCEQ determined that, owing to the stringent conservation measures implemented by El Paso Water Utilities (EPWU), a GCD was not currently necessary, but stipulated that a regular re-analysis must continue to take place to ensure the sustainability of the Hueco Bolson (Far West Texas Planning Group, 2016). Thus, while TCEQ may not have the regulatory power to implement groundwater pumping restrictions, the commission does have the power to create a GCD, if El Paso does not continue its rigorous conservation efforts. This is the case for other transboundary aquifers in the Texas-Mexico border region as well. However, there are currently only seven GCDs along the Texas-Mexico border (Foster, 2018)

Local Actors along the Texas-Mexico border

Along the Texas-Mexico border, there are numerous different types of local level institutions in place to manage surface water and groundwater. County and city governments are responsible for a wide variety of management activities and are led by elected officials that serve to guide the direction of local policies. In terms of managing water, city and county governments are primarily the multi-function actors who have a wide range of responsibilities, where water management is just one small component. Municipal Utility Districts (MUDs) and other types of public and private water suppliers are primarily responsible for treating and distributing drinking water for cities and towns. Irrigation districts are directly responsible for managing surface water allocations. Soil and Water Conservation (SWCD) districts are a quasi-governmental organization that landowners within a district can vote to create. Once created, a SWCD is responsible for educating communities on conservation measures for both soil and water to help improve water quality and quantity. This group is comprised of all the local institutions that are appropriating or distributing appropriations out of the Rio Grande. Local actors on the Texas side of the border hold a variety of decision-making positions primarily regarding how water is distributed. While the federal government addresses major treaties and agreements with Mexico, it is the local actors who address the day-to-day operations.

CPR Design Principles: Surface water versus Groundwater

As we have seen, there are vast differences in the ways that surface waters from the Rio Grande versus transboundary groundwater along the Texas-Mexico border are regulated. There are a number is international treaties and agreements over transboundary surface water, with very little attention paid to groundwater. This section will attempt to briefly describe the differences of management in terms of the CPR design principles outlined by Elinor Ostrom (Ostrom, 1990; Poteete, Janssen, and Ostrom, 2010).

1) **Clearly defined boundaries:** In the Rio Grande/Rio Bravo Basin, the system boundaries are clearly defined and well-understood. However, for transboundary aquifers along the Texas-Mexico border this is not the case. Unfortunately, only a few of the well-studied aquifers, such as the Hueco and Mesilla Bolsons, have clearly defined boundaries. Other potentially transboundary aquifers in this region are poorly understood, lack data, or are categorized differently by binational counterparts (Sanchez and Eckstein, 2017).

2) **Congruence between appropriation and provision rules and local conditions:** For the surface waters of the Rio Grande, the appropriation and provision rules are usually based on prior appropriation and are allocated based on a 'first in time, first in right' approach, which favors agricultural users. This historical approach may have been appropriate for local contexts when the dependent users were primarily agricultural; however, with the major growth in urban areas, municipal users are demanding more water. Surface water rules for appropriation and provision are not always appropriate for dynamic local contexts, where urban demand is rising. This has caused potential for conflict. For transboundary groundwater, congruence between local context and appropriation and provision rules are inconsistent and in areas where groundwater reliance is high, there are not appropriate rules in place.

3) **Collective-choice arrangements:** Users of the Rio Grande waters do not always have the ability to change the operational rules. The La Paz Agreement and the CEC created the Border 2020 program, which has given users some voice to address issues and problems that may arise. However, the primary organization in charge of changing both collective-choice rules and operational level rules is the IBWC/CILA, which does not have a strong public-participation component. In the U.S. Section of the IBWC, there is a Citizen's Forum, where users can bring up issues. However, users are not able to alter or modify the operational level rules. For transboundary aquifers, the only collective-choice arrangements are made by GCDs, which may or may not exist for aquifers in question and may or may not have any power to regulate well-withdrawals. On the border there are only seven GCDs in the region and they are drawn on political lines, not hydrological.

Additionally, the biggest recognized transboundary aquifer on the border, the Hueco-Mesilla Bolson, is not covered by a GCD.

4) **Monitoring:** Monitoring in the Rio Grande is clearly established by the IBWC/CILA. The monitors in these systems are not always accountable to the appropriators, because the monitors are operating at the state or federal level and appropriators can range from municipalities to irrigation districts. Furthermore, there are not sufficient monitors on both sides of the border to catch illegal appropriations. For transboundary aquifers, there is very little monitoring, except for in the Hueco and Mesilla Bolsons. Even where monitoring exists, appropriators are not regulated.

5) **Graduated Sanctions:** Appropriators of the Rio Grande can be held accountable via graduate sanctioning by the IBWC and associated federal institutions, such as the USBR and USACE. However, there is not enough monitoring in place along the length of the river to catch illegal appropriations, particularly on the Mexican side of the border.

6) **Conflict-resolution mechanisms:** The only conflict-resolution mechanism on the Texas-Mexico border is found in the IBWC/CILA, where representatives from both the U.S. and Mexico meet regularly to discuss problems. However, many stakeholders in this region find the conflict-resolution mechanism in place to be too slow. Within Texas, many stakeholders try to increase the speed of conflict resolution by placing pressure on locally- elected city, county, and state officials to, in turn, place pressure on federal actors. Thus, while there is an appropriate formal conflict-resolution mechanism in place for the U.S. and Mexico, there are no rapid, low cost ways for local appropriators in Texas and its binational state counterparts. There is currently no formal conflict-resolution mechanism in place for transboundary aquifer issues.

7) **Minimal recognition of rights to organize:** Within the U.S., the Border States are given authority to manage when and how stakeholders within their respective states organize. As can be imagined, each state has different rules in place to address the rights to organize. In Texas, stakeholders are free to collaborate over shared water management. However, Texans are not given the right to change how surface water is allocated under the 1906 and 1944 Water Treaties. For groundwater, Texan are given much more leeway to organize. The GCDs are an example of this right to organize. However, Texans view groundwater rights as a private property right, and rarely opt to place regulations on those property rights.

8) **Nested Enterprises:** For the Rio Grande, the appropriation, provision, monitoring, enforcement, conflict resolution, and other governance activities are nested within a highly polycentric system. Unfortunately, this means that there are gaps in management and overlapping jurisdictions which can, and often does, lead to inefficient management of the river. Transboundary aquifers are not well regulated and, as we have seen, there are not clear appropriation, provision, monitoring, enforcement, or conflict resolution mechanisms in place. While Texans have the right to form GCDs to address some of these issues, they rarely choose to do so.

This section has shown that there are vast differences in the presence and application of Ostrom's CPR design principles for transboundary surface water versus groundwater in this focal SES. While this was not an in-depth analysis, it was meant to serve as a brief exploration of the different institutional structures in place for management of these common pool resources.

For the Rio Grande, approximately five to six of the CPR design principles are currently in place, though they are not perfectly designed. There are clearly defined boundaries, there are nested institutional structures, and there is some congruence between appropriation/provision rules and local context. Monitoring and graduated sanctions are both in place, but there is no clear connection between appropriators and those tasked with the monitoring and sanctioning activities. Additionally, there are consistently gaps in monitoring and in catching illegal appropriations owing to the sheer size of the border. Conflict resolution mechanisms work well for the nation-to-nation problems, but do not provide access to local appropriators to resolve conflict in a timely manner. Finally, while there are clear collective action rules in place, the appropriators that are impacted by the operational level rules do not have the ability to change them, nor do appropriators have the ability to organize to change how water is allocated.

For transboundary aquifers, the only real design principle that is present is the minimal recognition of the rights to organize. It could also be argued that the ability for nested enterprises exists for these aquifers but is not used effectively. Essentially, transboundary aquifers are currently left up to sovereign takings, where users on each side of the border may use the groundwater without consideration of their binational counterparts. In Texas, groundwater is considered a private property right and, while GCDs can be formed to help create limitations on these rights, limitations on groundwater are rarely monitored or enforced even when they do exist.

These stark differences in the institutions, rules, and procedures in place for transboundary aquifers versus surface water are instrumental in developing how individuals perceive risks for formal or informal cooperation or conflict. For instance, there are clear rules in place for appropriations out of the Rio Grande and a user must adhere to those formal rules. Groundwater sharing could be seen as a riskier endeavor, particularly formal cooperation over groundwater, which currently doesn't exist and could potentially impact current institutional structures, rules, and procedures over the surface water resources.

It is important to understand how CPR design principles apply to the different transboundary resources along this international boundary. As was shown in Chapter 2, when there are not appropriate rules in place for common pool resources, it can lead to a 'tragedy of the commons' situation. Resource users and institutional actors must be willing to cooperate to form collective-action rules in order to prevent system degradation or collapse.

Case Study applied to hypotheses: measuring Interactions and Outcomes

This project systematically investigates hypotheses related to levels and types of conflict and cooperation on water issues along the Texas-Mexican border. This project examines variation in the formal and informal systems of water governance, using Texas as an initial case study. Future studies will expand analysis to include New Mexico, Arizona, and the Mexican states of Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas. Transboundary water governance presents one of the most complex and challenging issues of coupled human-natural systems anywhere in the world. Although there has been significant research on management and cooperation over cross-national water resources, existing research has not advanced theoretically or empirically to a point where there are clear conclusions concerning the conditions under which cooperation can be achieved, or what impact cooperation has on access and usage of water. Case study analyses have carefully documented the special circumstances of transboundary water conflicts, tensions or cooperation in particular places, but without much that can be said to be generalizable (Wolf and Delli Priscoli, 2008). Recent comparative analyses of cooperation along five transboundary rivers suggest that a small number of variables, all related to perceived risks, can explain cooperation (Subramanian, Brown, and Wolf, 2014). Since much of the existing analyses of transboundary water governance are derived from the Middle East, Asia, and North Africa, this project seeks to fill a gap in the literature by focusing on the North American water challenges between the U.S. and Mexico.

Primary research for this study on risk perception and trust occurred along the Texas-Mexico border. Texas provides a compelling geographic frame of reference to deepen the understanding of state-to-state coordination and decision making on transboundary water resources (surface and groundwater). Additionally, since Texas simultaneously comprises the largest stretch of the U.S.-side of the international border and has the laxest regulatory structure for groundwater, it serves as an ideal frame of reference for understanding the challenges of cooperative management faced by the U.S. and Mexico, particularly for transboundary aquifers. This region has already been targeted for improved trans-border cooperation, which includes: the TX-COAH-TAMP-NL and TX-NM-CHI Regional Workgroups (under Border 2020); the Rio Grande Advisory Council; and the Paso Del Norte Water Task Force. Each of these initiatives and their underlying processes has sought to make progress toward water cooperation, with the focus being on surface water (Brown, 2004; Hamlyn et al., 2000). This provides an excellent opportunity to study how binational cooperation impacts risk perception and trust. The result of this overarching study will be a clear articulation of the conditions under which trust can be built and perceived risks of bilateral cooperation can be reduced or managed, all with an eye toward improving the willingness of those involved in water governance to cooperate either formally or informally in order to avoid unnecessary depletion of shared water resources.

Interactions and Outcomes

Within the SES Framework, an emphasis is placed on interactions and outcomes of the focal action situation. The focal SES that is considered in this case study is how water decision-makers in Texas use perceptions of risk and levels of trust to make decisions to engage in cooperation or conflict.

For this case study, interactions include the degree of data sharing for surface water versus groundwater, the deliberation processes, such as the IBWC conflict resolution mechanism, and different types of conflict between users. This case study will attempt to measure willingness to engage in some of these types of interactions by measuring how individual willingness to cooperate or engage in conflict, both formally and informally, varies within different institutional settings. Specific information on the questionnaire will be presented in Chapter 4. While stakeholders from all relevant U.S. and Texas institutions were measured, these results were combined at different tiers of governance in order to capture variation in perceptions at the local, state, and federal level.

Outcomes of a focal action situation include social performance measures, such as efficiency, equity, and accountability. Outcomes can also be ecological performance measures, such as the level of resilience to hazards, and the sustainability of the resources. This study measures perceptions of risk to several social performance measures at different tiers of governance: 1) sovereignty and autonomy 2) accountability and voice, 3) capacity and knowledge, 4) equity and access, and 5) stability and support. Additionally, this study measures the degree in which individual trust in current international or state procedures will lead to social or ecological outcomes.

This chapter provided necessary context for understanding the Texas-Mexico case study by exploring different components using the SES Framework. Chapter 4 will delve into the actual study design and methods of analysis.

CHAPTER IV

METHODS OF ANALYSIS: PUSHING THE BOUNDARIES OF UNDERSTANDING

This chapter outlines the study design, the process of data collection, and the statistical analysis preformed. The study design is firmly rooted within the theory and conceptual underpinnings and fills several gaps within the literature. A detailed description of the metrics chosen to measure specific variables is provided. The questionnaire design process is described, as well as the survey distribution. The final section of the chapter presents an in-depth description of the statistical methods to set the stage for how the chosen variables contribute to furthering the understanding of transboundary water sharing from a new quantitative perspective. The main thrust of this chapter will be to explain how the data was collected, the quality of the data, and how the data was analyzed.

Introduction

Few studies of risk perception or trust have focused specifically on an application to binational water cooperation, much less cooperation over groundwater. Most literature on risk perception and trust has been applied to understanding perception to physical risks, such as natural hazards (Slovic, 1993). Studies on binational water cooperation have emerged primarily out of international relations and water security literature. As previously discussed, within the water security literature there has been a strong focus on the country-level decisions and not as much focus on individual level actors, though the application of IWRM principles has begun to change this top-down, command and control mindset. Additionally, CPR theories have been applied to water management to study groundwater management, but very few of these studies have been applied to international, transboundary aquifers (Theesfeld, 2010).

Despite that fact, there have been very few attempts to merge these bodies of literature for binational water cooperation and most of the literature that does exist is based on case study analysis (Bilder, 1981; Subramanian, Brown, and Wolf, 2012). Notably, Bilder's 1981 book on *Managing the Risks of International Agreements* was one of the first comprehensive attempts to understand the impact of risk on international cooperation. The focus of this body of work was to deepen the understanding of risk management in the formation of formal and informal cooperative mechanisms for management and the analysis presented was based on a qualitative examination of existing legal frameworks and case studies. Work by Trevin and Day (1990) attempted to build on this work by applying concepts of risk perception and trust to the case of the Plata Basin, shared by Argentina, Bolivia, Brazil, Paraguay, and Uruguay, where distrust was a serious hindrance to cooperation. This case study was an interesting application of risk and trust, particularly within the broader global context of IWRM evolution. The most relevant application of risk perception to understanding binational water cooperation is the work that has been done by Subramanian, Brown, and Wolf (2012, 2014). This body of work utilized the Transboundary Freshwater Dispute Database, managed by Aaron Wolf, to analyze a broad set of case studies in order to pick out trends related to the impact of perceived risk on the development of formal and informal cooperative mechanisms. As a result of this work, Subramanian, Brown, and Wolf (2012) found five main categories of risk perception in transboundary water sharing: 1) sovereignty and autonomy; 2) equity and access; 3) capacity and knowledge; 4) accountability and voice; 5) and stability and support.

The only known attempt to quantifiably measure risk in an international water basin setting was done by Rai, Sharma, and Lohani in 2014. This study utilized a fuzzy synthetic evaluation technique to try and generate a risk assessment process that could predict international basins at risk (Rai, Sharma, and Lohani, 2014). However, this approach did not attempt to quantify risk perceptions, but rather was an exercise in risk assessment. A more recent study was performed by Garrik et al. (2018), which attempted to use the IAD-SES framework to understand how institutions adapted to risks of drought. While this paper clearly outlined the institutional systems or 'institutional catchments,' the analysis was focused primarily on institutional decision making and did not include a measurement of how perceptions of the risk to drought impacted decision-makers. Additionally, none of these approaches consider how individuals, operating within institutional settings, use perceptions of risk and trust to make cooperative or conflictual decisions.

Methodology: Operationalizing Risk Perception and Trust Metrics

For the purposes of this research, data collection combined approaches in risk perception and trust analysis from Slovic, Cvetkovich, Siegrist, and Earle with risk perception categories suggested by Subramanian, Brown, and Wolf (2012). This was accomplished by operationalizing Subramanian, Brown, and Wolf categorical risk perception concepts into measurement approaches used by Slovic, Cvetkovish, Siegrist, and Earle. The result is a quantitative analysis that combines elements of political science, international relations, social psychology, and sociology. The survey results help explain when and why stakeholders at various tiers of governance make the decision to cooperate/engage in conflict either formally or informally over surface and groundwater resources. Data was collected about individual perceptions of risk and trust, individual levels of engagement in binational cooperative efforts, and individual attitudes toward cooperative or conflictual behavior. Data was aggregated into institutional settings and analyzed by looking at different tiers of governance to provide a deeper understanding of how individual behavior is aggregated at the institutional level.

Study Design

A cross-sectional study design was used to collect and analyze survey data from known transboundary water policy decision-makers in Texas along the border with Mexico. Because the response rate for elite surveys is extremely important in establishing the external validity of the resulting data, this study was designed to follow a protocol expected to maximize the response rate (Dillman, Smyth, and Christian, 2009).

Questionnaire Development

The focus in this proposed study was to measure the influence of perception of risks and trust on decisions to engage in binational water cooperation and/or conflict. While the categories of perceived risks identified by Subramanian, Brown, and Wolf are considered to be more intangible concepts, this study is an initial step to identifying and quantifying the perceived risks that are representative of these concepts. These types of perceived risk relate specifically to water supplies, water access, and water quality. In this study, measurement of identified categories of risk was attempted in the following way. In order to create a survey that didn't put off survey respondents with negative language, several of the questions were measured with positive language, where a high score indicated a decrease in risk perception and a low score indicated an increase in risk perceptions. The only question that did not fall on this scale was the question on sovereignty, where a high score was indicative of high perceptions of risk. This was normalized to match the others for the purpose of data analysis. See Table 1 below for more specific information on the categories and questions used for measurement.

Table 1: Representative Risks of Subramanian, Brown, and Wolf's 5 Risk Categories

Risk Category	Questions for Measurement	Likert Scale Range
Loss of Sovereignty	"Formal cooperation with Mexico will lead to a loss of local authority and control over decision making."	(1) Very unlikely to (5) Very likely
Increased Equity	"Cooperation with Mexico over shared groundwater will lead to equitable water distribution."	(1) Very unlikely to (5) Very likely
Adequate Knowledge	"The U.S. federal government has the knowledge necessary to accurately negotiate groundwater management in aquifers shared with Mexico."	(1) Strongly disagree to (5) Strongly agree
Appropriate Accountability	"The U.S. federal government has the ability to uphold and enforce cooperation commitments."	(1) Strongly disagree to (5) Strongly agree
Support	"As far as I know, most water users within Texas will support cooperation with Mexico over shared groundwater."	(1) Strongly disagree to (5) Strongly agree

Whenever possible, each relevant variable was measured with multiple questions and with different levels of measurement. For example, fixed-response questions were fashioned to include dichotomous, ordinal, and where possible, interval measures. For this example, measures of risk perceptions included questions in reference to the five dimensions of perceived risk suggested by Subramanian, Brown, and Wolf (2014). The survey questionnaire was designed to include measures of both risk perception and trust. The five categories of risk perception were initially measured by two questions each, for a total of ten questions, but results of pre-testing (procedures and results described below) indicated that each category could be sufficiently measured by one question each, for a total of five questions, which are listed in Table 1.

Risk perception was also measured using a psychometric paradigm approach, as advocated by Paul Slovic. While there have been a few studies looking at perceptions of risk over water, as described in Chapter 3, no one has looked at perceptions of risk over transboundary water sharing. As such, it was necessary to create metrics to measure risk perceptions within a transboundary water setting that were contextually appropriate. Within the broader risk perception literature, several factors came up repeatedly for being important for calculating risk; specifically, controllability and knowledge. While there is a large variety of potential factors for analysis within the risk perception literature, controllability and knowledge were the most studied and most well represented in the literature. In addition to these two factors, this study also took a similar approach used by McDaniels et al. (1997), which measured perceptions of ecological risks to water. Their study considered ecological impacts, controllability, knowledge, and benefits. These same four factors were chosen (ecological impacts, controllability, knowledge, and benefits) and adapted for the purpose of this study. However, the sub factors, which were used to measure the main factors, had to be altered for this study, in attempt to make them most contextually appropriate for the transboundary study location. Sub factors included risks such as flood, drought, and water for irrigation, political rhetoric, corruption, unregulated groundwater pumping, groundwater degradation, and the lining of irrigation canals. While these sub factors were measured consistently for ecological impacts, controllability, and knowledge, the approach this study used to measure benefits deviated from the approach used by McDaniels et al. To measure benefits, a list was generated of the top benefits gained from cooperation with Mexico over transboundary water. This list included things such as sustainable development, joint management of infrastructure, economic development, reduced uncertainty, more efficient groundwater management, increased knowledge sharing, adaptable water management, and improved groundwater protection, the ability to quickly resolve common concerns, better flood control, and improved emergency response. While this deviation will remove the ability to measure risk perception associated with the benefits factor, it was necessary to capture perceptions regarding the benefits associated with transboundary water cooperation.

Trust was measured in a variety of different ways. Initially, respondents were asked about their general belief that people can be trusted. This is followed with two measures of relational trust; dispositional and affinitive. Dispositional trust measures respondents' general disposition towards trusting Mexican water managers. Affinitive trust measures respondents' level of trust that Mexican water managers will manage water according to the respondents' values. Two additional measures of calculative trust or confidence are also considered; rational trust and procedural trust. Rational trust measures whether or not respondents believe that the benefits of trusting Mexican water managers outweigh the potential costs. Procedural trust measures the respondents' belief that the current international rules in place are adequate. Five measures of trust can be seen in Table 2 below.

Table 2: Trust Metrics

Measures of Trust	**Questions used to measure trust**	**Likert Scale Range**
General Trust	"Generally speaking, most people can be trusted."	(1) Strongly Agree to (5) Strongly Agree
Relational		
- Dispositional	"In general, water managers in Mexico can be trusted to manage water efficiently."	(1) Strongly Agree to (5) Strongly Agree
- Affinitive	"Water managers in Mexico can be trusted to manage water in accordance with your personal values."	(1) Strongly Agree to (5) Strongly Agree
Calculative/ confidence		
- Rational	"The benefits of trusting water managers in Mexico outweigh the costs."	(1) Strongly Agree to (5) Strongly Agree
- Procedural	"Current international rules provide adequate procedures for managing shared groundwater."	(1) Strongly Agree to (5) Strongly Agree

Cooperation and conflict were considered central dependent variables for measuring the independent variables of risk perception and trust. Cooperation was measured by six questions looking at willingness to cooperate and six questions measuring actual experience with cooperation, for a total of 12 questions. Of those 12 questions, half were representative of formal types of cooperation and half were informal types of cooperation. The primary dependent variable was willingness to cooperate, which included issues on previous participation in binational stakeholder engagement, cooperative management of shared resources, and sharing of hydrologic data. Conflict is similarly measured, with six questions about willingness to engage in conflictual behaviors and six questions about actual experience of others engaging in conflictual behaviors, for a total of 12 questions, where half were formal types of conflict and half were informal types of conflict. Within these measures of cooperation and conflict, several questions asked about risks associated with groundwater and surface water to capture possible differences in perceptions and trust regarding the two sources.

The questionnaire also included general positional questions, such as time worked in position, perceived reliance on groundwater, and perceived transboundary nature of border aquifers. Demographic information was collected on age, gender, race, educational background, and political affiliation. The full questionnaire is presented in Appendix 1.

Pre-Testing the questionnaire

After initial questionnaire development, a number of pretest steps were undertaken to assess the validity and efficacy of the questions and the survey instrument. Two specific issues were addressed. First, informal feedback suggested that the questionnaire was too long. The primary reason why the questionnaire was so long is that it incorporated multiple measures of the same concepts to be used in hypothesis testing. For instance, in the original questionnaire, each of the five categories of risk perception had two questions instead of one. The pretest was undertaken with the expectation that it would reveal which questions could be prime candidates for deletion. Second, in an effort to assess the efficacy of two different approaches to positively influencing the response rate, the second wave started with mailing an initial “alert letter” to prime potential respondents, followed by mailing the questionnaire packet (Alert letter found in Appendix 2). The first wave omitted the alert letter and started with mailing the questionnaire packet itself. Both pre-tests also included network affiliation questions regarding the frequency of contact between different agencies. While this data would have allowed for network analysis, it was deemed less vital for inclusion and was cut to allow for a shorter questionnaire.

The initial wave questionnaire packet included a cover letter (Appendix 3) on Institute for Science, Technology and Public Policy (ISTPP) letterhead describing the study and detailing the anonymous, voluntary nature of responses, as well as the Institutional Review Board (IRB) approval number. The mailing also included a one-dollar bill as a token of appreciation, a prepaid postcard for participants to enter to win one of two $75 amazon gift cards, and a prepaid envelope with ISTPP branding to allow respondents to fill out and return the survey without incurring additional postage costs. The questionnaire itself was four pages, double-sided, or eight pages total length.

As mentioned, the second wave included an alert letter, with ISTPP letterhead, that was sent out about a week prior to the questionnaire packet. The alert letter detailed the purpose of the study and the need for participants. The alert letter also gave participants a warning to expect the questionnaire, thereby reducing the possibility that the questionnaire would be thrown away or ignored. As stipulated in the letter, this mailing was followed a week later by the actual questionnaire packet, which included the same materials as the initial wave.

The two pretest waves, consisting of two waves of 100 and 99 initial mailings, respectively, were placed in the U.S. Postal Service with first-class postage stamps on each envelope. Each of these waves consisted of a random sample of city and county public officials selected from a full list of 954 officials. Wave P1 was mailed on February 14th, 2018 to 100 prospective respondents and four were returned by the U.S. Postal Service as 'undeliverable.' This wave yielded 14 returned completed questionnaires, for a response rate of 6.9 percent. Wave P2 was sent on April 9th, 2018 to 99 prospective respondents, six of which were returned undeliverable. About a week after the initial surveys were sent, a reminder email was sent to 81 distinct emails, eight of which turned out to be undeliverable. This wave yielded 13 returned questionnaires, for a response rate of 7.2 percent.

Wave P1 of the pretest revealed that there were issues with the ordering of questions and questionnaire completion. Only 14 participants responded, and missing data was a big issue, where at least four of the respondents didn't complete the second half of the survey and two skipped the first few questions. For Wave P2 of pretesting, a number of changes were made to the survey to help with completion rate. While the rate of return was similar in both pretest waves, the responses for Wave P2 were of much higher quality, with more fully completed surveys, only two skipped the back half of the survey and one of those was a respondent online who dropped out early on in the survey. Additionally, an alert letter was added to Wave 002 in attempt to increase the response rate. An increase of 6.9 percent to 7.2 percent was seen, and while this is not a large increase, it was deemed enough to improve response rate for the official survey distribution.

One of the primary purposes of the pretest was to try to facilitate shortening of the questionnaire. In an attempt to identify questions to eliminate, the data from pretest Waves P1 and P2 were combined for a total of twenty-seven (n=27) respondents. It was determined that part of the poor response rate was due to the onerous length of the questionnaire, in part because many respondents did not complete questions after a certain number had been answered. This was particularly the case for online respondents, who dropped out of the survey early on. To evaluate a questionnaire in an attempt to remove unnecessary/redundant questions two statistical methods were utilized, Cronbach's Alpha and Factor Analysis.

There were eight concepts measured by questions within the questionnaire being analysis: (1) risk perception, (2) risk perception-psychometric paradigm, (3) relational trust, (4) calculative trust, (5) willingness to cooperate, (6) propensity toward conflict, (7) engagement in cooperative behavior, and (8) engagement in conflict behavior. Each concept was assessed through multiple questions. In order to identify potential questions for removal, these concepts were evaluated for pattern responses utilizing factor analysis, to see if multiple questions were measuring the same concepts. A screen plot, component matrix, and rotated factor loading pattern matrix were produced. Two of the eight concept groupings did not have enough respondents for analysis. Factor loadings with ≥ 0.8 were identified for potential removal, so as to cut questions that were measuring the same concepts.

To measure internal consistency within each concept Cronbach's Alpha was calculated. Item-total statistics and correlation matrix were produced and internal consistency if items were removed were assessed with a goal of achieving $\alpha \geq 0.7$, if consistency was improved with removal of a specific question it was highlighted as a candidate for removal. Questions identified through both approaches were removed from the questionnaire, this totaled two complete questions and 30 sub-questions removed.

Administering the questionnaire

The questionnaire (Appendix 1) was administered by using mixed modes. Potential participants were initially contacted with an alert letter on official ISTPP letterhead to inform them of the upcoming study, with information about voluntariness of participation, importance and potential outcomes of study, along with important information about anonymity of participation and protection of confidentiality of information. In addition to the ISTPP letterhead, two more institutional logos were added to the alert letter and the cover letter: The Meadows Center for Water and the Environment (MCWE) and the Texas Water Resources Institute (TWRI). These institutions were added as co-sponsors because they are two of the most well-known water research centers in Texas and it was thought that this addition would lend additional credibility to the study and improve response rate. The initial survey was then mailed with a pre-paid return envelope. The mailed survey included, in the cover letter and at the top of the questionnaire, a web link to an online version of the questionnaire that has the exact same content as the paper questionnaire. This provided participants the option of responding online or in print. For those respondents whose email addresses were known, follow up notices were sent out two weeks after the paper questionnaire was sent.

The survey provided an incentive for participation in the form of a chance to win one of two $75 Amazon gift cards, where the winner was selected randomly from among those who indicated that they responded to the survey. The initial mailing included a separate pre-paid postcard (Appendix 5) where respondents could supply their contact information to enter into the prize drawing. These returned postcards were never connected in any way to completed questionnaires. They were designed to provide a mechanism for survey participants to selfidentify, and the postcards were used to identify for follow-up notifications to those who had not responded.

Surveys were administered to all appropriate public local, Texas state, and federal water decision-makers with official responsibilities for water policy and management along the Texas-Mexico border. The targeted population for this survey was ALL public officials with water policy and management relevant responsibilities. An initial list of 755 officials was compiled consisting mainly of municipal, county, regional, statewide, and federal officials. In order to ensure full coverage of the relevant population, a snowball sampling method was used to identify other potential public officials for inclusion, where respondents had the opportunity to suggest other potential respondents. Approximately, 85 percent of the list of potential participants were local public officials. These local public officials include those from municipal governments, county governments and commissions, irrigation districts, groundwater conservation districts, and other special districts associated with groundwater or surface water management. Approximately 15 percent of the list of potential participants were state or federal officials. The list included Texas state officials in the Texas Commission on Environmental Quality (TCEQ), Texas Water Development Board, and Texas Department of Parks and Wildlife. The federal and international officials included those in the U.S. Section of the International Boundary and Water Commission (IBWC), the Border Environment Cooperation Commission and North American Development Bank (BECC/NADB), the U.S. Bureau of Reclamation (USBR), U.S. Department of Agriculture (USDA), Region 10 of the U.S. Environmental Protection Agency (EPA), National Parks Service (NPS) on the border, U.S. Fish and Wildlife Service (USFWS), and the Army Corp of Engineers (USACE).

The questionnaire was distributed in three separate waves. Wave 1 consisted of 302 recipients, all city and county officials, from mayors and commissioners down to city managers. The 27 pretest respondents were not included in the final sample and the 199 pretest recipients were also removed. The first wave alert letter was sent out on May 21, 2018. The full questionnaire packet was sent out on May 28, 2018 and included a cover letter, the questionnaire, a postcard for entry into the Amazon gift card, as well as a postage-paid return envelope for the completed questionnaire. Out of the first wave of respondents, 12 letters were undeliverable. Two weeks later, these mailed packets were followed up with an email reminder on June 11, 2018. Out of 302 initial participants, emails were only available for 279, and out of those, only 193 emails were deliverable. This first wave received three reminder emails on June 11th, June 19th, and July 2nd, 2018. Of this group, 56 responded, for a total response rate of 19.3 percent of Wave 1.

Wave 2 included 338 representatives of local officials from municipal utility districts, irrigation districts, soil and water conservation districts, groundwater conservation districts, and other special districts that manage water on the border. The Wave 2 alert letter was sent out on May 30, 2018. The full questionnaire packet was sent out on June 6, 2018 and included a cover letter, the questionnaire, a postcard for entry into the Amazon gift card, as well as a postage-paid return envelope for the completed questionnaire. Out of the second wave of respondents, 20 letters were undeliverable. Two weeks later, these mailed packets were followed up with an email reminder on June 20, 2018. Out of 338 initial participants, emails were only available for 239, and out of those, only 89 emails were deliverable. This was the lowest of the three waves, in part, because of the nature of these institutions surveyed, which often lack email access or lack institutional transparency. This second wave received three reminder emails on June 20th, June

27th, and July 9th, 2018. Of this group, 79 responded, for a total response rate of 24.8 percent of Wave 2.

Wave 3 included all federal and state officials, a group of 115 representatives. These representatives were from federal and international agencies such as the IBWC, BECC/NADB, USBR, NPS, USDA, USFWS, EPA, and USACE, as well as state agencies such as TWDB, TCEQ, TPWD, Groundwater Management Areas (GMAs), and state representatives for the House and Senate. The Wave 3 alert letter was sent out on June 7, 2018. The full questionnaire packet was sent on June 14, 2018 and included a cover letter, the questionnaire, a postcard for entry into the Amazon gift card, as well as a postage-paid return envelope for the completed questionnaire. Out of the third wave of respondents, 16 letters were undeliverable. Two weeks later, these mailed packets were followed up with an email reminder on June 28, 2018. Out of 115 initial participants, emails were only available for 93, and out of those, only 88 emails were deliverable. This third wave received three reminder emails on June 28th, July 9th, and July 16th, 2018. Of this group, 33 responded, for a total response rate of 33 percent of Wave 3.

Table 3: Questionnaire Distribution and Response Rate

Wave #	Total Surveyed	Undelivered	Net surveyed	Respondents	% of the total net surveyed	% of total Respondents	% under or over represented
Wave 1	302	12	290	56	41.0%	33.3%	**-7.7%**
Wave 2	338	20	318	79	45.0%	47.0%	2.0%
Wave 3	115	16	99	33	14.0%	19.6%	**5.6%**
TOTAL	755	48	707	168	100.0%	100.0%	
	Total response rate		**23.8%**				

For Waves 1 through 3, a total of 755 decision-makers were contacted on the Texas-Mexico border, because of undeliverable mail a net number of 707 recipients were ultimately contacted. Of 707, 168 people responded for a collective response rate of 23.8 percent. For further breakdown of response by respondent type, please see Table 4 below.

Table 4: Breakdown of Response Rate by Respondent Type

Category of Organization	**Total Surveyed**	**Undelivered**	**Net surveyed**	**Number of Respondents***	**% dist. of total net surveyed**	**% dist. of total Respondents***	**% under or over represented***
Municipal Utility District	18	1	17	17	2.4%	10.1%	7.7%
Groundwater Conservation District	24	0	24	10	3.4%	6.0%	2.6%
Soil and Water Conservation District	57	0	57	11	8.1%	6.5%	**-1.5%**
Irrigation District	36	1	35	15	5.0%	8.9%	4.0%
City Agency	246	10	236	41	33.4%	24.4%	**-9.0%**
County Agency	56	2	54	15	7.6%	8.9%	1.3%
State Agency	62	13	49	14	6.9%	8.3%	1.4%
Federal Agency	53	3	50	19	7.1%	11.3%	4.2%
Other	203	18	185	26	26.2%	15.5%	**-10.7%**
TOTAL	755	48	707	168	100.0%	100.0%	

During the data collection phase, there was massive flooding on the border, particularly in cities of the Rio Grande Valley during June of 2018 (Alamdari, 2018). This could have influenced the response rate for city officials and for utilities or other types of water managers, who are often the primary agencies to respond to these types of hazards. Another limitation to data collection was the extremely limited available public data on emails for local, special district officials. This is, in part, due to the nature of these districts, which don't have a lot of interaction with the public, thus the need for transparency is lower. Additionally, in a conversation with the manager of the TCEQ Watermasters program, it was communicated that many local water managers on the border simply don't have access to a computer or email. Regardless, as can be seen in Figure 4.4 above, the survey response was fairly representative, with only SWCD officials, city officials, and other special district officials underrepresented. Additionally, it is suspected that the other category, which included a wide variety of special districts and public/private utilities, may have frequently selected the municipal utility district category, because it seemed close to their actual institution type. In Table 4.3, overall, the only category that was underrepresented was city and county government. As mentioned, city officials may be underrepresented because of flooding in the border region during the data collection phase. Other than this category, overall, all other categories were well-represented within the sample.

Methods of Analysis

Data Cleaning, Variable Creation, and Data Assumptions

A variety of approaches were utilized to test the hypothesis that lower perceptions of risk and increased levels of trust will produce more examples of cooperative behavior. Missing data was assessed if it was missing at random or not. Further, the database was assessed for duplicates, out-of-range values, and any outliers that overly skewed the variable. Multicollinearity was checked for all independent variables through variance inflation factor (VIF) and through monitoring changes in coefficients and standard error when removing variables on all logistic regression.

The composite variables, risk perception, trust, propensity towards conflict, and willingness to cooperate were created from multiple individual ordinal variables. For instance, with a score of 4 on a 1 to 5 scale (strongly disagree, agree, neither, disagree, strongly agree) on the question “Generally speaking, most people can be trusted” this would add 4 to the composite trust variable (the full survey can be seen in Appendix 1). The sub-categories of informal and formal willingness to cooperate were also created from six ordinal variables into a composite score of an individual’s overall willingness to cooperate within these facets. Similarly, propensity to engage in conflict was created out of six variables into a composite score.

The strata of organization and governance structure that respondents work for was collapsed and categorized into three tiers; local, state, and federal agencies. This was done for clarity in analysis as well as under representation within certain groups, for instance Soil and Water Conservation Districts which accounted for rough 6 percent of the respondents. Likewise, years’ work at current position was categorized into 3 or fewer years, 4-6 years, 7-9 years, and 10 or more. Race/Ethnicity was categorized into non-Hispanic white, Hispanic/Latinx, and Other due to low representation from African American, Native American, or Asian American individuals. Descriptive statistics were created to characterize the research population. Sample characteristics include demographic data (sex, age, and race/ethnicity), education, and political ideology.

Risk Perceptions and Willingness to Cooperate

Risk perception was evaluated through the generated trust composite score, as well as across five categories: sovereignty, equity, accountability, support, and knowledge. Ordinal logistic regression was utilized to assess if an increase in risk perceptions across the five categories was associated with a willingness to cooperate over shared transboundary water resources. Regression coefficients, standard errors, and corresponding p-values were reported. Further, as political ideology (very liberal, liberal, moderate, conservative, very conservative) have been found to be associated with risk and trust (Jost et al., 2003). Due to this, the analysis was adjusted on political ideology to remove the potential for confounding.

Propensity to engage in conflictual behavior was also assessed through ordinal logistic regression across the five categories of risk perception. Regression coefficients, standard errors, and corresponding p-values were reported to gauge if an increase in perceptions risk was correlated with an increase in conflictual behavior. The crude and adjusted (by political ideology) findings were reported. To determine the degree to which governance tier (local, state, and federal) differ on perceptions of risk, multinomial logistic regression with reported coefficient values, ratios between governance tier, 95 percent confidence intervals (CIs), and p-values were reported.

To determine the relationship between informal and formal cooperative and conflictual behavior, linear regression was performed, stratified across the five risk perception categories. The informal and formal composite scores were utilized for measuring attitudes toward cooperative and conflictual behavior.

To assess risk perception in transboundary water sharing settings using the psychometric paradigm, eight items were created to assess for ecological risk perceptions across three factors. The three factors were controllability, knowledge, and ecological impact, while the sub factors included drought, water used for irrigation, flooding, political rhetoric, unregulated groundwater pumping, corruption, groundwater degradation, and lining irrigation canals. A correlation matrix was produced and to determine underlining dimensions, factor analysis was utilized. Orthogonal rotation was applied on the interrelationships between the mean response scores for the ecological risk items. Factor scores were produced to determine the largest perceived risk impact across the three factors (ecological impact, knowledge, and controllability). The score for each item was created by (1) weighing the score proportionally to the scales ability to determine each factor and (2) summing across all scales. This resulted in three factor scores for each item. This method had been utilized in previous risk perception research in water settings (McDaniels et al., 1997). While interesting, this approach does not have the ability to predict willingness to cooperate or engage in conflict, but it does provide insight into perceptions held by decision-makers over tangible risks or hazards within a transboundary water setting.

Trust and Willingness to Cooperate

Descriptive statistics were generated for governance tier, cooperative behavior in transboundary stakeholder engagement efforts (attendance in workgroups, councils, forums, and cooperatives), and trust across five measures; general trust, dispositional trust, affinitive trust, rational trust, procedural trust. Cross tabulations of trust and governance tier were created to assess differences among local, state, and federal actors and their respective willingness to cooperate over shared water resources.

Odds Ratios (OR) and 95% confidence intervals (CIs) were produced within each of the five trust measures, stratified by participation in transboundary cooperative stakeholder engagement efforts. Participation was categorized into a binary variable as either (1) at least annual attendance or (2) never attended. In addition to crude ORs, adjusted ORs and CIs were produced controlling for governance tier of the respondents.

A two-way scatterplot was created, and a fitted regression line placed for the composite trust and composite willingness to cooperate scores. A coefficient of determination (r^2) was calculated and the correspondent p-value reported to determine correlation between individual's levels of trust and their willingness to engage in cooperative behavior. Regression coefficients, standard errors, and corresponding p-values were reported.

Risk Perception and Trust

A two-way scatterplot was created, and a fitted regression line placed for the composite trust and composite risk perception scores. A coefficient of determination (r^2) was calculated and the correspondent p-value reported to determine correlation between individual's levels of trust and perceptions of risk. Regression coefficients, standard errors, and corresponding p-values were reported.

Impact of natural resource complexity on perceptions and decision-making outcomes Descriptive statistics were generated for groundwater reliance for the region the respondent lived in (heavy, somewhat heavy, moderate, somewhat weak, weak, or unsure), as well as if they thought they lived in a region that had a shared transboundary aquifer, or if they resided in an urban (greater than 50,000 residence) or rural (<50,000) area. Boxplots comparing the regions with perceived shared versus no shared aquifer were created looking at the composite score of risk perceptions and cooperative composite score.

To gauge the effect of environmental complexity three variables were assessed against perceptions of risk. Environmental complexity included if the respondent perceived that they had a shared transboundary aquifer with Mexico, their perception of how heavily they relied on groundwater to meet the needs of the region, and if they resided in an urban (greater than 50,000 population) or rural setting. It was assessed for heteroscedasticity and Ordinary Least Squares (OLS) was used to correlate the composite risk perception variable against the three environmental complexity variables. Regression coefficients, standard errors, and p-values were reported.

The results from this analysis is presented in Chapter 5, along with limitations of the study, and a summary and conclusion.

CHAPTER V

SUMMARY AND CONCLUSIONS: DISSECTING THE RELATIONSHIP BETWEEN RISK PERCEPTION AND TRUST IN BINATIONAL STAKEHOLDER RELATIONSHIPS

This chapter will outline, in detail, the results from the analysis described in Chapter 4 and will draw conclusions for how the results show evidence for the hypotheses and contribute to the broader understanding of cooperation and conflict behaviors over international, transboundary water management. The chapter will start off with an explanation of the results based on statistical analysis performed, complete with appropriate charts, graphs, and other visual representations of the data. The chapter will then summarize the results within the context of the hypotheses and the objectives of the study and conclude with how the results fit within the broader literature and how this approach could be used in other transboundary water sharing settings.

Introduction

The purpose of this study was to explore how perceptions of risk and levels of trust influence decision-makers' willingness to cooperate or engage in conflictual behavior over shared, international water resources. This chapter provides a real-world example of how risk perception and trust can influence cooperative or conflictual relationships between co-riparian nation-states, specifically looking at how individuals, within the context of institutional constraints, make decisions based on perceptions of trust and risk. This study brings together multiple bodies of literature and theoretical concepts to try and find a better way of measuring outcomes associated with improved transboundary water sharing, in particular measuring willingness to cooperate or engage in conflict. While conflict can sometimes drive cooperation, it is important to gain insight into when and why individual decision-makers within different institutional settings decide to engage in cooperative or conflictual behavior.

This study fills important gaps within the broader literature. While international relations literature offers clear conceptual approaches to understanding issues of water security, power dynamics, and nation-to-nation cooperation and conflict, it does not consider the role that individual decision-makers play from within institutions responsible for executing international treaties and agreements. Common Pool Resource (CPR) theory is ideal for exploring the relationships between individual resource users in a given system; however, this approach has not been often applied to large-scale transboundary resources and it doesn't consider the role of individual decision-makers nested within larger institutional settings. Instead, CPR theory offers insight into resource user decisions, based on institutional constraints. Risk perception and trust literature have been traditionally applied to understand how lay versus expert stakeholders within a system use risk perceptions to respond to specific hazards. However, while this approach offers an ideal model for understanding individual perceptions to physical hazards, it doesn't consider how those perceptions can be aggregated by institutional setting, nor how those perceptions may drive willingness to cooperate or engage in conflict. This study fills several gaps within the literature by combining several theoretical concepts under a clear SES Framework to understand how perceptions of risk and trust held by individuals within larger institutional settings can be aggregated to predict willingness to cooperate or engage in conflict over transboundary water resources in an international setting.

The Texas-Mexico border was chosen as an appropriate case study to pilot this novel approach to exploring the potential drivers of cooperation and conflict, which are vital for understanding what leads to improved water security outcomes. This is also an interesting case study because of how complicated the natural systems are in this region and the complex, polycentric governance structures that are in place on the border to manage these remarkable natural resources. As seen in Chapter 3, this socio-ecological system is complicated politically, socially, economically, and environmentally. Clear delineations of the surface water system, the Rio Grande/Rio Bravo, are present and a polycentric governance system is in place for this resource. However, there are still issues of overdraft, pollution, and poor collective management because of a lack of consistent monitoring, effective sanctioning, and enforcement of the rules in place. Additionally, management along this massive system is very disjointed, leaving gaps in management, as well as overlaps in jurisdiction. Transboundary groundwater offers a larger challenge still because of the vastly different approaches to groundwater management on both sides of the border. Not only are boundaries not clearly delineated, in some cases the aquifers are still poorly understood, lack data, or the approach to data collection is completely different on both sides of the border- making data sharing efforts even more challenging (Sanchez and Eckstein 2017). Additionally, there are no transboundary groundwater sharing agreements in place on the Texas-Mexico border and there is little to no political incentive to negotiate such an agreement. Thus, there are no clear boundaries, there are not adequate rules or procedures in place for management, and there is no monitoring, sanctioning, or enforcement. In short, transboundary aquifers along the Texas-Mexico border are an ideal example of a common pool resource that is vulnerable to the "tragedy of the commons." Water managers and decision-makers in the border region offer an ideal case to study how perceptions of risk and levels of trust influence willingness to cooperate or engage in conflict. By starting with just decision-makers in Texas, this new approach can be piloted.

Results from this study could be very helpful for other transboundary water sharing settings, particularly for groundwater issues, where international customary law principles are still in a nascent state and bilateral or multilateral agreements rarely consider groundwater resources. This study offers a novel approach to measuring how individual decision-makers, nested within larger institutional settings, use perceptions of risk and levels of trust to make decisions regarding willingness to participate in cooperative or conflictual behaviors. This approach can be adapted and applied to a variety of transboundary water settings. Results are presented in the following section.

Results

This case study was an opportunity to pilot a new approach to understanding cooperation and conflict over shared transboundary waters. This section explores the results of the study by looking first at the relationship between trust and willingness to engage in cooperation. The next section looks at the relationships between risk perception and willingness to engage in cooperation or conflict. Results are also provided on the relationship between perceptions and complexity of the natural system, such as reliance on groundwater. Finally, a focus is placed on the dynamic between risk perception and trust to try and understand if trust has the potential to mitigate risk perception to generate cooperative outcomes.

The sample included a comprehensive list of decision-makers in Texas that operate at the local, state, and federal level to make decisions about water management in the border region. As described in Chapter 4, out of 707 net surveyed recipients, 168 responded either online or via mailed response for a total response rate of 23.8 percent. The sample was comprised of 77.8 percent men and 22.2 percent women (Table 5.1). This is not a surprise, as it is well known that men dominate the water management field, as well as elected positions in government, though this trend is starting to change. The sample population was 47.4 percent Non-Hispanic White, 47.4 percent Hispanic, and 5.3 percent 'Other.' As seen in Table 5.1, the sample population was also older and more well-educated, with 60.4 percent 55 years or older and over 75 percent having a bachelor's degree or higher. Within the sample, there are more conservatives than liberals, with 54.3 percent (n=82) conservative-leaning, 29.8 percent (n=45) moderates, and 15.8 percent (n=24) liberal-leaning.

Table 5: Sample Characteristics

Sample Characteristics	N (%)
Gender	
Male	119 (77.8%)
Female	34 (22.2%)
Race	
Non-Hispanic White	72 (47.4%)
Hispanic or Latino	72 (47.4%)
Other	8 (5.3%)
Age in Groups	
< 35	7 (4.6%)
36 – 54	54 (35.1%)
55 – 74	81 (52.6%)
75+	12 (7.8%)
Education	
At least some college	29 (18.9%)
Associates Degree	8 (5.2%)
Bachelor's Degree	57 (37.3%)
Graduate Degree	43 (28.1%)
Terminal or professional degree	16 (10.5%)
Political Ideology	
Very Liberal	9 (5.9%)
Slightly Liberal	15 (9.9%)
Moderate	45 (29.8%)
Slightly Conservative	54 (35.8%)
Very Conservative	28 (18.5%)

Overall, respondents thought that benefits of cooperation outweighed the potential costs. Most respondents were willing to cooperate and were less willing to accept conflict, even in the face of severe water shortages. The only deviations from this trend were found in one measure of conflict that asked respondents if they were willing to withhold water from the Colorado River in protest to failed Mexican deliveries to the Rio Grande. In response to this question, most were willing to accept this type of conflict. It is suspected that this result is due to more recent negative experiences with failed Mexican deliveries out of the Rio Conchos during times of severe drought. “Trust” revealed more mixed responses. While most respondents felt that, in general, people were trustworthy, the majority did not think that Mexican water managers could manage water efficiently. Respondents also felt that international rules for groundwater sharing were inadequate. Over 32 percent of the respondents reported that their communities relied heavily or somewhat heavily on groundwater resources. While respondents reported that they were willing to participate in binational stakeholder engagement efforts, very few actually had participated in these types of efforts. Additional information regarding general responses can be found in Appendix 8.

Relationship between Trust and Cooperation and Conflict

This section is designed to answer the following questions. **(1) How does trust across multiple levels of governance vary, and does trust impact the degree of cross-border cooperation (or willingness to cooperate formally or informally) in shared transboundary water resources?**

H1: Trust will vary based on level and type of governance tier; respondents operating within institutions that are more directly engaged in transboundary water decision-making will have higher levels of trust.

The first hypothesis in this section predicted that trust would vary based on level and type of governance tier. Table 6 below shows the descriptive statistics of trust across five measures, with the respective mean (**μ**) and standard deviation (**σ)**. The higher the mean the higher the levels of trust. Most respondents across all tiers of government reported that in general most people could be trusted. This was a measure to calibrate general willingness to trust.

Table 6: Inclinations Towards Trust Stratified by Tier of Governance

	Local Government			**State Government**			**Federal Government**		
Issue	**n**	**μ**	**σ**	**n**	**M**	**σ**	**n**	**μ**	**σ**
General Trust	99	3.5	1.02	14	3.6	1.02	18	3.7	0.77
Dispositional Trust	100	2.5	1.09	14	2.7	1.00	18	3.3	0.91
Affinitive Trust	101	2.5	1.04	14	2.8	1.12	18	3.2	1.04
Rational Trust	100	2.8	1.10	14	2.7	0.99	18	3.6	0.98
Procedural Trust	98	2.4	0.96	14	2.2	0.98	18	2.5	1.20

As seen in Table 6 above, local and state actors tend to score very closes on measures of trust. The federal government has a higher average trust score compared to state and local across all trust measures. It was predicted that this would be the case based on actual levels of experience, knowledge, and frequency of interaction with binational Mexican counterparts. Participation in binational stakeholder engagement efforts served to test this hypothesis.

H2: Trust will vary based on stakeholder engagement: stakeholders who regularly engage in binational stakeholder engagement efforts are more likely to exhibit high levels of trust than stakeholders who do not regularly engage in binational stakeholder efforts.

The second hypothesis asserted that trust would vary based on stakeholder engagement and, when stakeholders engage regularly in binational efforts, it was predicted that trust would be improved. Federal and state officials interact more frequently in binational stakeholder engagement; thus, these groups were expected to have higher levels of trust for their binational counterparts. Table 7 below shows the relationship between those who participate in at least annual cooperative workgroups and/or councils across the five trust measures. Odds Ratios (OR) were reported in order to reveal the magnitude that at least annual participation in cooperative workgroups or councils has on self-reported levels of trust against those who have not attended. The crude OR shows that those who participate in binational stakeholder engagement efforts are more trusting than those who never participate across all measures of trust except "procedural trust," where respondents indicated that they did not think current international rules on groundwater were adequate. While results for procedural trust measures were not statistically significant, all the other measures of trust were statistically significant. Due to the fact that those in different levels of governance (local, state, and federal) have dissimilar requirements and responsibilities to attend cooperative workgroups and councils, this analysis adjusted the results by controlling for this variable to remove any potential confounding that could arise from this difference. While the adjusted ORs did produce slightly different measures of effect this did not change any interpretations compared to the crude ORs.

Table 7: Odds Ratios (OR) and 95% Confidence Intervals (CI) of Perceptions of Trust of Water Management Along the U.S. Mexico Boarder in 2018 Stratified by Participation in Cooperative International Workgroups or Councils

Issue	OR	95% CI	p-Val	Adj. OR*	95% CI	p-Val
General Trust						
Never Participate	1.00	Reference		1.00	Reference	
At Least Annual Attendance	2.26	1.11-4.63	0.03**	2.27	1.03-5.04	0.04**
Dispositional Trust						
Never Participate	1.00	Reference		1.00	Reference	
At Least Annual Attendance	4.21	1.95-9.07	<0.01**	3.35	1.45-7.74	<0.01**
Affinitive Trust						
Never Participate	1.00	Reference		1.00	Reference	
At Least Annual Attendance	3.37	1.52-7.46	<0.01**	3.02	1.27-7.17	0.02**
Rational Trust						
Never Participate	1.00	Reference		1.00	Reference	
At Least Annual Attendance	2.37	0.19-1.18	0.01**	1.98	0.94-4.19	0.07
Procedural Trust						
Never Participate	1.00	Reference		1.00	Reference	
At Least Annual Attendance	0.96	0.38-2.39	0.93	0.86	0.29-2.45	0.77

*Adjusted by level of governance (local, state, and federal)

** Significant at <0.05

Table 7 above shows that participation within binational stakeholder engagement efforts does lead to an increase in trust outcomes for all measures of trust, except for procedural trust, which was not impacted by participation in stakeholder engagement efforts. Generally speaking, trust was higher across most measures if participants engaged in collaborative efforts.

H3: Trust will be positively correlated with willingness to cooperate.

The third hypothesis in this section expected that trust would be positively correlated with willingness to cooperate. To test this hypothesis, linear regression was utilized to compare the composite trust score against the composite cooperation score. Figure 6 visualizes this relationship with a scatterplot and a fitted ordinary least squares regression trend line.

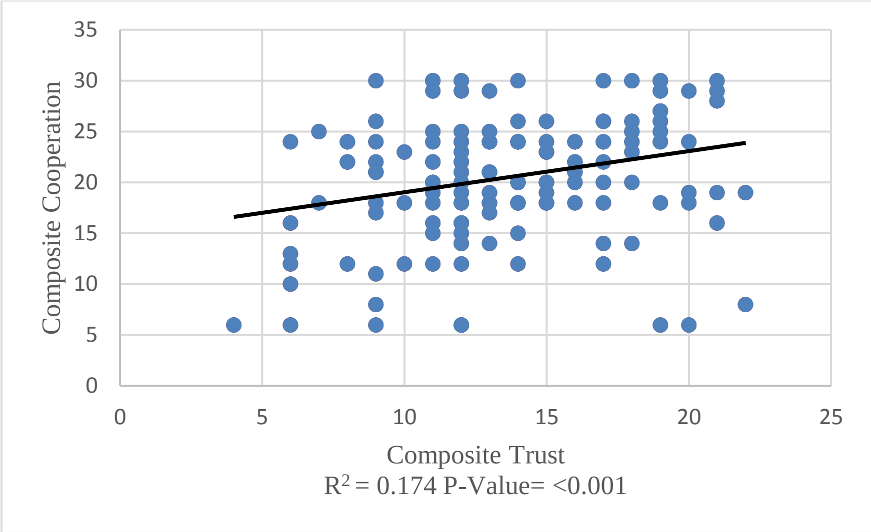

Figure 6: Composite Cooperation Score by Composite Trust Score

While the regression model only accounted for 17.4 percent of the variance (R^2=0.174) it was highly significant (p-value=<0.001). This finding suggests that as trust rises so too does willingness to cooperate. While this does not indicate a causal relationship, this correlation does provide evidence to support the hypothesis.

Risk Perception and Cooperation and Conflict

The purpose of analysis in this section was to answer the following questions. **(2) What risk perception factors impact international cooperation over shared transboundary water resources across different tiers of governance? How do perceptions of risk differ over formal versus informal cooperation for surface water or groundwater resources? Can the complexity of the natural environment impact perceptions of risk over cooperation?** All these questions have the potential to shed insight on the relationships between risk perceptions held by individual decision-makers within larger, nested, governance settings and their decisions to engage in cooperative or conflictual behaviors over transboundary water resources.

H1: Stakeholders involved in transboundary water management who exhibit higher perceptions of risk will exhibit lower levels of willingness to cooperate over shared transboundary water resources than those who exhibit lower levels of risk perception.

The first hypothesis posits that stakeholders or decision-makers involved in transboundary water management who exhibited higher perceptions of risk would exhibit lower levels of willingness to cooperate over shared transboundary water resources. As can be seen in Table 8 below, this hypothesis was supported by the data, where an ordinal logistic regression showed that high levels of risk perception are associated with low levels of willingness to cooperate. Essentially, there was an inverse correlation between risk perception and willingness to cooperate.

Table 8: Ordinal Logistic Regression on Willingness to Cooperate and Perceptions of Risk

Independent Variable	Coef	SE	p-Val	Adj.* Coef	SE	p-Val
Sovereignty	-0.27	0.12	0.03**	-0.26	0.12	0.04**
Equity	-0.14	0.12	0.24	-0.09	0.12	0.46
Accountability	-0.23	0.12	0.06	-0.21	0.09	0.09
Support	-0.30	0.15	0.03**	-0.27	0.15	0.07
Knowledge	-0.46	0.13	0.01**	-0.42	0.13	<0.01**

*Adjusted by political beliefs (very liberal, liberal, moderate, conservative, very conservative)
** Significant at <0.05

While there was a consistent trend seen in all five categories of risk perception, only three categories were statistically significant at <0.05; sovereignty, support, and knowledge. These were all adjusted for political affiliation, which showed that political affiliation did have a confounding effect. After adjusting for political affiliation, only sovereignty and knowledge were statistically significant at < 0.05.

Similarly, results of an ordinal logistic regression on the relationship between risk perception and willingness to engage in conflictual behavior were as predicted. Table 9, shown below, indicates that there is a positive relationship between perceptions of risk and willingness to engage in conflict; where, as perceptions of risk increased, willingness to engage in or accept conflictual behavior also increased.

Table 9: Ordinal Logistic Regression on Willingness to engage in Conflictual Behavior and Perceptions of Risk

Independent Variable	Coef	SE	p-Val	Adj.* Coef	SE	p-Val
Sovereignty	0.17	0.12	0.15	-0.12	0.12	0.31
Equity	0.41	0.12	<0.01**	0.37	0.13	<0.01**
Accountability	0.11	0.12	0.35	0.05	0.12	0.67
Support	0.04	0.14	0.79	0.06	0.15	0.70
Knowledge	0.17	0.12	0.15	0.20	0.12	0.12

*Adjusted by political beliefs (very liberal, liberal, moderate, conservative, very conservative)
** Significant at <0.05

Prior to adjusting for political affiliation, the only category that was statistically significant was the category looking at perceptions of risk to equity, which was highly statistically significant at <0.01. This category was still highly significant at < 0.01, even after being adjusted for political affiliation. While the other categories were not statistically significant, there was still a trend indicating a direct, positive correlation between perceptions of risk and willingness to engage in or accept conflict.

H2: Perceptions of risk will be different based on the institutional affiliation of governmental actors; those who are part of networks with high-level ties (international, federal, state level) will have perceived risk of formal cooperation higher than those who are part of networks primarily with low-level ties (municipal, non-governmental).

The second hypothesis asserted that perceptions of risk would be different based on the institutional affiliation of governmental actors; those who are part of networks with high-level ties (international, federal, state level) would have higher perceptions of risk over formal cooperation than those who are part of networks primarily with low-level ties (municipal, non-governmental). Owing to lack of complete data on institutional affiliation, these categories were combined into tier of governance; local, state, and federal. Additionally, the sample size was not sufficient to determine how perceptions of risk stratified by governance tier impacted willingness to cooperate. However, by running a multinomial regression, results did suggest that different categories of risk were ranked differently, based on tier of governance. Local level actors had the highest perceptions of risk, followed by state, with federal actors primarily having the lowest levels of risk perception to most categories. It is believed that this is owing to deeper levels of knowledge regarding governance structures and actual water use information, experience managing the whole system versus a smaller portion, and frequency of contact with binational partners. As can be seen in Table 10 on the following page, there was some variation in these dynamics based on institutional affiliation, as predicted. In terms of risk perceptions of loss of sovereignty, local levels had the highest, followed by state, while federal actors had the lowest. Even though this finding was not statistically significant, it does indicate that knowledge, experience, and frequent interactions with binational counterparts can have a big influence on levels of trust and perceptions of risk.

Table 10: Multinomial Logistic Regression with reported Coefficient Values and Ratios with Respective 95% Confidence Intervals (CI) on Perceptions of Risk at Different Tier of Governance (local, state, federal)

Issue		Coef	Ratio	p-Val
Sovereignty				
	Local		1.00	Reference
	State	-0.11	0.90	0.64
	Federal	-0.27	0.76	0.20
Equity				
	Local		1.00	Reference
	State	-0.09	0.92	0.71
	Federal	-0.22	0.80	0.30
Accountability				
	Local		1.00	Reference
	State	-0.13	0.88	0.57
	Federal	-0.33	0.71	0.12
Support				
	Local		1.00	Reference
	State	0.52	1.69	0.09
	Federal	0.72	2.04	0.01**
Knowledge				
	Local		1.00	Reference
	State	0.35	1.41	0.14
	Federal	-0.18	0.83	0.40

** Significant at <0.05

One interesting deviation was with support. The question on support measured whether or not the respondent thought most Texans would support formal cooperation with Mexico over groundwater. Statistically significant results showed that local level actors were most likely to think that other Texans would support formal cooperation, while state, and especially federal actors were less likely to think that most Texans would support formal cooperation over groundwater. The question on knowledge measured whether or not respondents thought that federal government had the knowledge necessary to adequately negotiate transboundary groundwater sharing between the U.S. and Mexico. The results showed that the federal actors thought that they had appropriate knowledge to negotiate groundwater, while the state actors felt the least secure in the knowledge of the U.S. to accurately negotiate groundwater. Local actors were in between federal and state.

H3: Perceptions of risk will be higher for formal cooperation over groundwater than surface water and risk perceptions will be lower for informal cooperation over groundwater and surface water, with risk still seen as higher for groundwater cooperation.

The third hypothesis posited that perceptions of risk would be higher for formal cooperation over groundwater than surface water and risk perceptions would be lower for informal cooperation over groundwater and surface water, with risk still seen as higher for groundwater cooperation. Unfortunately, because of the original length of the survey, some of the questions distinguishing between formal and informal groundwater cooperation/conflict and formal versus informal surface water cooperation/conflict were cut in the final version. However, in the final version, there were three measures of formal and three measures of informal for both cooperation and conflict, so some analysis was possible.

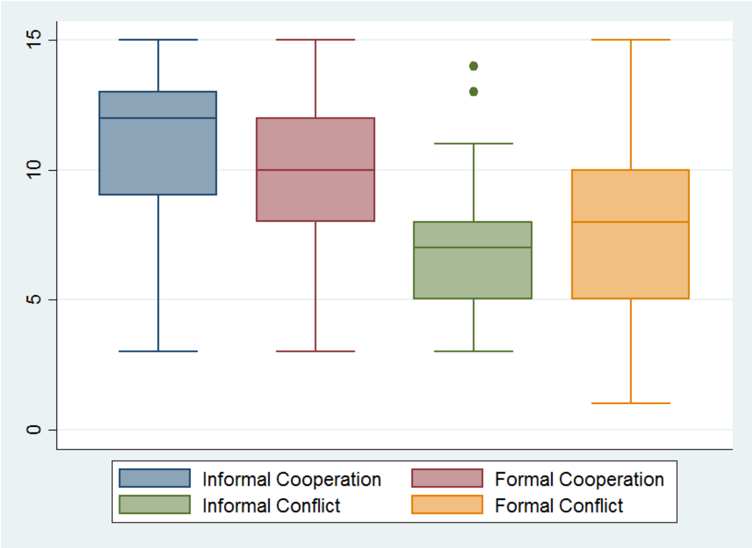

Figure 7: Formal versus Informal Cooperation and Conflict

As can be seen in Figure 7 above, the mean score between formal cooperation (μ=9.76 σ = 3.11) and informal cooperation (μ=10.78 σ = 3.08) has similar values. Likewise, formal conflict (μ=7.58 σ = 3.06) and informal conflict (μ=6.98 σ = 2.22) also provided similar means and standard deviations. When statistical analysis was performed to test the hypothesis that perceptions of risk would be different based on formal versus informal cooperation or conflict, no trend or correlation was found.

H4: Complexity within the natural system will be positively correlated with higher perceptions of risk over cooperation; as natural, hydrological complexity increases (measured by self-reported reliance on groundwater and knowledge of transboundary nature of groundwater), so will perception of risk.

Hypothesis four predicted that complexity within the natural system would be positively correlated with higher perceptions of risk over cooperation; as natural, hydrological complexity increased, so would perception of risk. To test this, respondents were asked to self-report several things about their environment including perceived reliance on groundwater and whether they thought that their local aquifers were transboundary or not. In Table 11 below, ordinary least squares regression was performed to see if perceptions of risk changed based on several self-reported environmental indicators.

Table 11: Ordinary Least Squares on Perceptions of Risk and Local Environmental Complexity

Independent Variable	Coef	SE	p-Val
Reliance on Groundwater	0.36	0.19	0.07
Shared International Aquifer	0.69	0.75	0.37
Urban Setting (greater than 50,000 pop)	-0.07	0.67	0.91

** Significant at <0.05

Results were mixed. Increased reliance on groundwater led to increased perceptions of risk, but while close, this was not statistically significant. Whether or not an aquifer was reported as shared did not seem to change perceptions of risk and, interestingly, neither did urban setting.

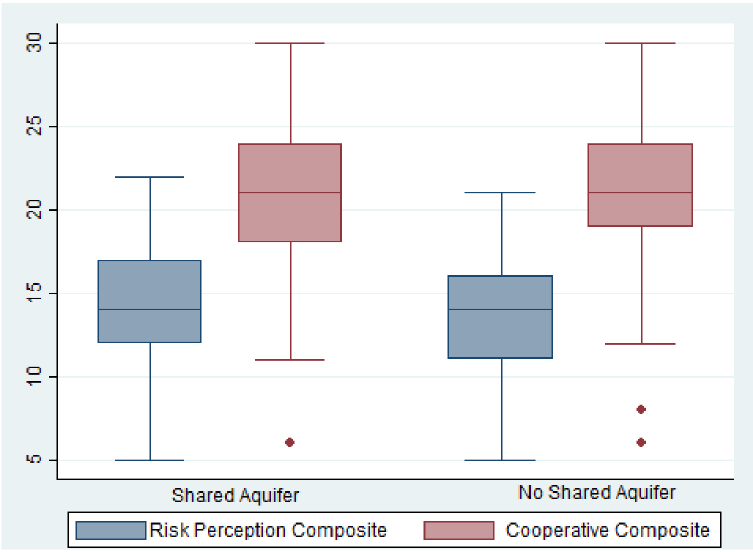

Figure 8: Impact of perceived transboundary nature of aquifer with perceptions of risk and willingness to cooperate

In Figure 8 on the previous page, a box plot was used to visualize the differences in risk perception composite scores and willingness to cooperate composite scores, depending on whether or not respondents self-reported their aquifers as being transboundary in nature. There is little to no differences seen in this comparison.

To measure risk perceptions using the psychometric paradigm, an approach was used that was based after a similar study done by McDaniels et al. (1997) but was modified to be more appropriate for a transboundary water setting. Using this approach, a comparison is provided, which ranks the order of a consistent list of sub-factors across three main factors that measure risk perception; ecological impact, knowledge, and controllability.

Table 12: Impact for Three Factors that Characterize Perceived Ecological Risk*

Factor 1 Ecological Impact		Factor 2 Knowledge		Factor 3 Controllability	
Flooding	0.63	Water Used for Irrigation	0.45	Water Used for Irrigation	1.45
Drought	0.37	Flooding	0.38	Flooding	1.38
Water Used for Irrigation	0.03	Drought	0.28	Drought	0.27
Corruption	-0.21	Political Rhetoric	0.02	Political Rhetoric	0.15
Unregulated Ground Pumping	-0.44	Lining Irrigation Canals	-0.05	Lining Irrigation Canals	-0.06
Groundwater Degradation	-0.46	Corruption	-0.08	Corruption	-0.08
Lining Irrigation	-0.51	Groundwater Degradation	-0.18	Groundwater Degradation	-0.84
Political Rhetoric	-1.81	Unregulated Ground Pumping	-0.94	Unregulated Ground Pumping	-1.09

*Table entries are factor scores

As seen in Table 12 above, for ecological impact, flooding was seen as the largest risk, followed by drought, while lining of irrigation canals was seen as having the least negative ecological impact. For knowledge, respondents indicated that they had the most knowledge about water used for irrigation, followed by drought and flooding. Respondents knew the least about unregulated groundwater pumping. Interestingly, when respondents were asked which risks they felt their Mexican counterparts were most capable of controlling, the order of the list was the same as the knowledge factors. Respondents felt that Mexican counterparts were most capable of controlling water used for irrigation and least capable of controlling unregulated groundwater pumping. While these results are interesting, they are not able to predict willingness to engage in conflict or cooperation.

Risk Perception and Trust

In this section, analysis was presented to answer the following questions. **(3) Are trust and risk perception correlated? Does trust act as a modifier to risk perception to predict cooperation? Or does high risk perception constrain cooperative behavior despite high levels of trust?**

H1: High perceptions of risk and high trust will create conditions conducive to very selective and situation-specific transboundary water cooperation; whereas high perception of risk and low levels of trust will create conditions more conducive to transboundary water conflict or absence of cooperation.

The first hypothesis predicted that risk perception and trust would be inversely correlated, where, as levels of trust increase perceptions of risk would decrease.

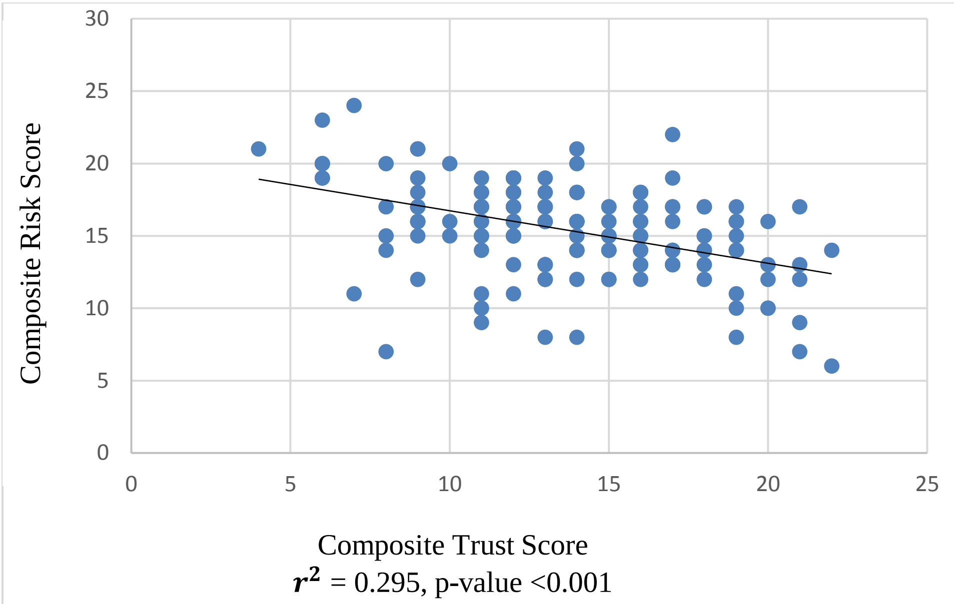

Figure 9: Scatter plot of Risk Perception composite score and Trust composite score

As seen in the scatterplot shown in Figure 9 above, there is an inverse correlation between the composite score of risk perceptions and the composite score of trust, which showed that as perceptions of risk increase, trust decreases, which supports the hypothesis. This relationship is highly statistically significant, with a r^2 value of 0.295 and a p-value of <0.001.

H2: Low perceptions of risk and high levels of trust will create conditions conducive to transboundary water cooperation; whereas low perceptions of risk and low levels of trust will create conditions conducive to very selective and situation-specific transboundary water cooperation.

The second hypothesis indicated that high perceptions of risk could be mitigated by high trust to create conditions conducive to very selective and situation-specific transboundary water cooperation. However, the sample size was too small and the distribution too skewed to assess those with a high-risk perception and a high composite trust score against willingness to cooperate. This is partially due to the correlated nature of risk perception and trust, but primarily due to a lack of enough individuals within the sample size.

Summary

To summarize, this study designed and tested a novel approach to measuring outcomes associated with willingness to engage in cooperative or conflictual behaviors over shared, transboundary water resources. The pilot study was conducted by surveying Texas and other U.S. decision-makers who have responsibility for water management decisions on the Texas-Mexico border over both surface water and groundwater resources.

Levels of trust were measured using five different metrics to assess how trust influenced willingness to cooperate over transboundary water resources. Results from analysis offered support for the hypothesis that trust is positively correlated to attitudes towards cooperative behavior. Additionally, it was found that levels of trust held by individuals within different governance tiers made a difference in trust outcomes, where federal actors, followed by state actors had higher degrees of trust than local actors. Additionally, the more frequently respondents engaged in binational stakeholder engagement efforts, the more likely they were to have higher levels of trust in their binational counterparts. This did not hold true for procedural trust, which measured whether or not respondents thought that the current international rules were adequate to protect groundwater resources. Most respondents felt that international procedures were inadequate to protect transboundary aquifers.

Perceptions of risk were measured at the individual level and then aggregated into local, state, or federal governance tiers to determine the impact that institutional constraints or mandates might have on the development of perceptions. Results from data analysis were found to support the hypotheses that perceptions of risk varied based on governance tier and that perceptions of risk were a driver of willingness to cooperate or engage in conflict. For the most part, federal actors, followed by state actors, had lower levels of risk perceptions than locals, who had the highest. The only deviations were on support and knowledge. Results on support showed that locals were more likely to believe that most Texans would support formal cooperation with Mexico, while federal and state actors were less likely. Results on knowledge showed that federal actors had the lowest perceptions of risk to knowledge, meaning that federal actors thought that the U.S. does have adequate knowledge to negotiate transboundary groundwater management. State actors had the highest perceptions of risk to knowledge, believing that the U.S. federal government does not have adequate knowledge to negotiate transboundary groundwater agreements. It is believed that perceptions of risk are mitigated by experience, knowledge, and frequency of interactions and, as shown in the section on trust, federal actors, followed by state actors have the highest degree of interaction with binational stakeholders. In terms of knowledge, the federal actors have the most knowledge of the whole system and the international treaties in place to manage surface water. In terms of experience, local level actors and federal actors have the most experience with the water management situation on the border, with state officials coming in last.

Additionally, results showed that there were no statistical differences found between willingness to cooperate formally versus informally and willingness to engage in formal versus informal conflict. It was predicted that complexity of the natural environmental would have a negative impact on perceptions of risk and willingness to cooperate. However, while it did seem like there was a trend between self-reported reliance on groundwater and increased risk perceptions, the results were not statistically significant. Future studies could incorporate actual environmental data, such as aquifer delineations or water quality information. This would provide with a more accurate representation of environmental complexity and thereby reveal potential trends. The chosen variables for representing environmental complexity were deemed insufficient to act as a true proxy.

Trust and risk perception were inversely correlated with each other; where, as trust increased, perceptions of risk decreased. While, this study was hoping to be able to see the combined effect of trust and risk perception on willingness to engage in conflict/cooperation, unfortunately there was not enough data to test this hypothesis. However, based on the results that were found in this study, it is still reasonable to expect a combined effect.

Limitations and Strengths of Study

There were several limitations to this study. By choosing to only pilot-test the study in Texas, comparative analysis of differing perspectives in Mexico were not conducted. The idea behind limiting the study was to initiate limited data collection in order to test proof of concepts. Now that there is enough data to support the efficacy of these metrics for predicting cooperation and conflict, an expanded study can focus more broadly on the entire U.S.-Mexico border. Another limitation is that the study did not include other important stakeholders in this region, including non-governmental organizations, academic communities, or user groups. Additionally, data for institutional affiliation had to be aggregated into governance tiers, due to the limited response rate. The response rate could have been improved by performing follow up phone calls and sending out postcard reminders and/or replacement questionnaire packets. Response rate was also impacted by massive flooding in several border cities during the data collection phase. The final major limitation of this study is that, owing to the cross-sectional study design, it was not possible to test for causality.

There were several strengths of this study. Most importantly, this study created a novel approach to measuring outcomes of willingness to engage in cooperative or conflictual behaviors over shared transboundary water resources. Risk perception over cooperation for transboundary waters has previously only been studied using case studies or qualitative research methods. This new approach utilized a quantitative research design to be able to actually measure changes in risk perception. Furthermore, trust has not been quantifiably measured for these stakeholders before and new, qualitative metrics were created to measure levels of trust held by decision-makers in the Texas-Mexico border region. This new approach is easily adaptable to different political or geographical settings and can be replicated. Additionally, the target population was on decision-makers within larger institutional settings who can influence policy decisions along the border. This target population also reveals a new insight into the role that individual decision-makers play within larger institutional settings. This study is also the first study to measure the influence that perceptions of risk and levels of trust have on individual willingness to cooperate or engage in conflict, specifically for transboundary groundwater resources.

Conclusions

Managing water across borders is complex and fraught with political, social, economic, and environmental challenges. However, the challenges of cooperative management of transboundary water are increased by issues of state sovereignty, increased pressures from population growth and competing water uses, uncertainties from climate change, and difficulties associated with modelling complex hydrological realities. Managing water resources that cross an international boundary has often created multilateral relationships that are characterized by tension or tenuous cooperation and these tensions are often exacerbated by power asymmetries. Transboundary water governance presents one of the most complex and challenging issues of coupled human-natural systems anywhere in the world and it is valuable to study the characteristics that influence decision-making in transboundary water sharing settings.

This study was primarily geared toward understanding the complex drivers of cooperation and conflict over shared transboundary resources, with a special focus on the common pool resource dilemmas of transboundary aquifer sharing. This study filled several major gaps by looking at how individual perceptions of risk and levels of trust influenced willingness to engage in conflictual or cooperative behaviors over shared transboundary resources, with an emphasis on groundwater. Traditionally, transboundary water management has been a challenge to be addressed by changes in rules, procedures, or international treaties or agreements. Much of the IR literature has looked primarily at nation-to-nation relationships and the resulting international agreements. CPR literature primarily considers how individual resource users/actors behave in response to adjustments in institutional structures, laws, rules, and policies. While both IR literature and CPR literature highlight risk and trust as key components in decision-making, neither approach empirically articulates how perceptions held by individuals within institutional settings can change or influence institutional decision-making. Social psychology literature, specifically psychometric paradigm approaches to studying risk perception, highlights how perceptions of risk and trust can influence individual decision-making, but this approach has never been applied to transboundary water sharing or even how individuals within institutional settings influence institutional decision-making. By studying how the attitudes of individuals, nested within institutional settings, influence perceptions of risk and trust, in this case willingness to engage in cooperative or conflictual behaviors, this study fills gaps within both IR literature and CPR literature. This study contributes to IR literature by articulating the importance of the role of individuals, operating within different institutional structures, can play in influencing decisions to adopt more cooperative policies or procedures. This approach also offers a way to quantitatively measure potential bottlenecks to overcoming conflict or promoting cooperation. Within CPR theories, Dr. Elinor Ostrom and others have highlighted the role that trust, and to a certain extent risk, plays in setting the stage for adopting new procedures or responding to new rules in use. However, this study offers a way to operationalize or measure quantitatively how perceptions of risk and trust influence attitudes towards certain cooperative or conflictual behaviors, which has not been done within the context of CPR literature.

Within this context, it is important to understand how institutions address the challenge of large-scale natural resource management across political jurisdictions, and the connection between individuals and the institutions that they create and manage (Ostrom, 2009). Institutions provide the framework for human interactions within a complex social, economic, and environmental system and help to provide order, rules, and a codification of norms, values, and beliefs (North, 1991). As seen in Chapter 1, transboundary water resources are a common pool resource and require special institutions to prevent the “tragedy of the commons.” Transboundary surface waters have been more heavily regulated through international treaties that were influenced by international water law principles and IWRM paradigms, which has helped to address the potential to overuse the resources, at least in some cases. Transboundary groundwater does not have the same guiding principles, institutional arrangements, or management structures to address its use- and as a result, it is often overdrawn, or polluted, which can sometimes have negative ramifications for surface water. International water law principles, IWRM, and resulting institutions have primarily focused on surface water rules, leaving groundwater up for the taking. Customary international water law principles for shared transbounday water and IWRM practices are both concerned with institutions and how institutions should function to effectively manage shared waters. IWRM provides a technical tool box for the actual management of water, while customary international water law principles provide guidance for countries to develop language within their treaties. Both also highlight the importance of cooperation. However, neither consider the role of the individual. Since institutions are comprised of individuals, it is important to be able to understand how individuals make decisions. By using risk perception and trust to model individual willingness to engage in cooperation, this approach fills that gap. “Institutions often deal with distributional issues, structuring joint decision making, stabilizing mutual expectations, and providing each party with information about the others’ capabilities and intentions” (Nincic and Weiss, 2016, p.723). This role is particularly important for managing nation to nation interactions over shared water, which can be seen in the Texas-Mexico case study, where there is a mismatch between the presence of Ostrom’s eight design principles for the Rio Grande (five to six design principles) versus the transboundary aquifers along the border (one design principle).

Institutions are comprised of individuals and the role of individuals within institutional settings have been understudied. The results of this study show that perceptions of risk and levels of trust held by individual decision-makers, nested within institutional settings, can offer insight into how decisions are made regarding willingness to cooperate or engage in conflict over shared, transboundary water resources. The case study between Texas and Mexico was an ideal political, institutional, and geographic setting for testing these concepts. Results showed that perceptions of risk did impact willingness to cooperate or engage in conflict; where, as perceptions of risk went up, willingness to cooperate went down and willingness to accept conflict went up. Results from the trust measures showed the opposite relationship; where, as trust increased, willingness to cooperate increased. There was an inverse correlation between risk perceptions and trust; where, as trust increased, risk perceptions decreased. These findings are useful for understanding what influences cooperative and conflictual behaviors over shared, transboundary waters.

In the U.S. – Mexico region, an expanded study could be performed by adjusting the questionnaire to make it more appropriate for each local setting. Comparative studies could then be performed to analyze different perceptions of risk and levels of trust to identify points of contention between binational counterparts. This information would be very useful for designing appropriate intervention strategies to improve levels of trust and reduce perceptions of risk. One finding that is particularly relevant for designing interventions is that the more frequently respondents participated in binational stakeholder engagement efforts, levels of trust increased, and perceptions of risk decreased. This indicates that individual decision-makers operating within their respective institutional settings are influenced by experience, knowledge, and frequency of interaction with binational counterparts. Future interventions could be designed at the constitutional, collective-choice, and operational levels to increase bilateral interactions.

Implications for future studies and other global questions

Not only can this approach be applied to the broader U.S. - Mexico border region, but it could be very useful for international, transboundary water sharing settings all over the world. Results from this study showed promise for a new qualitative study design, which tested how perceptions of risk and levels of trust held by individual decision-makers within institutional settings could influence willingness to cooperate over shared, transboundary waters, in particular groundwater. Future studies could use this novel approach in more contentious international water sharing settings to gain a deeper understanding of potential barriers to cooperation. While international water law principles and IWRM concepts are useful for countries in the development of bilateral or multilateral agreements, often this language is not included in the final agreements. The approach used within this study could provide additional insight into the institutional barriers by analyzing individual decision-makers perceptions of risk to cooperation and levels of trust in bilateral or multilateral counterparts. Additionally, this approach can reveal perceived challenges from power asymmetries and perceived problems with current international treaties, agreements, or other procedures for water management. This study also offers support for the idea that the degree of governing structures, rules in use, and procedures in place have the ability to impact or influence perceptions of risk and level of trust for cooperating over surface water versus groundwater, and when combined with a strongly CPR approach, this quantitative measurement of stakeholder perspectives has a potential to increase understanding on the role of trust and risk in making cooperative decisions over shared natural resources. Future studies could also use this approach to explore perceptions of water value, water-trade links across borders, and other issues that come up between counties that share valuable water resources. To conclude, the novel approach utilized by this study has great potential for identifying and addressing barriers to cooperation or barriers to overcoming conflictual relationships in many different international, transboundary water sharing settings.

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APPENDIX 1

QUESTIONNAIRE

Institute for Science Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

Texas Water Resources Institute
make every drop count

THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

Water Management in the Texas-Mexico Border Region

Thank you for taking a few minutes to answer the questions about water management and related issues in the Texas-Mexico border region. Your answers will be held in the strictest confidence. If you would prefer to answer the questions online with a computer, there is a link provided below. This questionnaire is completed more easily on a computer, rather than a mobile device.
To complete the survey digitally, please go to the following link:
https://u.tamu.edu/texasborderwater

Q1 How much time, approximately, do you currently work on water issues in the Texas-Mexico border region (even if you work primarily on domestic water issues)?
- 0% -10% (1)
- 11% - 20% (2)
- 21% - 30% (3)
- 31% - 40% (4)
- 41% - 50% (5)
- 51 % - 75% (6)
- 76% - 100% (7)

Q2 What type of organization do you work for? (City, Irrigation district, MUD, etc…)
- Municipal Utility District (1)
- Groundwater Conservation District (2)
- Soil and Water Conservation District (3)
- Irrigation district (4)
- City Agency (5)
- County Agency (6)
- State Agency (7)
- Federal Agency (8)
- Other (please specify) ____________________ (9)

Q3 How long have you worked in your current position?
- Less than one year (1)
- 1 to 3 years (2)
- 4 to 6 years(3)
- 7 to 9 years (4)
- 10 or more years (5)

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Q4 Please indicate what you think the **level of likelihood** is for each of the statements below:

	Very unlikely (1)	Somewhat unlikely (2)	Neither (3)	Somewhat likely (4)	Very likely (5)
a. Formal cooperation with Mexico over shared groundwater will lead to a loss of local authority and control over decision making.	❍	❍	❍	❍	❍
b. Cooperation with Mexico over shared groundwater will lead to equitable water distribution.	❍	❍	❍	❍	❍

Q5 Please indicate how likely it is that **cooperation with Mexico** would generate the following **benefits** for water management outcomes in Texas.

	Very unlikely (1)	Unlikely (2)	Undecided (3)	Likely (4)	Very likely (5)
a. Sustainable development	❍	❍	❍	❍	❍
b. Joint management of infrastructure	❍	❍	❍	❍	❍
c. Economic development	❍	❍	❍	❍	❍
d. Reduced uncertainty	❍	❍	❍	❍	❍
e. More efficient groundwater management	❍	❍	❍	❍	❍
f. Increased knowledge sharing	❍	❍	❍	❍	❍
g. Adaptable water management	❍	❍	❍	❍	❍
h. Improved groundwater protection	❍	❍	❍	❍	❍
i. Quickly resolve common concerns	❍	❍	❍	❍	❍
j. Better flood control	❍	❍	❍	❍	❍
k. Improved emergency response	❍	❍	❍	❍	❍

Q6 Over the last year, **how often have you participated** in any of the listed **cooperative international or domestic stakeholder efforts**?

	Never (0)	Annually (1)	Quarterly (2)	Monthly (3)	Weekly or more (4)
a. TX-Coahuila-Nuevo Leon-Tamaulipas Regional Workgroup (Border 2020)	❍	❍	❍	❍	❍
b. TX-New Mexico-Chihuahua Regional Workgroup (Border 2020)	❍	❍	❍	❍	❍
c. Rio Grande Advisory Council	❍	❍	❍	❍	❍
d. Paso del Norte Watershed Council	❍	❍	❍	❍	❍
e. IBWC Citizen's Forum	❍	❍	❍	❍	❍
f. Desert Landscape Conservation Cooperative	❍	❍	❍	❍	❍

Q7 To what extent does the city or town where you work rely on groundwater to meet its various needs?

- ❍ Very heavy reliance (5)
- ❍ Somewhat heavy reliance (4)
- ❍ Moderate reliance (3)
- ❍ Somewhat weak reliance (2)
- ❍ Very weak or no reliance (1)
- ❍ Unsure (0)

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Q8 As far as you know, is the groundwater in the city or town where you work part of an aquifer shared with Mexico or is it part of a Texas-only aquifer?

- ❍ Part of a shared aquifer (4)
- ❍ Part of a Texas-only aquifer (3)
- ❍ There is little to no groundwater in the city or town (2)
- ❍ Don't know, unsure (1)
- ❍ Not applicable, do not work near the border (0)

Q9 Please indicate your level of **agreement or disagreement** with each of the statements below:

	Strongly disagree (1)	Somewhat disagree (2)	Neither (3)	Somewhat agree (4)	Strongly agree (5)
a. Generally speaking, most people can be trusted.	❍	❍	❍	❍	❍
b. In general, water managers in Mexico can be trusted to manage water efficiently.	❍	❍	❍	❍	❍
c. Water managers in Mexico can be trusted to manage water in accordance with your personal values.	❍	❍	❍	❍	❍
d. The benefits of trusting water managers in Mexico outweigh the costs.	❍	❍	❍	❍	❍
e. Current international rules provide adequate procedures for managing shared groundwater.	❍	❍	❍	❍	❍
f. The U.S. federal government has the ability to uphold and enforce cooperation commitments.	❍	❍	❍	❍	❍
g. As far as I know, most water users within Texas will support cooperation with Mexico over shared groundwater.	❍	❍	❍	❍	❍
h. The U.S. federal government has the *knowledge* necessary to accurately negotiate groundwater management in aquifers shared with Mexico.	❍	❍	❍	❍	❍

Q10 Please indicate how likely you think it is that effects from the following factors will be **adequately controlled by water managers in Mexico.**

	Very unlikely (1)	Somewhat unlikely (2)	Undecided (3)	Somewhat likely (4)	Very likely (5)
a. Drought	❍	❍	❍	❍	❍
b. Water used for irrigation	❍	❍	❍	❍	❍
c. Flooding	❍	❍	❍	❍	❍
d. Political rhetoric	❍	❍	❍	❍	❍
e. Unregulated groundwater pumping	❍	❍	❍	❍	❍
f. Corruption	❍	❍	❍	❍	❍
g. Groundwater degradation	❍	❍	❍	❍	❍
h. Lining irrigation canals	❍	❍	❍	❍	❍

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Q11 Please indicate your **level of willingness** to do each of the following activities:

	Very unwilling (1)	Somewhat unwilling (2)	Neither (3)	Somewhat willing (4)	Very willing (5)
a. Participate in updating or renegotiating the current international water treaties to include groundwater sharing.	❍	❍	❍	❍	❍
b. Participate in writing a new treaty for groundwater sharing.	❍	❍	❍	❍	❍
c. Participate in developing localized agreements between sister-cities.	❍	❍	❍	❍	❍
d. Share data on groundwater	❍	❍	❍	❍	❍
e. Jointly share infrastructure benefits (e.g. wastewater treatment plants, dams, hydro power).	❍	❍	❍	❍	❍
f. Participate in an international stakeholder engagement process over shared water.	❍	❍	❍	❍	❍

Q12 In times of **extreme water scarcity**, how **acceptable or unacceptable** would you find the following forms of water management or water interactions?

	Highly unacceptable (1)	Somewhat unacceptable (2)	Neither (3)	Somewhat acceptable (4)	Highly acceptable (5)
a. Dispose of untreated waste, even if it could lead to downstream degradation.	❍	❍	❍	❍	❍
b. Develop ground or surface water resources in border region without prior notification to Mexican authorities (1944 Water Treaty: Min 242: Article 6.)	❍	❍	❍	❍	❍
c. Publicly reprimand decision makers in Mexico.	❍	❍	❍	❍	❍
d. Ensure Texas has sufficient water, even if it impinges on treaty agreements.	❍	❍	❍	❍	❍
e. Withhold water from downstream users in Mexico out of the Colorado river in protest to failed Mexican water deliveries in Rio Grande.	❍	❍	❍	❍	❍
f. Cut off water supplies to Mexico.	❍	❍	❍	❍	❍

Q13 Please identify all types of activities that you have **engaged in with partners from Mexico** within the last **ten years**.

	Yes (1)	No (0)
a. Worked on or suggested water treaty development or amendments.	❍	❍
b. Developed localized agreements over water.	❍	❍
c. Shared data over groundwater.	❍	❍
d. Jointly-managed an international water project.	❍	❍
e. Participated in an international stakeholder engagement over shared water.	❍	❍
f. Served on a joint technical committee over shared water.	❍	❍

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Q14 Please indicate how **informed** you are about the **extent or frequency** of following factors along the Texas - Mexico border.

	Uninformed (1)	Somewhat uninformed (2)	Undecided (3)	Somewhat informed (4)	Informed (5)
a. Drought	❍	❍	❍	❍	❍
b. Water used for irrigation	❍	❍	❍	❍	❍
c. Flooding	❍	❍	❍	❍	❍
d. Political rhetoric	❍	❍	❍	❍	❍
e. Unregulated groundwater pumping	❍	❍	❍	❍	❍
f. Corruption	❍	❍	❍	❍	❍
g. Groundwater degradation	❍	❍	❍	❍	❍
h. Lining irrigation canals	❍	❍	❍	❍	❍

Q15 Have you been **made aware** of water managers **engaging in the following behaviors**?

	Yes (1)	No (0)
a. Texans disposing untreated waste, knowing it might lead to downstream degradation.	❍	❍
b. Mexicans disposing untreated waste, knowing it might lead to downstream degradation.	❍	❍
c. Developing ground or surface water resources in border region without prior notification to Mexican authorities as stipulated in 1944 Water Treaty, Min 242, Article 6.	❍	❍
d. Publicly reprimanding a Mexican decision-maker (via media, in person, via shared emails, or any other form of public reprimand).	❍	❍
e. Securing sufficient water for Texas, despite potential to impinge on treaty agreements.	❍	❍
f. Cutting off supplies to Mexico.	❍	❍

Q16 Please indicate if the following factors will have a negative or positive **impact on the ecological system** in the Texas - Mexico border region.

	Very negative (1)	Somewhat negative (2)	Undecided (3)	Somewhat positive (4)	Very positive (5)
a. Drought	❍	❍	❍	❍	❍
b. Water used for irrigation	❍	❍	❍	❍	❍
c. Flooding	❍	❍	❍	❍	❍
d. Political rhetoric	❍	❍	❍	❍	❍
e. Unregulated groundwater pumping	❍	❍	❍	❍	❍
f. Corruption	❍	❍	❍	❍	❍
g. Groundwater degradation	❍	❍	❍	❍	❍
h. Lining irrigation canals	❍	❍	❍	❍	❍

Q17 What is your age?
- Under 18 (1)
- 18 – 25 years old (2)
- 26 – 34 years old (3)
- 35 – 44 years old (4)
- 45 – 54 years old (5)
- 55 – 64 years old (6)
- 65 – 74 years old (7)
- 75 years or older (8)

Q18 What is your gender?
- Male (0)
- Female (1)

Q19 Please select the categories that best describe your background.
- White (1)
- Black or African American (2)
- American Indian or Alaska Native (3)
- Asian (4)
- Latino (5)
- Native Hawaiian or Pacific Islander (6)
- Other (7)

Q20 What is the highest level of schooling you have completed to date?
- Less than a high school diploma (1)
- High school degree or equivalent (e.g. GED) (2)
- Some college, no degree (3)
- Associate's degree (e.g. AA, AS) (4)
- Bachelor's degree (e.g. BA, BS) (5)
- Master's degree (6)
- Professional degree (7)
- Doctorate (8)

Q21 Generally speaking, do you consider yourself:
- Very Liberal (1)
- Slightly Liberal (2)
- Moderate (3)
- Slightly Conservative (4)
- Very Conservative (5)

Q22 What is the zip code for the place where you work?

Q23 Do you know anyone else that works on water issues in the Texas-Mexico border region who you think we should contact? If so, please provide their name(s) and contact information in the box below:

IRB Approval Number: IRB2017-0346M IRB Approval Date: 06/07/2017

APPENDIX 2

ALERT LETTER

Institute for Science Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

Texas Water Resources Institute

THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

«Salutations» «FirstName» «LastName»
«TitlePosition»
«Organization»
«StreetAddress»
«City», «State» «ZipCode»

Month Day, Year

Dear «Salutations» «LastName»:

I am heading a project being conducted under the auspices of the Institute for Science, Technology, and Public Policy at Texas A&M University, in cooperation with *Texas Water Resources Institute* and *The Meadows Center for Water and the Environment* and I need your help.

The Institutes are working to develop a deeper understanding of water management in the Texas-Mexico border region. I am writing to you because you hold an important position relevant to Texas water management in the border region and I would greatly appreciate your help with one simple task.

In about a week, I will be sending you a questionnaire in the mail that I hope will begin the process of giving us some basic information about your ideas regarding border water management. I will be sending the questionnaire on paper and there will be an online version if you would prefer to respond that way. I only ask that you fill out this questionnaire as best you can. Your answers are very important to us.

This research has been reviewed and approved by the Texas A&M Institutional Review Board (IRB). By completing the questionnaire, you are giving permission for us to use your anonymous response for research purposes. If you have any questions, would like more information, or would like us to share the survey results with you, please do not hesitate to contact me. Thank you in advance for your assistance.

Sincerely,

Lindsay Sansom, Project Coordinator
U.S. – Mexico Transboundary Water Governance Project
Institute for Science, Technology and Public Policy
Texas A&M University

IRB NUMBER: IRB2017-0346M
IRB APPROVAL DATE: 06/07/2017
IRB EXPIRATION DATE: 06/01/2022

(979) 862-8855 • F (979) 862-8856
Texas A&M University • 4350 TAMU • College Station, TX 77843-4350

APPENDIX 3

COVER LETTER

Institute for Science Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

Texas Water Resources Institute
make every drop count

THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

«Salutations» «FirstName» «LastName»
«TitlePosition»
«Organization»
«StreetAddress»
«City», «State» «ZipCode»

Month Day, Year

Dear «Salutations» «LastName»:

The Institute for Science, Technology, and Public Policy at Texas A&M University, in cooperation with *Texas Water Resources Institute* and *The Meadows Center for Water and the Environment*, is working to develop a deeper understanding of cooperation and conflict surrounding water management in the Texas-Mexico border region. You have been selected because you hold a position relevant to Texas water management in the border region, and we would like to ask if you would be able to help us with this task. We have enclosed a questionnaire that we hope will begin the process of giving us some basic information. Please fill out this questionnaire as best you can. Your answers are very important to us.

As a very small token of our appreciation, we include a $1 bill. If you fill out and return this questionnaire by June 28th, you will be provided with an opportunity to be entered into a drawing for one of two $75.00 Amazon.com gift cards. To enter, return the post-paid postcard that was included with the questionnaire OR fill out the page at the end of the online questionnaire. Your contact information will be used only for selecting a winner in the random drawing and will not be not be connected with the questionnaire or shared with anyone.

This research has been reviewed and approved by the Texas A&M Institutional Review Board (IRB). By completing the questionnaire, you are giving permission for us to use your anonymous response for research purposes. If you have any questions, would like more information, or would like us to share the survey results with you, please do not hesitate to contact us. Thank you in advance for your help.

Sincerely,

Lindsay Sansom, Project Coordinator
U.S. – Mexico Transboundary Water Governance Project
Institute for Science, Technology and Public Policy
Texas A&M University

IRB NUMBER: IRB2017-0346M
IRB APPROVAL DATE: 06/07/2017
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APPENDIX 4

EMAIL LETTTER

Dear «Salutations» «LastName»,

Recently, you received a questionnaire by mail on behalf of the Institute for Science, Technology, and Public Policy at Texas A&M University, in cooperation with *Texas Water Resources Institute* and *The Meadows Center for Water and the Environment*. If you have already completed the questionnaire, thank you for doing so and please disregard this email.

If you have not yet filled out the questionnaire, I hope you can find the time to do so soon. Your response will help us build a complete picture of Texas water management perspectives on the border. It should only take about 10-15 minutes to complete. To answer the questionnaire online, we suggest using a computer, not a handheld mobile device. Please visit the following link:

https://u.tamu.edu/texasborderwater

Your response to this questionnaire is voluntary and your answers will be kept confidential. After completing the questionnaire, we offer you the opportunity to be entered into a drawing for one of two $75.00 Amazon.com gift cards. To enter, return the post-paid postcard that was included with the questionnaire OR fill out the page at the end of the online questionnaire. Your contact information will be used only for selecting a winner in the random drawing and will not be not be connected with the questionnaire or shared with anyone.

This research has been reviewed and approved by the Texas A&M Institutional Review Board (IRB). By completing the questionnaire, you are giving permission for us to use your anonymous response for research purposes.

Thank you in advance for taking the time to help with this project. If you have any questions, please do not hesitate to contact me at (512) 496-5873 or Lindsay.sansom@tamu.edu.

Best,

Lindsay Sansom

Lindsay Sansom
Project Coordinator for U.S. - Mexico Transboundary Water Governance Project
Institute for Science, Technology and Public Policy
Texas A&M University
42200 TAMU | College Station, TX 77843-2142
Lindsay.sansom@tamu.edu

APPENDIX 5

POST CARD

Institute for Science
Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

Return to:

Lindsay Sansom
Institute for Science, Technology and Public Policy
4350 TAMU
Texas A&M University
College Station, TX 77843-4350

Institute for Science
Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

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College Station, TX 77843-4350

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Texas A&M University
College Station, TX 77843-4350

Institute for Science
Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

Return to:

Lindsay Sansom
Institute for Science, Technology and Public Policy
4350 TAMU
Texas A&M University
College Station, TX 77843-4350

I have completed the *Texas-Mexico Water Management* questionnaire:

☐ On paper, and mailed it under separate cover

☐ Online

☐ Please enter me in the drawing for a $75.00 gift card to Amazon.com

Email address (for raffle notification only)________________________

Name____________________________
Address 1 __________________________
Address 2 __________________________
City and State _______________________
Zip Code ___________________________

Please return this postcard separately. Thanks for your help!

I have completed the *Texas-Mexico Water Management* questionnaire:

☐ On paper, and mailed it under separate cover

☐ Online

☐ Please enter me in the drawing for a $75.00 gift card to Amazon.com

Email address (for raffle notification only)________________________

Name____________________________
Address 1 __________________________
Address 2 __________________________
City and State _______________________
Zip Code ___________________________

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Email address (for raffle notification only) ______________________

Name____________________________
Address 1 __________________________
Address 2 __________________________
City and State _______________________
Zip Code ___________________________

Please return this postcard separately. Thanks for your help!

APPENDIX 6

SURVEY DESIGN

Survey Design

Concept	Variable to Measure	Question to Measure Variable	Actual Question used
Risk Perception	Sovereignty –**Q4a**	Cooperation with Mexico over shared transboundary waters could lead to a loss of control over local decision making authority.	Formal cooperation with Mexico over shared groundwater will lead to a loss of local authority and control over decision making.
	Equity- **Q4b**	Cooperation with Mexico over shared water resources will lead to inequitable water sharing.	Cooperation with Mexico over shared groundwater will lead to equitable water distribution.
	Support- **Q9g**	Constituents within Texas will support cooperation with Mexico over shared transboundary water.	As far as I know, most water users within Texas will support cooperation with Mexico over shared groundwater.
	Knowledge – **Q9h**	My state/government/institution has the knowledge necessary to accurately manage water resources.	The U.S. federal government has the knowledge necessary to accurately negotiate groundwater management in aquifers shared with Mexico.
	Accountability- **Q9f**	I believe that my co-riparian partners (Mexico) has the willingness and ability necessary to uphold its commitments.	The U.S. federal government has the ability to uphold and enforce cooperation commitments.
Risk Perception-psychometric paradigm			
	Benefits- **Q5**		Please indicate how likely it is that cooperation with Mexico would generate the following benefits for water management outcomes in Texas.
	Controllability- **Q10**		Please indicate how likely you think it is that effects from the following factors will be

			adequately controlled by water managers in Mexico.
	Knowledge- **Q14**		Please indicate how informed you are about the extent or frequency of following factors along the Texas - Mexico border.
	Ecological Impact- **Q16**		Please indicate if the following factors will have a negative or positive impact on the ecological system in the Texas - Mexico border region.
General trust	General- **Q9a**		Generally speaking, most people can be trusted.
Relational Trust/ "trust"	Dispositional- **Q9b**	In general, I trust my bi-national counterparts to manage water efficiently.	In general, water managers in Mexico can be trusted to manage water efficiently.
	Affinitive –**Q9c**	I trust my bi-national counterparts to manage water in accordance with my own values/beliefs.	Water managers in Mexico can be trusted to manage water in accordance with your personal values.
Calculative trust/ "confidence"	Rational –**Q9d**	The benefits of trusting my bi-national counterpart outweigh the potential costs, based on previous experience.	The benefits of trusting water managers in Mexico outweigh the costs.
	Procedural- **Q9e**	I trust that the current international rules in place provide an adequate procedure for managing shared transboundary waters.	Current international rules provide adequate procedures for managing shared groundwater.
Willingness to Cooperate	Development of Treaties (F&I) **Q11a & Q11b**	I would participate in updating, renegotiating, or writing a new treaty for water sharing between the U.S. and Mexico	a) Participate in updating or renegotiating the current international water treaties to include groundwater sharing. b) Participate in writing a new treaty for groundwater sharing.

	Development of Agreements (F) – **Q11c**	I would participate in developing localized agreements between sister cities for the management of shared water.	Participate in developing localized agreements between sister-cities.
	Data-sharing (I) – **Q11d**	I am willing to share data on shared water sources with binational partners.	Share data on groundwater
	Benefit-sharing (F) – **Q11e**	I am willing to share benefits (e.g. dams, hydro power, Wastewater treatment plants) of shared water with my binational counterparts.	Jointly share infrastructure benefits (e.g. wastewater treatment plants, dams, hydro power).
	Participation in binational stakeholder engagement (I) **Q11f**	I would like to participate in a binational stakeholder engagement.	Participate in an international stakeholder engagement process over shared water.
Propensity toward Conflict	Withhold water allocations (F) **Q12e and Q12f**	I am willing to withhold water allocations to co-riparian, downstream users.	e) Withhold water from downstream users in Mexico out of the Colorado river in protest to failed Mexican water deliveries in Rio Grande. & f) Cut off water supplies to Mexico.
(F) = Formal	Intentionally inequitable use (I) **Q12d**	I am willing to use more than my share of water so that downstream users on the other side of the border have less.	Ensure that Texas water needs are met, even if Mexico gets less.
(I) = Informal	Intentional degradation of WQ (I) **Q12a**	I am willing to intentionally degrade WQ to punish Mexican water users.	Dispose of untreated waste, even if it could lead to downstream degradation.
	Lack of prior notification (F or I) **Q12b**	I am willing to develop on my side of the international border without prior notification to Mexican authorities, even if it may negatively impact their water resources.	Develop ground or surface water resources in border region without prior notification to Mexican authorities (1944 Water Treaty: Min 242: Article 6.)
	Lack of Treaty enforcement (F)- **Q13f**	I am willing to ignore treaty requirements.	Ensure Texas has sufficient water, even if it impinges on treaty agreements.
	Public Reprimand (I) – **Q12c**	I am willing to publically reprimand Mexican decision-makers.	Publicly reprimand decision makers in Mexico.

Engagement in Cooperative Behavior	Development of Treaties (F) – **Q13a**	I have worked on developing new or updated treaty language.	Worked on or suggested water treaty development or amendments.
(F) = Formal	Development of Agreements (F) – **Q13b**	I have worked on developing localized binational agreements.	Developed localized agreements over water.
	Data-sharing (I) **Q13c**	I have freely shared data with my binational counterparts.	Shared data over groundwater.
	Benefit-sharing (F) – **Q13d**	I have benefitted from a jointly managed binational water project (dam, hydropower, WWTP).	Jointly-managed an international water project.
	Participation in binational stakeholder engagement (I)- **Q13ef**	I have participated in binational stakeholder engagement.	Participated in an international stakeholder engagement over shared water.
	Participation in joint technical committee (F) **Q13f**	I have served on a joint technical committee with counterparts in Mexico.	Served on a joint technical committee over shared water.
Engagement in Conflictual Behavior	Withhold water allocations (F) **Q15f**	I have intentionally withheld water allocations for binational downstream users.	Cutting off supplies to Mexico.
(I) = Informal	Intentional degradation of WQ (I) –**Q15a & Q15b**	I have intentionally degraded WQ for binational downstream users	c. Texans disposing of untreated waste, knowing it might lead to downstream degradation. & d. Mexicans disposing of untreated waste, knowing it might lead to downstream degradation.
	Lack of prior notification (F or I) **Q15c**	I have known about or been a part of infrastructure development that took place near the border without prior notification to Mexico.	Developing ground or surface water resources in border region without prior notification to Mexican authorities as stipulated in 1944 Water Treaty, Min 242, Article 6.
	Lack of Treaty enforcement (F)- **Q15e**	I have knowingly ignored treaty violations.	Securing sufficient water for Texas, despite potential to impinge on treaty agreements.
	Public Reprimand (I) – **Q15d**	I have publicly (in person, or through media) reprimanded a Mexican decision-maker.	Publicly reprimanding a Mexican decision-maker (via media, in person, via shared emails, or any other form of public reprimand).
Experience	% of time working on water- **Q1**		How much time, approximately, do you currently work on water issues in the Texas-Mexico border region (even if you work primarily on domestic water issues)?
	Organizational affiliation- **Q2**		What type organization do you work for?
	Time worked in current position- **Q3**		How long have you worked in your current position?
	Groundwater reliance- **Q7**		To what extent does the city or town where you work rely on groundwater to meet its various needs?
	Transboundary nature of groundwater- **Q8**		As far as you know, is the groundwater in the city or town where you work part of an aquifer shared with Mexico or is it part of a Texas-only aquifer?
	Binational Stakeholder participation- **Q6**		Over the last year, how often have you participated in any of the listed cooperative international or domestic stakeholder efforts?
Demographics	Age- **Q17**		What is your age?
	Gender- **Q18**		What is your gender?
	Race- **Q19**		Please select the categories that best describe your background.

	Education- **Q20**		What is the highest level of schooling you have completed to date?
	Political affiliation- **Q21**		Generally speaking, do you consider yourself:
	Location- **Q22**		What is the zip code for the place where you work?

APPENDIX 7: QUESTIONNAIRE CODING FORM

Coding Form for
***Water management in the Texas-Mexico Border Region* Survey**

Wave ☐

Case Number

☐☐☐

Q1. ☐

Q2. ☐

Q3. ☐

Q4A. ☐

Q4B. ☐

Q5A. ☐

Q5B. ☐

Q5C. ☐

Q5D. ☐

Q5E. ☐

Q5F. ☐

Q5G. ☐

Q5H. ☐

Q5I. ☐

Q5J. ☐

Q5K. ☐

Q6A. ☐

Q6B. ☐

Q6C. ☐

Q6D. ☐

Q6E. ☐

Q6F. ☐

Q7. ☐

Q8. ☐

Q9A. ☐

Q9B. ☐

Q9C. ☐

Q9D. ☐

Q9E. ☐

Q9F. ☐

Q9G. ☐

Q9H. ☐

Q10A. ☐

Q10B. ☐

Q10C. ☐

Q10D. ☐

Q10E. ☐

Q10F. ☐

Q10G. ☐

Q10H. ☐

Q11A. ☐

Q11B. ☐

Q11C. ☐

Q11D. ☐

Q11E. ☐

Q11F. ☐

Q12A. ☐

Q12B. ☐

Q12C. ☐

Q12D. ☐

Q12E. ☐

Q12F. ☐

Q13A. ☐

Q13B. ☐

Q13C. ☐
Q13D. ☐
Q13E. ☐
Q13F. ☐
Q14A. ☐
Q14B. ☐
Q14C. ☐
Q14D. ☐
Q14E. ☐
Q14F. ☐
Q14G. ☐
Q14H. ☐
Q15A. ☐
Q15B. ☐
Q15C. ☐

Q15D. ☐
Q15E. ☐
Q15F. ☐
Q16A. ☐
Q16B. ☐
Q16C. ☐
Q16D. ☐
Q16E. ☐
Q16F. ☐
Q16G. ☐
Q16H. ☐
Q17. ☐
Q18. ☐
Q19. ☐
Q20. ☐

Q21. ☐
Q22.
☐☐☐☐☐
Q23. ☐☐

Paper ☐
Online ☐