


May 2015

# The Impact of International Water Treaties on Transboundary Water Conflicts: A Study Focused on Large Transboundary Lakes

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**THE IMPACT OF INTERNATIONAL WATER TREATIES ON  
TRANSBOUNDARY WATER CONFLICTS  
A STUDY FOCUSED ON LARGE TRANSBOUNDARY LAKES**

by

Victoria Lubner

A Thesis Submitted in  
Partial Fulfillment of the  
Requirements for the Degree of

Master of Science  
in Freshwater Sciences and Technology

at

The University of Wisconsin-Milwaukee

May 2015

## **ABSTRACT**

# **THE IMPACT OF INTERNATIONAL WATER TREATIES ON TRANSBOUNDARY WATER CONFLICTS A STUDY FOCUSED ON LARGE TRANSBOUNDARY LAKES**

by

Victoria Lubner

The University of Wisconsin-Milwaukee, 2015  
Under the Supervision of Professor Jenny Kehl

Lakes are the largest reservoir of available surface freshwater on Earth, representing an irreplaceable ecosystem, essential for all life. Despite the crucial need for these lakes, there has been minimal research focused on their health and security. There are over 1,600 transboundary lakes worldwide, which do not follow political borders and thus result in governance and management challenges. International water treaties have been cited to be a main mechanism for cooperation between riparian countries. This study researches the impact of international water treaties as well as economic, political, and environmental variables on transboundary water conflict between riparian countries of the 35 largest transboundary lakes. The goal is to understand if the implementation of an international water treaty impacts the occurrence of conflict between riparian countries of large transboundary lakes. Datasets were created from existing international water treaty and conflict databases focused on transboundary waters. The created datasets were used to analyze the relationship between treaties and conflicts on a primary focus, annual, and lake basis. Furthermore, an event analysis of case studies was completed for each lake. There were 52 international water treaties, focused on joint management, water quality,

and water quantity implemented between 1990 and 2013. Between 1990 and 2013, 53 international water conflicts occurred with the primary focuses of water quantity and border issues. The content of the treaty is an essential aspect to understand the effectiveness of preventing conflict after implementation; the majority, 28, of the 53 conflicts that occurred after a treaty was implemented were not related to the content of that treaty. The majority of the international lake treaties lack vital components for successful compliance including enforcement, conflict resolution, and monitoring. Overall, the implementation of a treaty does not result in a disappearance of conflict between riparian countries. The specific details of the treaty, as they relate to conflicts are the best indicators of successful and effective compliance of the treaties.

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## **ACKNOWLEDGEMENTS**

First, I would like to thank my advisor Dr. Jenny Kehl for continuous guidance and support.

Thank you to my committee members, Dr. Ramiro Berardo and Dr. Tim Ehlinger who provided suggestions and guidance throughout the research process. I owe a tremendous amount of thanks to Aaron Thiel, for the numerous edits, constant advice and guidance, and keeping me sane for the last two years. Finally, I would like to thank my family and friends, especially my parents and John Ziegler, for continued support, patience, and love.

## 1.0 Introduction

Lakes represent unique ecosystems containing large volumes of water vital for a variety of human uses and biological services. Over 27 million natural lakes exist with a surface area over one hectare (ha) and a half million artificial lakes with a surface area over one ha (Texas State University 2014). The total volume of these lakes accounts for almost 70 percent of the available surface freshwater on the earth (ICA Report 2014).

Despite the large volume of water stored in lakes, there has been little attention paid to understanding their health and security. Looking to the future, humanity will not be able to continue their high rate of consumption and minimal knowledge of lakes. A greater understanding of the health, uses, and security of natural and artificial lakes are necessary, since the water is used for drinking, irrigation, navigation, fishing, and recreation. Due to the lack of knowledge regarding large lakes, it is imperative to conduct research with the goal to obtain data on these lakes, especially transboundary lakes. Missing data includes, water quality, retention rates, and uses which are essential for successful management and protection of the world's lakes. A lack of equitable water management has the potential to cause increased inequalities and increased water insecurity (UN Water 2008).

Due to the fact that lakes are used for a wider range of human activities than almost any other freshwater ecosystem, lakes are more susceptible to conflict. It is crucial to study the relationship between international water treaties and international water conflict between riparian countries to understand the impact of treaties. Research shows international treaties have the ability to decrease conflict and promote cooperation between otherwise hostile riparian countries (Yoffe *et al.* 2003, de Stefano *et al.* 2010, Barnaby 2009, Brochmann and Hensel 2009, Wolf *et al.* 2003 and Wolf 1997).

Furthermore, “the record of acute conflict over international water resources is overwhelmed by the record of cooperation” (Wolf *et al.* 2003).

The goal of this study was to use quantitative data to determine the impact of international water treaties on international water conflict between riparian countries of large transboundary lakes. Additionally, this study explored the impact of economic, political, and environmental on international water conflict. This is a quantitative study analyzing if transboundary water treaties are a pathway for decreased conflict between riparian countries. The content of conflicts and treaties, the strengths and weaknesses of the treaties, and the effect of political, economic, and environmental variables have on conflict are explored.

## 2.0 Project Specification

Treaties are an essential part of the governance of transboundary lakes, since they lessen the effects of conflicts and increase cooperation between riparian countries (Brochmann and Hensel 2009, Wolf *et al.* 2003 and Wolf 1997). When cooperation is established through treaties, it will be resilient even between hostile countries (Wolf 1997). In order to understand the relationship between international water treaties and international water conflicts regarding large transboundary lakes, this study collected data on treaties, conflicts, and contextual variable from a variety of sources between 1990 and 2013. Existing databases were used to extract information on international water treaties and international water conflicts to create a treaty dataset and conflict dataset. Annual data on the following contextual variables were included: population growth, GDP per capita, GINI Index, political stability, voice and accountability, total water per capita, precipitation, and external water dependence. These variables have been cited to impact

the likelihood of environmental conflict, therefore, were included to increase the understanding that international water treaties have on transboundary water conflict (Brochman and Gleditsch 2012; Brochmann 2012; Zawahri and Mitchell 2010; Miquel et al. 2004; Bernauer et al. 2012; Hauge and Ellingsen 1998). Furthermore, including contextual variables would allow to compare the impact of international water treaties on the likelihood of transboundary conflict of large lakes. After the collection of data, qualitative and quantitative analyses were completed to understand the relationship between international water treaties and international water conflicts. Treaty and conflict data were analyzed annually, by primary focus, lake, relationship to one another, content of the treaty, and region. Furthermore, a logistic regression was completed to understand if the chosen contextual variables increased or decreased in odds of conflict occurring and compared to the impact of international water treaty implementation.

### 3.0 Literature Review

Serving industry, municipalities, agriculture, ecosystems, households, and energy, water is vital for life. “Human well-being, ecosystem health and functions, even economics and politics all depend on how much, when, and where water is available” (Gleick 2000). Water ignores political boundaries and fluctuates in time and space depending on climate and use. The fact that water is tied to everything, results in water as the mechanism that is capable of bringing countries together when nothing else will (Wolf 2007).

While 71 percent of Earth is covered with surface water, 97.5 percent is salt water; leaving a mere 2.5 percent to be freshwater. (USGS 2014a). Lakes contain 67.5 percent of the total available surface freshwater in the world (Figure 1), resulting in lakes

as the largest source of available surface freshwater on Earth (Global Water Security 2012). There is an estimated 27 million natural lakes with a surface area larger than one hectare (ha) and 0.5 million artificial lakes with a surface area larger than one ha (TWAP 2014).

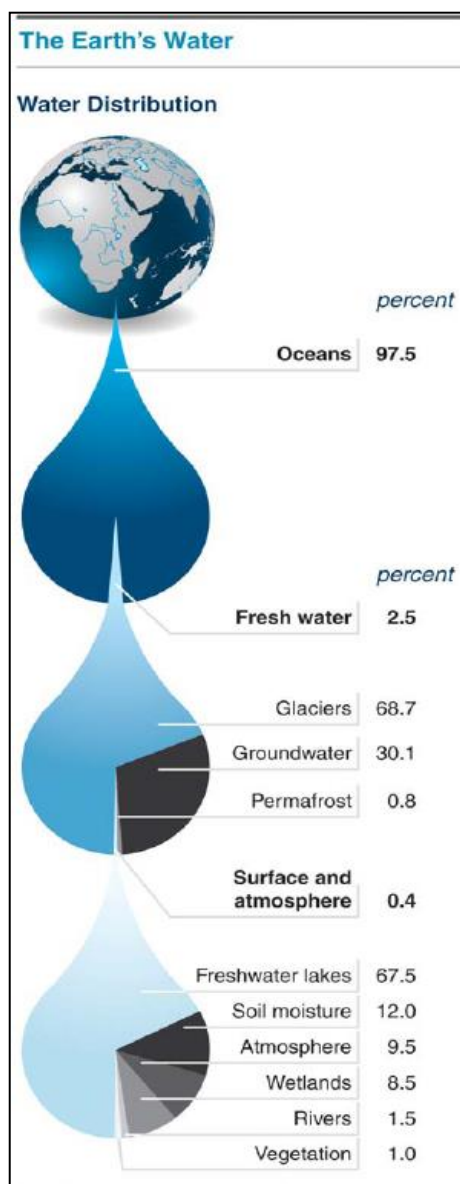


Figure 1: Water distribution on Earth. Source: ICA Global Water Security Report 2012

One weakness of the current literature on transboundary waterbodies is the lack of research conducted on transboundary lakes, reservoirs, and aquifers. Transboundary waters research has focused on rivers, potentially due to the fact that rivers are the main source of available freshwater for human use (USGSb 2014). Research needs to be conducted on transboundary lakes, because lakes are the largest reservoir of available surface freshwater (USGSb 2014). Overall, there is a lack of data regarding international transboundary lake management as well as data on water quantity and water quality. There is also minimal work completed analyzing the effectiveness of international water treaties implemented regarding large transboundary lakes on increasing cooperation and decreasing conflict.

### *3.1 Transboundary Lakes*

Transboundary waters, lakes, reservoirs, streams, rivers, or aquifers, are referred to water that crosses between, or is shared by, nations, sub-national political units, economic sectors, or interests (Beach et al. 2000). This study will explore transboundary lakes that are shared by multiple countries. Transboundary waterbodies cover 70 percent of the Earth's surface (TWAP 2014). There are more than 1,600 transboundary lakes, 455 transboundary aquifers, 276 transboundary rivers, and 55 large marine ecosystems worldwide (Figure 2) (TWAP 2014). More than 40 percent of the world's population lives in a transboundary water basin (Watkins 2006). Transboundary waterbodies have increased over time due to new countries; in 1978 there were 214 international river basins and in 2006 there were 263 international river basins (MacQuarrie et al. 2008). There are approximately 145 countries located in transboundary river basins and over 30 countries located completely within transboundary water basins (Watkins 2006).



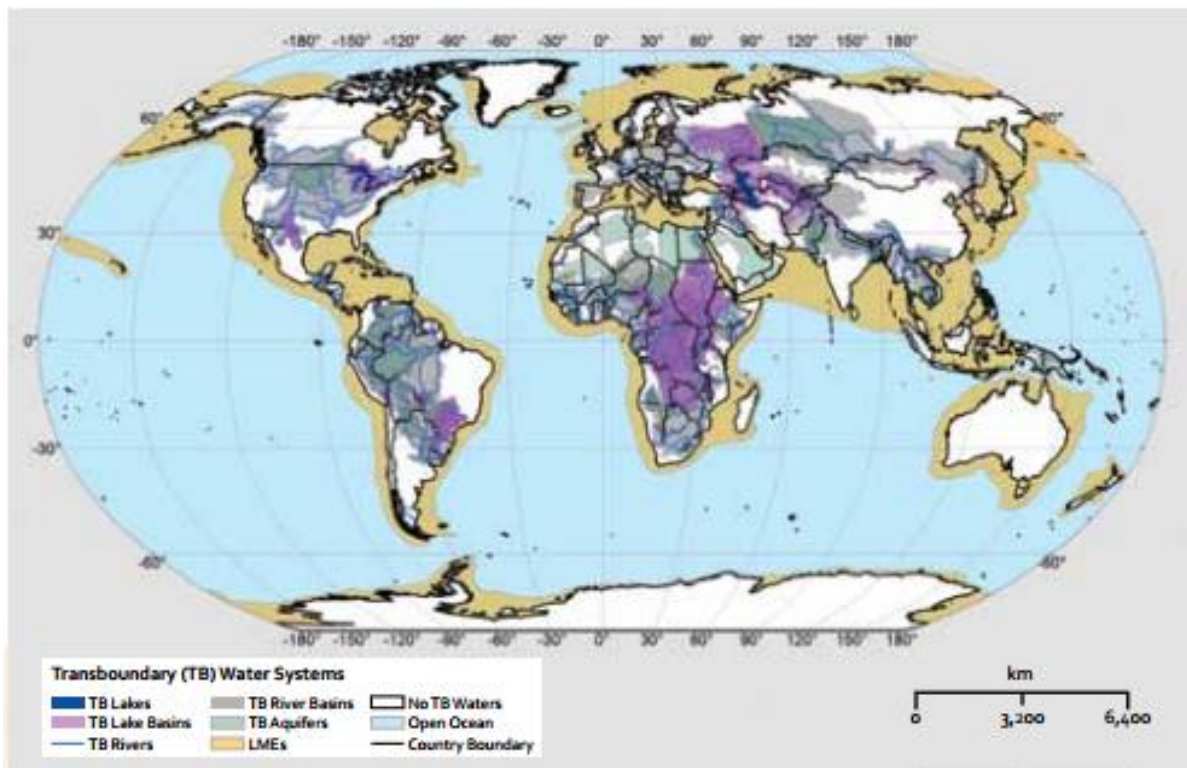


Figure 2: Location of transboundary water systems. Source: TWAP 2014

Few studies have been completed on large lakes, especially in regards to international water treaties and international water conflict. The majority of previous studies have focused on the physical aspects of lakes, such as water quality. Texas State University started the Transboundary Water Assessment Programme (TWAP) to address the lack of a comprehensive assessment of transboundary waterbodies. TWAP set out to conduct the first global assessment of transboundary waters: groundwater, lakes/reservoirs, rivers, large marine ecosystems, and the open ocean. The TWAP's, led by the International Lake Environment Committee (ILEC) with national, regional, and international organizations, goal is to provide a comparative assessment of the current state of transboundary waters using existing data and stakeholder information (TWAP 2014). The TWAP includes 159 transboundary lakes and reservoirs which are eligible for Global Environmental Facility (GEF) funding and 47 lakes and reservoirs not eligible for GEF funding. In total, TWAP collects and analyzes data for 206 lakes and reservoirs.

GEF is a partnership for international cooperation where 183 countries work with institutions, civil society organizations, and private companies to address global environmental issues (GEF 2013). While the goal of the project is to guide GEF and other organizations on how to properly allocate funding for management and conservation, the project concluded there is a “lack of systematized data on a global scale” regarding transboundary waterbodies (TWAP 2014). Due to the minimal data found on lakes and reservoirs, a GIS based analyses is the primary output of the study, scheduled to be released in mid-2015.

Another study that attempts to research the importance of international lakes is the Lake Basin Management Initiative (LBMI). In 2002, GEF approved a \$1.5 million project titled “Towards a Lake Basin Management Initiative: Sharing Lessons for GEF and non-GEF Lake Basin Management Projects”. Carried out by ILEC and LakeNet, this project produced 28 policy briefs, each on a different lake system (LakeNet 2004). The goal of the project was to “strengthen the capacity for improved lake and reservoir basin management at the local, basin, national, and global levels” (LakeNet 2004). While the policy briefs allowed for sharing of information between management leaders, LBMI’s reports were inconsistent. Some reports gave detailed information on the pollution, primarily nitrogen and phosphorus of the lakes (i.e. Lake Victoria), while other reports only alluded to potential sources of pollution and contained no quantitative data. Inconsistency in data collection and reporting has the potential to result in different perspectives on effective water management. For example, when there is a minimal data reported on pollution concentrations in a lake, correct management procedures will not be taken to reduce pollution since the level of contamination is unknown. There needs to be

standard data collection to ensure effective management procedures are taken for all waterbodies.

The “Second Assessment of Transboundary Rivers, Lakes, and Groundwaters” studies the transboundary water bodies in Europe and Asia in the United Nations Economic Commission for Europe (UNECE) region. Forty percent of this area is covered by transboundary waters and encompasses more than 50 percent of the European and Asian population of UNECE (Lipponen *et al.* 2011). The goal of the report is to give an up-to-date overview of the status of transboundary waters in the UNECE region. It presents an analysis of pressures on supply, the status of quality and quantity, transboundary impacts and future predictions (Lipponen *et al.* 2011). While this report is detailed for the lakes studied, it does not provide a global assessment of transboundary lakes.

Transboundary lakes provide numerous challenges for management and governance. One reason is transboundary waters do not follow political boundaries. Transboundary water resources are under stress as a result of poor implementation of management practices, increased pollution, overexploitation, unsustainable water consumption, and low efficiency of water use (Uitto and Duda 2002). As water scarcity becomes more prevalent with a changing climate, water management will need to adapt to maintain a sustainable freshwater supply.

### *3.2 Neo-Malthusians, Cornucopians, and Neo-Institutionalists*

Neo-malthusians, cornucopians, and neo-institutionalists are three viewpoints on resource scarcity. Neo-malthusians claim that there are finite limits to natural resource and once these limits are passed widespread poverty and social breakdown will occur (El-

Anis 2013). Environmental scarcity is seen as a direct threat to security since environmental scarcity will increase frustration and create grievances against the state (Bernauer et al. 2012). Cornucopians are resource optimists, acknowledging that environmental degradation periodically challenges human well-being, but they argue humans have the capacity to adapt to resource scarcities primarily with technology (Bernauer et al. 2012). Third, liberal institutionalists believe there is capacity in institutions to govern resource scarcities. Institutions encourage conservation, resource distribution, and the development of alternative sources of scarce resources (El-Anis 2013). Overall, “neo-malthusians have regularly predicted water wars while cornucopians have argued that there is no inherent scarcity and liberal institutionalists have seen cooperation as more likely outcome of competition for limited water resources than violent conflict” (Brochmann and Gleditsch 2012).

### *3.3 Treaties*

As stated above, transboundary lakes are a challenge to govern resulting in the lack of a global governing organization or document that is effective. With numerous countries, communities, and tribes using the same resource with different perspectives on the most effective way to govern the resource, transboundary waters have been believed to be associated with international conflicts (Hensel 2008). The variation in regulatory frameworks between countries results in the challenge of efficient and successful resource management. Political boundaries rarely follow the same pathway as watersheds, resulting in difficulties when creating effective water policy (Gleick *et al.* 2012). International water treaties may be a solution for effective governance of these vital resources.

On August 17, 2014, the Convention on the Non-Navigation of International Water Sources was ratified by 35 states and entered into force. The Convention, originally created in 1997, has the purpose of governing transboundary freshwater resources, groundwater, rivers, and lakes (Mohamdo 2003). The Convention provides a framework focusing on the equitable and reasonable use of water, including prohibiting causing significant harm to other users of the transboundary water (Mohamdo 2003). Furthermore, Article 10 of the Convention states if a conflict is to occur it will be resolved depending on the situation (Mohamdo 2003). While the Convention is a step in the right direction to establishing international water policy, it has been criticized for being vague resulting in limited direction for the governance of transboundary waterbodies (Beaumont 2000). The Convention lacks practical guidelines for water allocations which is the primary focus of most water conflicts (Beaumont 2000). Furthermore, there is a lack of enforceable international guidelines for transboundary lakes. The Convention is the first and only agreement on the governance of lakes, groundwater, and rivers.

Oregon State University (OSU) Department of Geosciences took on the challenge of analyzing cooperation verses conflict for transboundary water bodies, focusing on rivers. Their research project, Transboundary Freshwater Dispute Database (TFDD), focused on quantifying the cooperation and conflict events on a scale from positive seven to negative seven, known as the BAR scale. Negative seven is considered the most conflictive event – formal declaration of war and positive seven is considered the most cooperative event – a formal formation of a treaty or agreement (Yoffe *et al.* 2003). TFDD concluded there were more than 400 water related treaties and agreements

enacted between 1820 and 2007 (Yoffe *et al.* 2003). The treaties analyzed correspond to “water as a scarce or consumable resource, a quantity to be managed, or an ecosystem to be improved or maintained” as well as focused on water rights, water allocation, water pollution, food control, and general environmental issues (Wolf 1997). Therefore, treaties focused on navigation rights and tariffs, fishing rights, and the delineation of river were excluded. Groundwater is often left out of international transboundary water agreements. When groundwater is mentioned in the treaty it is usually in regards to contamination and not water use or allocation (Gleick 2012). The UN Food and Agriculture Organization (FAO) identified more than 3,600 water related treaties regarding international water bodies from 805 AD to 1984, most focused on navigation (FAO 1987 and 1984).

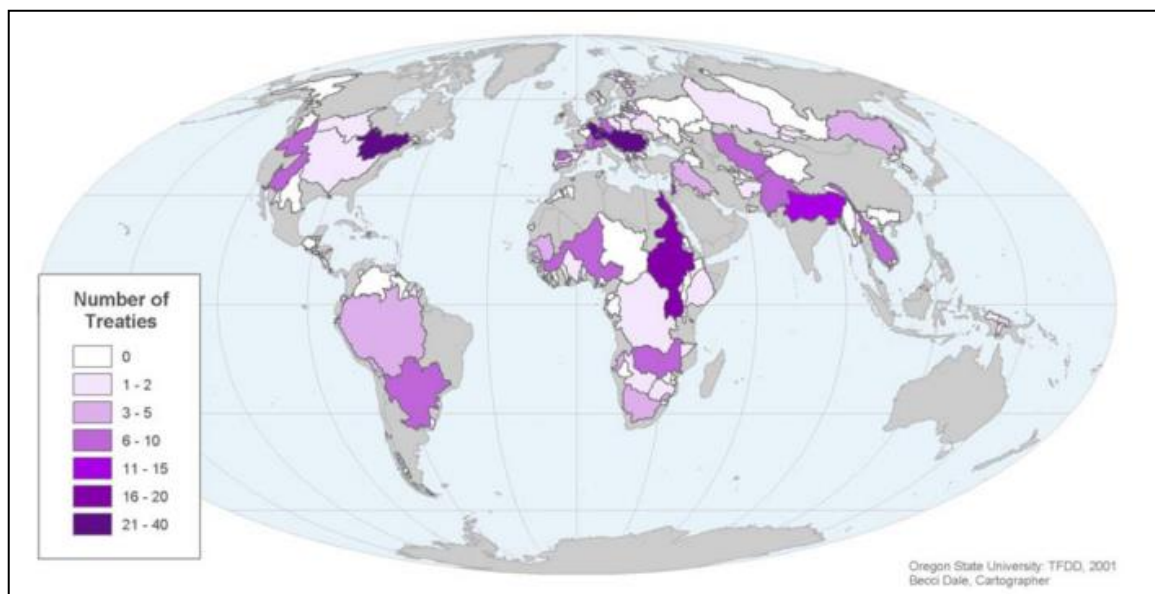


Figure 3: Number of treaties per international river basin. Source: Chalecki et al. 2002

According to the TFDD project during the 20<sup>th</sup> century 145 treaties regarding transboundary waters were negotiated. The primary focus of water supply and hydropower accounted for 110 of the 145 treaties analyzed (Wolf 1997 and Hamner and Wolf 1998) (Figure 4). Another important conclusion is 80 percent of the treaties have

no enforcement mechanism and only 54 percent of the treaties provide some type of monitoring (Wolf 1997). If enforcement or monitoring was included in the treaty, it was rudimentary (Gleick *et al.* 2012; Hamner and Wolf 1998). Additionally, 86 percent of the treaties are bilateral leaving only 14 percent to be multilateral. It is alarming that such a low percentage of treaties are multilateral when the majority of the river basins analyzed have multiple riparian countries, leading to a lack of comprehensive water management between riparian countries in the basin (Wolf 1997).

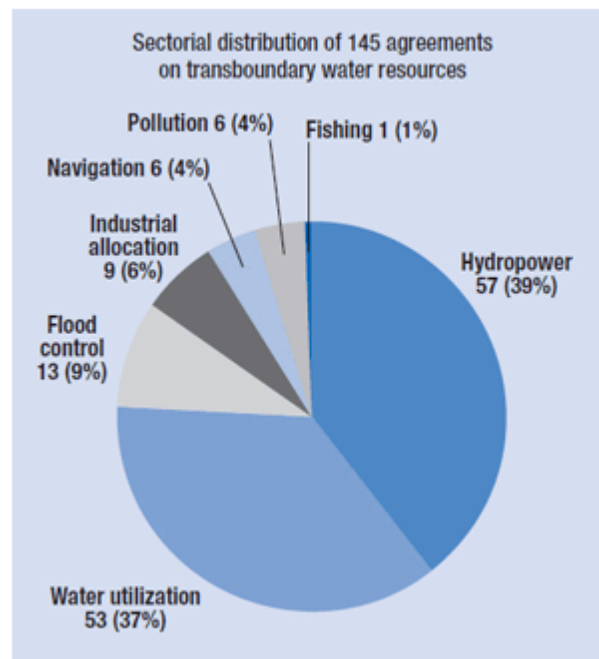


Figure 4: Percent of water treaties by category. Source: Human Development Report 2006

Despite the lack of monitoring mechanisms and the majority of treaties being bilateral in the OSU TFDD project, treaties have been shown to allow prior hostile countries to cooperate (Wolf *et al.* 2003). Overall, “international relations over freshwater resources were overwhelmingly cooperative and covered a wide range of issues, including water quantity, water quality, joint management and hydropower” (Yoffe *et al.* 2003). Once cooperation has been established between riparians through

treaties, they are resilient over time (Yoffe *et al.* 2003, de Stefano *et al.* 2010, Barnaby 2009, Brochmann 2012, Brochmann and Hensel 2009, Wolf *et al.* 2003 and Wolf 1997). Wolf *et al.* (2003) concluded that cooperation has dominated conflict in transboundary rivers in the last 100 years mostly from the signing and implementation of treaties. Between 1948 and 1999, 1,831 water events were recorded, both conflictive and cooperative. Of these events, only 28 percent were conflictive, while 67 percent were cooperative and four percent were neutral (Yoffe *et al.* 2003).

Existing treaties play an essential role in peaceful management as well as mitigate the effects of conflicts (Brochmann 2012, Brochmann and Hensel 2009, Zawahri and Mitchell 2011, de Stefano *et al.* 2010). In addition to treaties, there are other factors that will lead countries to cooperate and not participate in conflict. The quality of the relationship between the countries, the political regime of the countries, and the geographical typology of the water body all have an impact on whether countries will experience cooperation or conflict (de Stefano *et al.* 2010).

Water quantity in transboundary lakes will decrease as a result of climate change as well as increased population growth creating a greater demand in the water, which will lead to potential water conflicts (Wilner 2005). Poverty, low levels of health and education, and high population growth have been linked to cause an increase in conflict (Klare *et al.* 2009). The United Nations estimates 300 potential conflicts over water exist in the world today, calculated by the number of transboundary river systems in the world (Klare *et al.* 2009). Water has already been used to achieve military and political goals, as well as water systems and infrastructure being the target of military attacks (Gleick *et al.*



2012). The Vice President of the World Bank, Ismail Serageldin, stated “the wars of the next century will be over water” in the New York Times in 1995 (Gleick *et al.* 2012).

As water scarcity increases there will be little room for conflict resolution and management between riparians (Wilner 2005). Of the 145 treaties documented the TFDD project, only 52 treaties address conflict resolution with the involved parties’ governments. Of the remaining treaties, 14 refer disputes to a third party, and 59 treaties either have no conflict resolution or are incomplete regarding dispute resolution methods (Hamner and Wolf 1998). “Establishing an international legal framework for resource and water conflict management is indeed a very difficult, and quite possibly, an unfeasible task” (Wilner 2005). However, as demonstrated by the TFDD project and the FAO treaties, an international legal framework has been successful in the past, but these treaties rarely include adequate conflict resolution. There has been only one water war in the past 4,500 years (Yoffe *et al.* 2003 and Wolf 1998).

Treaties are not the only mechanism that is used to determine whether countries will cooperative or engage in conflict over transboundary waterbodies. Political, economic, and environmental factors have been shown to have a significant impact on predicting the occurrence of conflict (Raliegh and Urdal 2007, Hauge and Ellingsen 1998, Brochmann and Gleditsch 2012, and Zawahri and Mitchell 2010). Rapid and extreme changes in political, economic, and environmental variables have the greatest impact on conflict. For example, construction of a large dam on a river results in extreme physical change leading to an increase in conflict (Yoffe *et al.* 2003). Additionally, rapid changes in the governing institutions is likely to cause conflict (Wolf *et al.* 2003).

Treaties have been an integral component to cooperation between riparian countries in river basins, and this study researched the impact international water treaties had on conflict regarding large transboundary lakes. Prior research has shown there is a lack of global data regarding transboundary waterbodies, cooperation has dominated conflict regarding transboundary waterbodies, and conflict may occur over water resources with the predicted changes in the climate and population growth. This study explored the importance of treaties between riparian countries for international transboundary lakes, analyzing all aspects of the treaties and the relationship to international water conflict.

#### 4.0 Research Questions

1. Do international water treaties have an effect on international water conflict between riparian countries of large transboundary lakes?
  - a. Is there a relationship between the main content of the treaty and the primary focus of the conflict? For example, if there are international water treaties focused on border issues are there less international water conflicts on border issues?
  - b. When an international water conflict occurs after an international water treaty has been implemented is the content of the conflict related to the content of the treaty?
  - c. Do the number of international water treaties increase over time as the number of international water conflict decreases? Or does the number of international water conflicts increase over time because

there is a legally binding document between the riparian countries  
therefore countries feel more empowered to take action?

2. Do contextual variables, population growth, GDP per capita, the GINI index, political stability, voice and accountability, total water per capita, precipitation, and external water dependence, have an impact on the occurrence of international water conflict?

## 5.0 Hypotheses

1. International water treaties will have an impact on international water conflict between riparian countries of large transboundary lakes.
  - a. If there is a large number of international water treaties with a specific primary focus, then there will be a minimal number of international water conflicts with that primary focus.
  - b. There will be more reported conflicts after the implementation of a treaty unrelated to the content of the treaty than related to the content of the treaty.
  - c. As the number of international water treaties increase the number of international water conflicts will decrease.
2. Economic, political, and environmental variables will have an impact on international water conflict. If a lake experiences high population growth there will be an increase in the international water conflict. Countries with higher Gross Domestic Product per capita will be less likely to experience conflict than countries with low GDP per capita. Countries with high income inequality are more likely to experience conflict. Countries with

consistent political regime and democracy will be less likely to experience conflict than autocracies and a changing political regime. Countries with low water stress, high precipitation, and low external water dependence will be less likely to experience conflict.

## 6.0 Methods

The goal of this study is to use quantitative data on international water treaties and international water conflict to determine the impact treaties have on transboundary water conflict between riparian countries of large transboundary lakes. Data were collected on international water treaties and international water conflict creating two datasets; one database on international water treaties and the other database on international water conflict. Annual data was collected on economic, political, and environmental factors to determine their impact on international water conflict in comparison to the impact international water treaties have.

### 6.1 Transboundary Lake Selection

This study analyzed large transboundary lakes (saltwater and freshwater) greater than 800 square kilometers (km<sup>2</sup>). The goal of the study was to study large transboundary lakes, therefore, lakes with a surface area of 800km<sup>2</sup> or greater were chosen. Furthermore, since larger lakes have a higher number of riparian countries this led to a more dynamic analysis of country interactions. The TWAP database on transboundary lakes was used to compile the 35 lakes with a surface area greater than 800km<sup>2</sup> (Figures 5 through 9). For each lake the name, surface area, riparian countries, latitude, longitude, and basin were recorded (Table 2).

Table 1: The international transboundary lakes with a surface area of 800 square kilometers or greater. The lake, surface area (km<sup>2</sup>), riparian countries, and basin are shown. Source: TWAP

LAKE	SURFACE AREA (km <sup>2</sup> )	RIPARIAN COUNTRIES	BASIN
Caspian Sea	377543.20	Azerbaijan; Iran; Kazakhstan; Russia; Turkmenistan	TBD
Superior	85893.7649	Canada; USA	St. Lawrence
Victoria	66841.53	Kenya; Tanzania; Uganda	Nile
Huron	60565.2168	Canada; USA	St. Lawrence
Tanganyika	32685.45	Burundi; DR Congo; Tanzania; Zambia	Congo/Zaire
Malawi/Nyasa	29429.15	Malawi; Mozambique; Tanzania	Zambezi
Erie	26560.7691	Canada; USA	St. Lawrence
Aral	23919.28	Kazakhstan; Uzbekistan	Aral Sea
Ontario	19062.2313	Canada; USA	St. Lawrence
Titicaca	7479.94	Bolivia; Peru	Lake Titicaca-Poopo System
Turkana	7439.18	Ethiopia; Kenya	Lake Turkana
Albert	5502.31	DR Congo; Uganda	Nile
Nasser/Aswan	5362.72	Egypt; Sudan	Nile
Kariba	5258.61	Zambia; Zimbabwe	Zambezi
Mweru	5021.54	DR Congo; Zambia	Congo/Zaire
Cahora Bassa	4347.37	Mozambique; Zambia; Zimbabwe	Zambezi
Xingkai/Khanka	4127.67	China; Russia	Amur
Merin	3896.70	Brazil; Uruguay	Lagoon Mirim
Sarygamysh	3777.69	Turkmenistan; Uzbekistan	TBD
Uvs/Usba	3613.33	Mongolia; Russia	Lake Ubsa-Nur
Peipsi/Chudskoe	3507.40	Estonia; Russia	Narva
Lake of the Woods	2964.7634	Canada; USA	Nelson-Saskatchewan
Kivu	2375.12	DR Congo; Rwanda	Congo/Zaire
Edward	2231.99	DR Congo; Uganda	Nile
Buenos Aires/General Carrera	1768.37	Argentina; Chile	Baker
Chad	1294.61	Cameroon; Chad	Lake Chad
Itaipu	1154.07	Brazil; Paraguay	La Plata
St. Clair	1114.0000	Canada; USA	St. Lawrence
Lago de Yacyreta	1109.41	Argentina; Paraguay	La Plata
Champlain	1098.9038	Canada; USA	St. Lawrence
Chilwa	1084.20	Malawi; Mozambique	NA
O'Higgins/San Martin	1013.13	Argentina; Chile	Pascua
Rainy Lake	852.4789	Canada; USA	Nelson-Saskatchewan
Szczecin Lagoon	822.4074	Germany; Poland	Oder/Odra
Zun-Torey	806.24	Mongolia; Russia	Amur

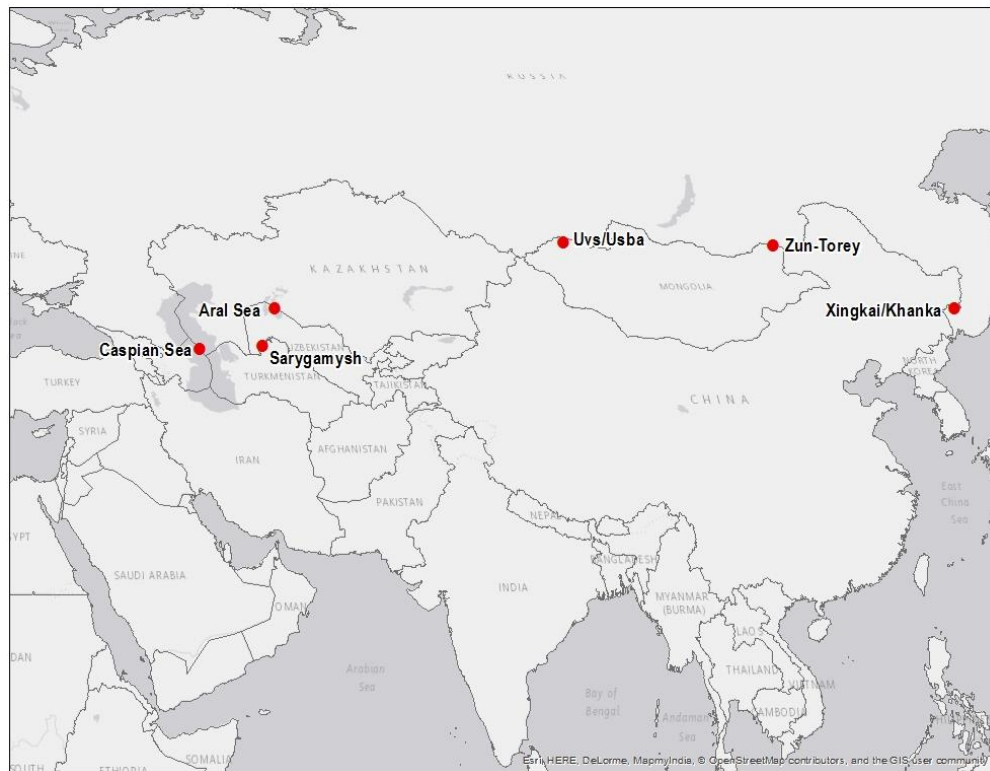


Figure 5: Transboundary lakes in Asia.



Figure 6: Transboundary lakes in Europe.



Figure 8: Transboundary lakes in North America.



Figure 7: Transboundary lakes in Africa.



Figure 9: Transboundary lakes in South America.



## 6.2 Data collection for International Water Treaties

For this research study, an international water treaty is defined as a formal document between countries referring to water as a scarce or consumable resource, a quantity to be managed, or an ecosystem to be improved or maintained (Hammer and Wolf 1998). Documents classified as treaties, agreements, revisions, conventions, and protocols regarding a transboundary lake were included in the international treaties dataset.

Previous research studies have focused on international water treaties relating to water as a consumable resource, disregarding treaties relating to boundary issues, navigation, and fishing (de Stefano *et al.* 2010 and Wolf 1998). This study considered all water related international treaties between riparian countries, including treaties that cover a large range of lakes and countries, deal with water as a consumable resource, boundary delineation, navigation, recreation, hydropower, fishing, wetlands, and general water management. This was done to encompass a larger set of international water treaties governing transboundary lakes, which influences the management of transboundary lakes. The goal was to encompass all international water treaties governing large transboundary lakes implemented between 1990 and 2013. This time period was chosen because the breakup of the Soviet Union was the last time a transboundary lake was created, the Aral Sea.

The International Union for Conservation of Nature and Natural Resources, report, *International Water Governance: Conservation of Freshwater Ecosystems* was used to collect treaty information included in the created dataset. This report provides a detailed understanding of existing governance agreements for the preservation of freshwater ecosystems (Iza 2004). Additionally, the report provides an analysis of

selected international water agreements, and was searched for international water treaties from 1990 to 2004 regarding the transboundary lakes for data compiling.

The first existing database used was the Transboundary Freshwater Dispute Database Project (TFDD), which focuses on transboundary rivers, but also includes transboundary lakes. It contains over 450 international freshwater agreements from 1820 to 2008. In using the TFDD, the database was first filtered by year, eliminating anything prior to 1990. Next, the TFDD was filtered by riparian country, removing treaties between countries that were not the riparians to the lakes of interest. Each treaty in the newly created dataset was reviewed to understand the components of the treaty. Additional international water treaty information was needed from 2008 to 2013 – the time span not covered by the TFDD.

The two other databases utilized, FAOLEX and FAO WATER TREATIES are not specific to transboundary water system, and therefore, data collection was limited to only international water treaties involving the transboundary lakes. FAOLEX contains a variety of domestic and international treaties. It is a “comprehensive and up-to-date legislative database, one of the world’s largest electronic collections of national laws and regulations on food, agriculture and renewable natural resources” (FAOLEX 2014). Due to the wide range of treaties covered in FAOLEX, the advanced search function was used to select for treaties relating to water. The advanced search option was not able to filter domestic treaties, therefore each riparian country of the 35 transboundary lakes was used for the ‘words from record’ search bar. Similar to the TFDD selection process, treaties were included if they were between the riparian countries of a large transboundary lake and implemented between 1990 and 2013.

The FAO WATER TREATIES database “carries the full text of treaties and agreements, bi-lateral, multilateral, concluded by sovereign countries in regard to the development and management of rivers and lakes, and/or of groundwater resources, which from an international boundary line or which are bisected by such boundary” (WATER TREATIES 2014). Each riparian country was searched in WATER TREATIES database for the 35 large transboundary lakes of interest in the specified time span, 1990 to 2013.

Some treaties regarding rivers were included in our dataset, if they included a transboundary lake of interest. For example, The Agreement between the Federal Republic of Germany, the Czech Republic, and the Republic of Poland on the protection of the Oder River from pollution was included. The Oder River discharges into the Szczecin Lagoon and the Szczecin Lagoon is mentioned in the Agreement, therefore the agreement governs the Szczecin Lagoon. International water treaties where the large transboundary lake was not mentioned or included in the watershed were not included in the dataset.

As stated above, in order for a treaty to be included in our dataset it must be an international water treaty between countries who directly border the same large transboundary lake. For example, the Agreement between the Government of Russian Federation and the Government of South Africa on Water Relations and Forest Management in 2007 was not included since Russia and South Africa are not riparian countries of a transboundary lake.

From the aforementioned databases, the following information was extracted for treaties between 1990 and 2013: treaty name, date signed, document type (adopted from

TFDD), basin name, region, primary country region, treaty basin, signatures (bilateral or multilateral), countries involved, geographical scope, institutional framework, primary focus (Table 3), strengths and weaknesses indicators (monitoring, information exchange, enforcement, and conflict resolution), and the source.

Additionally, information was collected on whether the treaty contained the following components: water quality and pollution, water quantity, allocation, invasive species, hydropower, irrigation, groundwater, local needs, construction right, construction ban, navigation, fishing, border issues, territorial issues, alternative scenarios, prediction model, joint management, technical assistance, information exchange, monitoring, conflict resolution, financial assistance, and enforcement. If a treaty contains one or more of these components, the article and/or the text was recorded.

Table 2: Primary focuses of international water treaties. Source: OSU

CODE	PRIMARY ISSUE	TFDD DEFINITION	ADDED DEFINITIONS
0	NA	NA	NA
1	Border Issues	Documents relating to rivers as shared borders/boundaries	Documents relating to the delimitation of the lake - present each riparian country owns of the lake.
2	Conservation	NA	Documents focused on the conservation of the ecosystem
3	Economic Development	General economic/regional development	NA
4	Fisheries	Documents relating to fishing	NA
5	Flood Control/Relief	Documents relating to flooding, flood control, flood damage, flood relief	NA
6	Groundwater	NA	Documents focused on the groundwater supply.
7	Hydropower	Documents relating to hydro-electricity or hydro-power facilities	NA
8	Infrastructure/Development	Documents relating to the infrastructure or development projects, including dams, barrages, draining of swamps for development purposes, canals.	NA
9	Invasive Species	NA	Documents focused on prevention of invasive species.
10	Irrigation	Documents relating to irrigation of agricultural areas	NA
11	Joint Management	Documents involving joint management of basin or water resources, especially where the management concerns cover a range of issue areas	NA
12	Navigation	Documents relating to navigation, shipping, ports	NA
13	Recreation	NA	Documents relating to access to water ways including access permits
14	Technical Cooperation/Assistance	Documents relating to technical or economic cooperation or assistance, including project evaluations or river surveys and funds for ranges of improvements to water-related technology/infrastructure	NA
15	Territorial Issues	Documents relating to territorial claims, where the territory is associated with a water body, e.g., a river island	NA
16	Water Quality	Documents relating to water quality or water-related environmental concerns	NA
17	Water Quantity	Documents relating to water quantity	NA

#### 6.4 Data Collection for International Water Conflicts

Conflict was defined as any form of hostility between riparian countries that was reported by one of the data sources for this study. The OSU Basins at Risk (BAR) scale and the conflict categories from the Pacific Institute were used to determine whether an event would be considered conflictive. The TFDD categorized water conflicts on a water event intensity scale; the BAR scale ranks water events from negative seven to positive seven (Yoffe *et al.* 2003). The negative events are considered conflictive events (Table 3). While conflicts were not placed into intensity categories based on the BAR scale, the descriptions of the negative event categories were used to determine whether a water event was conflictive. Conflicts, on an international scale, included formal declaration of war, military mobilization, damage to property, verbal treats showing hostility, deaths, and lawsuits.

Table 3: Oregon State University Water Intensity Scale: BAR Scale Source: Oregon State University

Oregon State University BAR SCALE	
BAR SCALE	EVENT DESCRIPTION
-7	Formal declaration of war
-6	Extensive water acts causing deaths, dislocation or high strategic cost: Use of nuclear weapons; full scale air, naval, or land battles; invasions of territory; occupation of territory; massive bombing of civilian areas; capturing of soldiers in battle; large scale bombing of military installations; chemical or biological warfare
-5	Small scale military acts: Limited air, sea, or border skirmishes; border police acts; annexing territory already occupied; seizing material of target country; imposing blockades; assassinating leaders of target country; material support of subversive activities against target country
-4	Political-military hostile actions: Inciting riots or rebellions (training or financial aid for rebellions); encouraging guerilla activities against target country; limited and sporadic terrorists actions; kidnapping or torturing foreign citizens or prisoners of war; giving sanctuary to terrorists; breaking diplomatic relations; attacking diplomats or embassies; expelling military advisors; executing alleged spies; nationalizing companies without compensation
-3	Diplomatic-economic hostile actions: increasing troop mobilization; boycotts; imposing economic sanctions; hindering movement on land, waterways, on in the air; embargoing goods; refusing mutual trade rights; closing borders and blocking free communication; manipulating trade or currency to cause economic problems; halting aid; granting sanctuary to oppositions leaders; mobilizing hostile demonstrations against target country; refusing visas to other nationals or restricting movement in country; expelling or arresting nationals or press; spying on foreign governments officials; terminating major agreements; unilateral construction of water projects against another country's protests; reducing flow of water to another country, abrogation of a water agreement
-2	Strong verbal expressions displaying hostility in interaction: Warning retaliation for acts; making threatening demands and accusations; condemning strongly specific actions or policies; denouncing leaders, systems, or ideology; postponing heads of state visits; refusing participation in meeting or summits; leveling strong propaganda attacks; denying support; blocking or vetoing policy or proposals in the UN or other international bodies
-1	Mild verbal expressions displaying discord in interaction: Low key objection to policies or behavior; communicating dissatisfaction through third party; failing to reach an agreement; refusing protest note; denying accusations; objecting to explanation of goals, position, etc.; requesting change in policy

International water conflict data were collected from 1990 to 2013. The first database used was the TFDD Event Database. The TFDD Event Database contains conflict and cooperative events over international freshwater resources from 1948 to 2008. The database has more than 6,400 historical events, the majority of which are cooperative. The Event Database was filtered for only conflictive events; meaning water

events with a negative BAR Scale were included. Next, conflictive events occurring before 1990 as well as conflictive events not regarding the large transboundary lakes of interest were eliminated.

The second database for transboundary conflicts used was The Pacific Institute Water Conflict Chronology. Conflicts in the Water Conflict Chronology includes intra-national and international conflict, therefore the database was filtered for international conflicts. Next, the database was filtered for conflicts that occurred between riparian countries of the large transboundary lakes of interest between 1990 and 2013.

The third source for international water conflicts was the online news source, OOSKANews. OOSKANews is a collection of water related news stories which started in May 2006 (OOSKANews 2014). OOSKANews produces five subscription-based newsletters weekly compiled from over 150 correspondents located in worldwide (OOSKANews 2014). The OOSKANews archive includes more than 20,000 water related news stories and is believed to be “the world’s most substantive archive of international water news” (OOSKANews 2014). A limited description on reported international water conflicts is available online, without the paid subscription. An online subscription was not obtained for this study, therefore only a minimal description was available for data collection.

OOSKANews was searched by lake name without “lake”, “lago” or “sea” due to the large amount of unrelated results when included. The water events that were determined to be conflictive by using the BAR Scale were compiled in a database. As with the Water Conflict Chronology and OSU Event Database, in order for a conflict to be included, it must be international between riparian countries, regarding one of the

large transboundary lakes. For example, a Malawian environmental group raised concerns over oil exploration in Lake Malawi is not included in this study, because it is not an international conflict between the riparian countries. The following data was recorded for each conflictive event from the databases: date, countries involved, lake, summary of event, non-violent or violent conflict, and primary focus of the conflict.

### *6.5 Contextual Data Collection*

Annual data was collected on political, economic, and environmental variables that have been previously shown to impact the likelihood of conflict (Brochman and Gleditsch 2012; Brochmann 2012; Zawahri and Mitchell 2011; Miquel et al. 2004; Bernauer et al. 2012; Hauge and Ellingsen 1998). Furthermore, the impact of international water treaties have on international water conflict was compared to the impact the contextual variables had on conflict, to determine which variables had the greatest impact on conflict. Contextual variables were needed to fully understand whether international water treaties have an effect on conflict. Annual data were collected from 1990 to 2013 for each riparian country of the of each transboundary lake for the following variables: population growth, GDP per capita, GINI index, political and stability, voice and accountability, total water per capita, precipitation, and external water dependence.



Table 4: The contextual variables included in this study. Components include the variable, rationale for using the variable, a description and definition of the variable, and the source of the data

VARIABLE	RATIONALE	DESCRIPTION	DATA SOURCE
Population Growth	The likelihood of conflict increases when an increase in freshwater scarcity is coupled with high population growth (Raleigh and Urdal 2007).	The exponential rate of growth of midyear population from year t-1 to t; expressed as a percentage.	World Bank
GDP per capita	The wealthier the country the less likely conflict will occur (Hauge and Ellingsen 1998; Brochmann and Gleditsch 2012; Raleigh and Urdal 2007)	Gross domestic product (GDP) divided by midyear population.	World Bank
GINI Index	Countries with high income inequality are more likely to experience conflict (Hauge and Ellingsen 1998)	Measures the extent to which the distribution of income or consumption expenditure amount individuals or households within an economy deviates from a perfectly equal distribution. Estimate in equivalized (square root scale) household disposable (post-tax, post-transfer) income, using Luxembourg Income Study data as the standard.	Standardized World Income Inequality Database
Political Stability and Absence of Violence	Countries with a consistent type of regime are less likely to experience conflict (Hauge and Ellingsen 1998)	Measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	World Governance Indicators
Democracy - Voice and Accountability	Countries with democracies are less likely to experience violent conflict and rebellion than autocracies (Hauge and Ellingsen 1998).	Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	World Governance Indicators
Total Water per capita	Water Stress - Falkenmark Index; as water scarcity increase the likelihood on conflict increase (Falkenmark).	The sum of internal renewable water resources and external actual renewable water resources leading to the actual amount of water available to each country.	AQUASTA Database
Precipitation	The higher the precipitation the higher the available freshwater leading to a decrease in the likelihood of conflict (Zawahri and Mitchell 2011)	Long-term average (over space and time) of annual endogenous precipitation (produced in the country) in depth.	AQUASTAT Database
External Water Dependence	The higher dependency on external water resources increases the chances for cooperation in the form of treaties (Zawahri and Mitchell 2011).	The part of the country's renewable water resources which is not generated in the country. This includes inflows from upstream countries (groundwater and surface water), and part of the water of border lakes and rivers.	AQUASTAT Database

## 7.0 Variable Descriptions

### 7.1 Environmental Variable Total Water per capita

There are a variety of indices created that attempt to measure water stress in a country. The Falkenmark indicator may be the most widely used measured of water stress (Brown and Matlock 2011). The units of water stress, as used by the Falkenmark's index, are cubic meters per person per year ( $\text{m}^3/\text{inhabitant}/\text{year}$ ). This index is typically used at a country scale where data is readily available (Brown and Matlock 2011), which makes it the ideal water stress index to use in this study. While the Falkenmark's index is widely accepted as an accurate measurement of water stress, there are some shortcomings. Using national annual averages leads to generalizations of water scarcity at small scales. Along with not accounting for spatial variability of water resources,

Falkenmark's index does not take into consideration technological or economic adaptability or water quality (Yoffe *et al.* 2003 and Brown and Matlock 2011).

Total water resources per capita, a measurement of water stress, was collected from the Aquastat. Aquastat is FAO's global water information system which was developed by the Land and Water Division and used for data collection of the environmental contextual variables. Total water resources per capita is defined as the "total annual actual renewable water resources per inhabitant" and is measured in cubic meters per inhabitant per year – the same units as Falkenmark's index. Total water per capita was reported in 1992, 1997, 2002, 2007, and 2012. The rationale for including a measurement of water stress is as water stress increases the likelihood of conflict increases (Brown and Matlock 2011).

Table 5: Amount of available water and corresponding level of water stress. According to Falkenmark 1,700 m<sup>3</sup> per person per year is when water stress occurs. Source: Brown 2011

Index (m <sup>3</sup> /person/year)	Level of Water Stress
>1,700	No Stress
1,000 – 1,700	Stress
500- 1,000	Scarcity
<500	Absolute Scarcity

## 7.2 Environmental Variable: External Water Dependence

External water dependence, collected from Aquastat is defined as "the part of the country's annual renewable water resources that are not generated in the country" (Aquastat 2014). This includes inflows from groundwater and surface water from upstream countries and part of the water of border lakes and rivers (Aquastat 2014).

External water dependence data was collected and reported for the following years 1992, 1997, 2002, 2007, and 2012. External water dependence was included, because the higher dependency on external water resources increases the chances of cooperation in the form of treaties in river basins (Zawahri and Mitchell 2010).

### *7.3 Environmental Variable: Precipitation*

Precipitation for this study was defined as the long-term average, over space and time, of annual endogenous precipitation produced in the country (Aquastat 2014).

Precipitation data was collected from Aquastat and recorded in depth, millimeters per year. Data for precipitation was collected from Aquastat every five years. Data was collected in 1992, 1997, 2002, 2007, and 2012.

The higher the precipitation in a country, the higher the available freshwater resulting in a decrease in the likelihood of conflict (Zawahri and Mitchell 2010). For example, higher rainfall makes civil conflicts less likely in Africa (Miquel *et al.* 2004). However, in a study completed in 2013, it was concluded warmer temperatures or more extreme rainfall events, defined as one standard deviations from normal, resulted in an increase of frequency of interpersonal violence by 4 percent and intergroup conflict by 14 percent (Hsiang *et al.* 2013). Interpersonal conflict consists of murder, assault, rape, and domestic violence, while an intergroup conflict could be an ethnic riot (Hsiang *et al.* 2013). Another study showed a similar pattern; the frequency of violent events in Uganda, Ethiopia, and Kenya increase in periods of extreme rainfall variations (Raleigh and Kniveton 2012). Increased rain events have the potential to increase or decrease conflict depending on the region of study and whether it is international, civil, or intergroup conflict.

#### *7.4 Economic Variable: Population Growth*

The World Bank's definition of population growth is the annual percentage is the "exponential rate of growth of midyear population from year  $t-1$  to  $t$ ", where  $t$  is equal to a year and is on a country level (World Bank 2014). Data was collected from the World Bank by country annually between 1990 and 2013. High population growth has been shown to increase conflict (Raleigh and Urdal 2001).

#### *7.5 Economic Variable: GDP per capita*

Gross domestic product (GDP) is the sum of gross value added by all residents producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (World Bank 2014). GDP per capita is GDP divided by the midyear population of the country. GDP per capita was collected annually between 1990 and 2013 from the World Bank and recorded in current US dollars. The rationale for including GDP per capita is the wealthier the country, the less likely conflict will occur (Hauge and Ellingsen 1998; Brochmann and Gleditsch 2012).

#### *7.6 Political Variable: Gini Coefficient*

The Gini index also known as the Gini coefficient's goal is to display inequality within a country. The Gini index provides information on the extent to which individuals/households within an economy deviate from a perfectly equal distribution of wealth. It is a measure of statistical dispersion intended to represent the income distribution of a nation's citizens. The scale can range from zero to 100. Zero indicates complete equality within the population, while 100 represents complete inequality. The index is calculated using a Lorenz curve, plotting the cumulative percentages of the total income received against the cumulative number of recipients (Figure 10). The Lorenz

curve starts with the poorest individual or household. The Gini index measures the area between the curve and a hypothetical line of absolute equality.

Data for the GINI index was collected from The Standardized World Income Inequality Database (SWIID). The SWIID was introduced in 2008 with the goal to “provide researchers with income inequality data that maximize comparability for the broadest possible sample of countries and years” (Solt 2009) Furthermore, it attempts to contain as much data on the Gini index as possible from 1960 to present for 174 countries. The Luxembourg Income Study is used as the basis for the SWIID. For the missing years, SWIID applies a custom missing-data algorithm to proximate missing annual data. The SWIID is the best suited database for cross-national research on income inequality when compared to other database sources (Solt 2014). Data was collected from the SWIID annually from 1990 to 2013. The GINI index was included because, countries with high income inequality are more likely to experience conflict (Hauge and Ellingsen

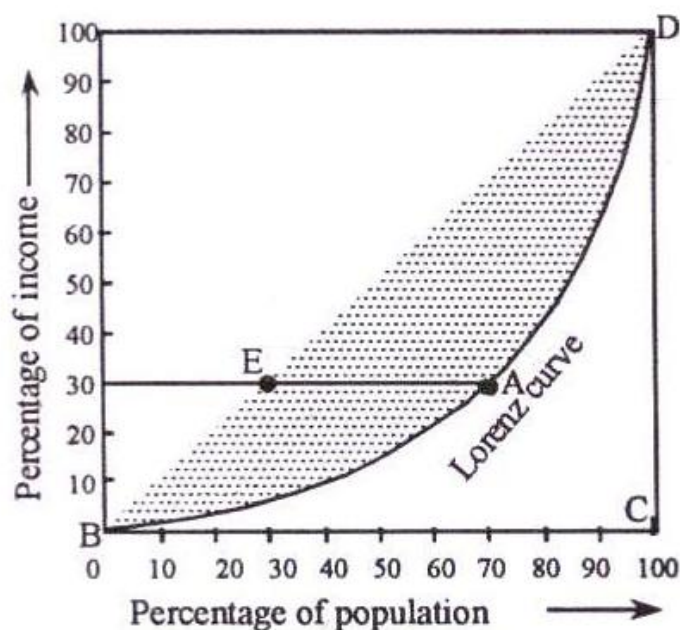


Figure 10: Example of a Lorenz curve. Source: Economic Concepts.

1998).

### *7.7 Political Variable: Political Stability and Absence of Violence*

The Worldwide Governance Indicators (WGI) examine six dimensions of governance for 215 countries from 1996 to 2013 using 32 data sources. The dimensions are voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. Four types of data sources were used to compile the WGI: surveys of households and firms (9 sources), commercial business information providers (4 sources), non-governmental organizations (11 sources), and public sector organizations (8 sources) (Kaufmann et al. 2011).

The political stability and absence of violence indicator measures perceptions of the likelihood that a country's government will be destabilized or overthrown by unconstitutional or violent means. Actions may include violent demonstrations, government stability, ethnic tensions, civil unrest, and terrorism. Data was collected annually starting in 1996, when WGI started. However, the following years had no data 1997, 1999, and 2001. Political stability was included as a indicator because countries containing a consistent type of regime are less likely to experience conflict (Hauge and Ellingsen 1998).

### *7.8 Political Variable: Voice and Accountability*

The voice and accountability indicators measures perceptions of the extent of a country's citizens are able to participate in selecting their governments. Additionally, this WGI measures freedom of expression, freedom of association, and a free media. As with political stability, data was not reported prior to 1996, in 1997, 1999, and 2001.

The rational for included voice and accountability is Mansfield et al. (2002), concluded that countries with democracies are more likely to cooperate with other

countries with democracies, than countries without democracies. Furthermore, Zawahri and Mitchell (2010) concluded, that when states with democracies participate in negotiation, there is an increase in trust between the two countries resulting in an increase in the willingness to fulfill contractual commitments.

## 8.0 Analysis:

After data on international water treaties, international water conflicts, and the contextual variables were collected for all 35 transboundary lakes from 1990 to 2013, various analyses were performed to determine if implementing an international water treaty has an impact on international water conflicts. Graphs were created to determine the relationship on an annual, regional, lake, and content basis. The following indicators were used to evaluate the overall strengths and weaknesses of large transboundary lake treaties: monitoring, enforcement, conflict resolution, and information exchange. These percentages of these indicators were then compared to previous data by Wolf (1998).

An event analysis in the form of a case study was completed for each large transboundary lake to further understand the relationship between the international water treaties implemented and international water conflicts between the riparian countries. Treaties and conflicts governing the transboundary lake of interest were further researched to determine the reason they occurred, the details of each, and the timeline between when conflict occurred and when a treaty was implemented. The case studies provided a comprehensive overview of each of the international water treaties and the international water conflict between 1990 and 2013.

Using the patterns observed in the case studies, conflicts were placed into three different categories. These categories were based on the content of the conflict as it

relates to a treaty implemented regarding a large transboundary lake. The first category includes international water conflicts that occurred prior to the implementation of an international water treaty. For example, conflicts between Egypt and Sudan regarding Lake Nasser occurred before an international water treaty was implemented during the time frame of this study.

The second category encompasses conflicts that occurred after the implementation of an international water treaty and are related to the content of the treaty. For example, in 2009 there was an international water conflict between the riparian countries of Lake Victoria with a primary focus of water quality. In 2003, the Protocol for Sustainable Development of Lake Victoria was implemented containing a “polluter pays principle” and water quality components; therefore the 2009 conflict regarding Lake Victoria was placed into the second category since the content of the conflict was related to the content of a treaty implemented prior.

The third category includes conflicts that occurred after the implementation of an international water treaty and are not related to the content of the treaty. For example, numerous international water conflicts occurred between Tanzania and Malawi regarding the border of Lake Malawi in 2012 and 2013. Between 1990 and 2013, no international water treaties were implemented regarding the border of Lake Malawi; therefore, the conflicts regarding border issues were placed in the third category.

One international water conflict was counted twice in this analysis. In 2012, Paraguay threatened to shut off energy supply produced by hydroelectric dams in Lake Itaipu and Lago de Yacyreta to neighboring counties. Since the international water treaty, Agreement of the Exchange of Notes on Creating a Security Zone Thousand Meters



Downstream and Upstream for the Entirety of the Yacyreta Hydroelectric Dam, was implemented in 2001, the conflict in 2012 was placed into the second category for Lago de Yacyreta, since it is related to the content of the treaty. However, this international water conflict is also regarding Lake Itaipu; since there was no international water treaty implemented prior to 2012 regarding hydroelectricity in Lake Itaipu this conflict was placed in the third category.

To understand the relationship between the contextual variables, water treaties, and water conflicts logistic regression was completed. Logit regression was the chosen method since it is an appropriate method when the dependent variable, the presence of conflicts annually, is binary. In this study the dependent variable is the presence of international water conflict between riparian countries, a binary variable. A “0” represents the absence of conflict and “1” represents the presence of conflict in a given year.

Logistic regression displays how closely the relationship between the dependent variable, presence of conflict, and the independent variables fits the non-linear relationship (Pollock 2012). Furthermore, logistic regression was chosen since the independent variables in this study are a mixture of continuous and categorical (Wuensch 2014). Overall, the goal was to determine how well the economic, political, and environmental variables predict the probability of international water conflict occurring.

Data was collected on a variety of contextual variables, including political, economic, and environmental variables all of which have been cited to have an impact on environmental conflict. The contextual variables, population growth, GDP per capita, GINI index, political stability, voice and accountability, total water per capita,

precipitation, and external water dependence were collected on a country level. To convert the country level data to represent a transboundary lake of interest, the riparian countries of a lake were average annually for each variable. For example, the population growth of Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan were averaged for 1990 to represent the population growth of the Caspian Sea in 1990.

Data imputation of incomplete datasets was necessary to run the logistic regression to understand the effect international water treaties have on international water conflict. It is important to note that when data imputation occurred, only data from the same large transboundary lake was used. The average population growth and the average GDP per capita were collected from the World Bank and contained full datasets; therefore, data imputation was not needed for average population growth or GDP per capita.

The average Gini index contained missing years. If a large transboundary lake was missing data for a particular year, the previous year was used. If there was not reported data for 1990, the value from 1991 was used. In general, if a large transboundary lake was missing day the year prior or after was used to complete the data set.

The indicators, political stability and voice and accountability had missing data prior to 1996 and in 1997, 1999, and 2001. For the following years: 1990, 1991, 1992, 1993, 1994, and 1995 the reported WGI in 1996 was used to complete the dataset. For 1997, 1999, and 2001, the mean of the year before and after was used to calculate the missing values. For example, the reported value of political stability in 1996 and 1998 were used to calculate the missing value in 1997 for political stability. It is important to note only values used were from the same transboundary lake.

Average water per capita, precipitation, and external water dependence were collected from Aquastat by country; Aquastat reports these variables every 5 years. The following years were missing data from the three environmental variables: 1990, 1991, 1993, 1994, 1995, 1996, 1998, 1999, 2001, 2003, 2004, 2005, 2006, 2008, 2009, 2010, 2011, and 2013. For 1990 and 1991, the reported value in 1992 was used. For the other missing years, a formula was created to impute data using a gradual change, increase or decrease depending on the change in reported value every 5 years for total water per capita. There was no variation between the reported values by Aquastat from external water dependence and precipitation; therefore, for the missing years of data the one reported value was used.

## 9.0 Case Studies

In order to understand the content of the international water treaties implemented between 1990 and 2013 and the international water conflicts, each were explored in depth. A case study on the international water treaties and international water conflict which occurred between the riparian countries was completed for each large transboundary lake.

### *9.1 Caspian Sea*

In 1992, a treaty was signed between the Republic of Kazakhstan and the Russian Federation concerning the protection of transboundary waters, including the Caspian Sea. It is unclear whether this treaty was in response to conflict before 1990 regarding the Caspian Sea, due to the limitation of this study - data was not collected before 1990.

An international water conflict occurred between the riparian countries of the Caspian Sea regarding oil extraction in 1997 (International Water Event Database). A variety of protest, fueled by disagreements on how to proceed with oil extraction since there were outstanding legal aspects of the Caspian Sea's development, took place in 1997. Azerbaijan wanted to divide the Caspian Sea into different national sectors, but this view point was not shared with other riparian countries. The varying opinions on how to proceed with oil extraction in the Caspian Sea led to tensions among the riparian countries (International Water Event Database).

In 1998, the Tashkent Declaration was signed by Central Asian States, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan. This international treaty focuses on the economic development of the Central Asian States. Furthermore, the signatures adopted a UN Special Program for the Economics of Central Asia (SPECA) (UNECE 2014). SPECA was created to support cooperation between countries and provide incentives for economic development. The international water conflict in 1997 over oil extraction and territorial issues in the Caspian Sea may have been a trigger for the development of the Tashkent Declaration including SPECA. Oil extraction from the Caspian Sea requires cooperation between riparian countries and further economic development.

In addition to the 1998 Tashkent Declaration, an agreement between Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan in the Sphere of Hydrometeorology was signed in 1999. The Parties agree to general cooperation including organization and exchange of information, prevention of dangerous natural phenomena, joint training and education of experts in the Sphere of Hydrometeorology (Tashkent 1998). Additionally, potentially in

response to oil extraction concerns, the Agreement incorporates transportation, allowing the transportation of fuel, food products, and instruments in and out of the region (Tashkent 1998).

In 2003, the Framework Convention for the Protection of the Marine Environment of the Caspian Sea, known as the Tehran Convention was signed by the five riparian countries, Azerbaijan, Iran, Kazakhstan, Russian, and Turkmenistan. The Tehran Convention, entered into force into 2006, aims to protect the Caspian Sea from all threats of pollution. Furthermore, the Tehran Convention's goal is to restore the Caspian Sea ecosystem for present and further generations (UNEP 2014). While the Tehran Convention attempts to reduce pollution in the Caspian Sea, water quality concerns still remain. The Tehran Convention outlines protocols needed to be adopted to achieve the most comprehensive protection against pollution. To date, three protocols have been adopted and implemented: "Aktau" Protocol on Regional Preparedness, Response and Cooperation in Combating Oil Pollution Incidents; the "Moscow" Protocol for the Protection of the Caspian Sea against Pollution from Land-based Sources and Activities; and the "Ashgabat" Protocol for the Conservation of Biological Diversity (UNEP 2014). These protocols have assisted in the reduction of future conflicts over water quality.

Two agreements were signed in 2010 regarding the Caspian Sea. First, the Agreement between the Government of the Russian Federation and the Government of the Republic of Azerbaijan on rational Management and Protection of the Water Resources of the Samur River was signed in 2010. This agreement determines the daily allocations of water in the Samur River, which affects the water quantity and water quality of the Caspian Sea since the Samur River directly flows into the Caspian Sea. The

second agreement signed in 2010 was the Agreement between the Government of the Russian Federation and the Government of the Republic of Kazakhstan on joint management of transboundary waters. This agreement between Russia and Kazakhstan deals with the water quantity by modifying the diversion amount and water quality by promoting data collection (Agreement between the Government of the Russian Federation and the Government of the Republic of Kazakhstan on Joint Management of Transboundary Waters 2010). There have not been any reported international water conflicts during 1990 to 2013 between Russia and Kazakhstan on water quality or pollution concerns, displaying the effectiveness of the treaty between Kazakhstan and Russia regarding water quality. Furthermore, a protocol from the Tehran Convention was adopted by Russia, once again showing the effectiveness of implemented international water treaties focused on the pressing concerns of the Caspian Sea.

There have been conflicts between the following riparian countries: Iran, Azerbaijan, and Russia regarding water quality. Between 2010 and 2013 three conflicts occurred with the primary focus of water quality especially pollution concerns (Ooskanews). For example, in 2010 Azerbaijan blamed Russia for being the biggest polluter of the Caspian Sea, while in 2010 Iran threatened to sue Azerbaijan for being the main source of pollution, particularly oil pollution (Ooskanews 2010; 2013). There are no individual treaties between Iran, Azerbaijan, and Russia (multilateral or bilateral) regarding transboundary waterbodies which may be a reason reported international water conflict occurs between Russia and Azerbaijan and Iran and Azerbaijan. Furthermore, the observed international water conflict following the international water treaty implementation, including the Tehran Convention, could be a result of a now legally

binding document between the riparian countries resulting in the empowerment of riparian countries to take action.

### *10.2 Lake Superior, Lake Ontario, Lake Erie and Lake Huron*

Lake Superior, Lake Ontario, Lake Huron, and Lake Erie experienced conflicts in 1999 and 2001 regarding water quantity. In 1999, water exports from the Great Lakes was a high profile issue after a United States Company sued the Canadian government for violating the North American Free Trade Agreement by preventing water exports (International Water Event Database). Furthermore, in 2001 the past president of North Shore Coalition, created in 1985 to represent thousands of Great Lakes residents affected by changing lake levels, called a 30.6 million dollar study on water levels in the Great Lakes “nothing but a five-year drain of taxpayers money” (International Freshwater Event Database).

Potentially in response to the conflicts regarding water quantity, an act to amend the International Boundary Waters Treaty was signed by the United States and Canada in 2002. The International Boundary Waters Treaty was originally signed on January 11, 1909 to address conflicts regarding transboundary waterbodies, specifically the Great Lakes, between the United States and Canada (Johansen 2002). The International Boundary Waters Treaty Act was created to increase implementation of the Treaty as well as increase clarification of Treaty elements (International Boundary Waters Treaty Act 2002). Additionally, the Act prohibits bulk removal of boundary waters from their basin of origin, requires licenses for water related projects impacting water quantity, and provides clear sanctions and penalties for violation (International Boundary Waters Treaty Act 2002). A recommendation to the International Joint Commission (IJC) is

made in the Act to study the effects of water consumption, diversion, and removal with a focus on the Great Lakes (Johansen 2002). The IJC recommended in their report, *Protection of the Waters of the Great Lakes*, to take action to protect the ecological integrity of the Great Lakes Basin. The conflicts in 1999 and 2001 regarding water quantity including bulk transfer of water in the Great Lakes may have sparked the Act in 2002 prohibiting the transfer of water from the basin of origin.

Even with the Act in 2002 to improve the International Boundary Waters Treaty of 1909, conflicts continued regarding water quantity in the Great Lakes. In 2004, the IJC voiced concerns over Waterloo's plans to divert water from Lake Huron to Lake Erie (International Water Event Database). In 2005, a verbal concern was expressed about the low water levels of the Great Lakes. The Great Lakes were recorded to be a foot less than average in 2005. The decrease in lake levels resulted from historical dredging to maintain the shipping channel in the St. Clair River. While this conflict is not directly related to diversions or bulk removal of Great Lakes it is a conflict over water quantity. It can be seen that the Act in 2002 did not eliminate all threats and conflicts to the water in the Great Lakes; further action was needed to prevent bulk diversions from the water in Lake Erie, Lake Ontario, Lake Superior, and Lake Huron.

As a result of continued conflicts about Great Lakes water transfer out of the basin, the Great Lakes Compact was implemented in 2008. The Great Lakes Compact is unique between the United States and Canada, because all eight Great Lake states and two Canadian provinces adopted the Compact with the exact same language, the United States Congress ratified the Compact, and the United States President signed the Compact into law. The Great Lakes Compact has three key components: in-basin uses,



conservation and efficiency, and diversions (Great Lakes Compact 2008). In accordance to the Great Lakes Compact, the eight Great Lake states and two Canadian provinces of the Great Lakes have the opportunity to comment on all large new or increased consumptive uses. Furthermore, the states and provinces are committed to uniform reporting on water use. In responses to the conflicts to bulk water removal, out of basin diversions, transferring water out of the Great Lakes watershed, is prohibited under the Great Lakes Compact (Great Lakes Compact 2008). The Great Lakes Compact was implemented as a result of past conflicts threatening the security of the Great Lakes' water quantity between the United States and Canada as well as other states. Conflicts in the Great Lakes region have resulted in comprehensive and enforceable treaties protecting the security of the Great Lakes' water and the Great Lakes ecosystem.

### *9.3 General African Treaties*

In 1995, two protocols on shared watercourses in the Southern African Development Community (SADC) were implemented; one protocol implemented in May 1995 and the other in August 1995. Both protocols are focused on the general framework for riparian interactions and general principles for management of shared watercourses systems. The Protocol in May 1995 promotes the creation of river basin management institutions, while the Protocol in August 1995 promotes the creation of river basin commissions. There is no mention of creating transboundary lake organizations or commissions. The two protocols govern the following lakes: Lake Victoria, Lake Tanganyika, Lake Malawi, Lake Kariba, Lake Mweru, Lake Cahora Bassa, and Lake Chilwa.

The Revised Protocol on Shared Water Courses in the Southern African Development Community was signed in 2000 by numerous African countries governs Lake Malawi, Lake Chilwa, Lake Victoria, Lake Tanganyika, Lake Cahora Bassa, Lake Mweru, and Lake Kariba. The Protocol was created recognizing that there are no regional conventions regulating utilization and management of resources of shared watercourses in the SADC (Revised Protocol on Shared Water Courses in the Southern African Development Community 2000). Parties should take all appropriate measures to prevent significant harm to other Parties, in regards to natural resources. Additionally, the Protocol promotes the establishment of shared watercourse agreements and promotes increased monitoring and harmonization of policies for planning, conserving, and allocating resources. Under the Protocol, Parties will exchange information, negotiate the possible impacts of planned measures, reduce and prevent pollution and environmental degradation, and obtain a discharge permit or license when needed (Revised Protocol on Shared Water Courses in the Southern African Development Community 2000). Furthermore, the 2000 Protocol created the Committee of Water Ministers who oversee and monitor the implementation of the Protocol, the Committee of Water Senior Officials who examine reports and documents, and Water Sector Coordinating unit who monitor, advise, organize, and manage.

In 2003, The African Convention of the Conservation of Nature and Natural Resources was signed by numerous African countries. The goals of the Convention are to enhance environmental protection, foster the conservation and sustainable use of natural resources, and to harmonize and coordinate policies in the field of natural resources (African Convention of the Conservation of Nature and Natural Resources

2003). In regards to water management the 2003 Convention states, “Parties shall manage their water resources so as to maintain them at the highest possible quantitative and qualitative levels” (African Convention of the Conservation of Nature and Natural Resources 2003). Additionally, Parties must take actions to ensure the protection of human health against pollutants and water-borne diseases. Similar to the 2000 SADC Protocol, Parties must “establish and implement policies for the planning, conservation, management, utilization and development of underground and surface water” (African Convention of the Conservation of Nature and Natural Resources 2003). Where surface water, groundwater, or related ecosystems (i.e. wetlands) are transboundary, Parties are encouraged to develop inter-State Commissions, to promote and ensure the rational management and utilization of natural resources. Furthermore, if a dispute arises the inter-State Commission will be tasked with conflict resolution and promote inter-state cooperative development, management, and conservation of transboundary resources. The African Convention of the Conservation of Nature and Natural Resources governs the following lakes: Lake Malawi, Lake Chilwa, Lake Victoria, Lake Tanganyika, Lake Cahora Bassa, Lake Mweru, Lake Kariba, Lake Turkana, Lake Nasser, Lake Kivu, Lake Edward, and Lake Chad.

#### *9.4 Lake Victoria*

The general trend of international water treaties and international water conflicts regarding Lake Victoria is the implementation of treaties during the 1990s and early 2000s and conflict from the mid-2000s to 2013. An increase in reporting in the riparian countries, Kenya, Tanzania, and Uganda may be one of the reasons for the increase in

conflicts seen since 2004. This includes the increase in available online resources from Ooskanews since 2006.

In addition to the general African international water treaties described above, the riparian countries of Lake Victoria implemented other treaties to govern this precious resource. In 1994, the Agreement to Initiate Program to Strengthen Regional Coordination in Management of Resources of Lake Victoria was signed by Uganda, Tanzania, and Kenya. The goal of the Agreement is to promote responsible management and general awareness of the pressing issues in Lake Victoria (1994). Each riparian country of Lake Victoria has a leadership role on a specific concern: Kenya's focus is on water quality and land use; Tanzania heads the Regional Policy Steering Committee; and Uganda leads efforts on fisheries management and control of water hyacinth as well as other invasive weeds (Agreement to Initiate Program to Strengthen Regional Coordination in Management of Resources of Lake Victoria was signed by Uganda, Tanzania, and Kenya 1994). Uganda is also the seat for the Lake Victoria Fisheries Organization created in 1994. The Lake Victoria Fisheries Organization addresses water quality concerns impacting fisheries. Additionally, the Organization promotes proper management, provides a forum for discussions, facilitates research, and evaluates the introduction of any non-indigenous aquatic animals or plants (Convention for the Establishment of the Lake Victoria Fisheries Organization 1994).

There have not been any recorded international conflicts over the fisheries in the Lake Victoria Basin since the creation of Lake Victoria Fisheries Organization. Invasive species, the water hyacinth, Nile perch and Nile tilapia, have been a concern of Lake Victoria for years; however, the Lake Victoria Fisheries Organization has promoted

management, facilitated research, and monitored the fisheries resulting in no reported international water conflicts since 1994. The Lake Victoria Fisheries Organization has been successful in its duties by decreasing the impact non-native species have on Lake Victoria.

In 1995, two SADC Protocols on shared watercourses were implemented as mentioned above. In 1999, a Treaty was signed by Kenya, Uganda, and Tanzania, for the Establishment of the East African Community (EAC). The EAC is a regional intergovernmental organization aimed at increasing cooperation among the partner states in political, social, and economic fields (African Union 2014). The Treaty promotes cooperation between riparian countries by intergovernmental organization in order to decrease conflict between the Parties.

In addition to The African Convention of Nature and Natural Resources signed in 2003, The Protocol for Sustainable Development of Lake Victoria Basin was signed by Uganda, Kenya, and Tanzania in 2003 in response to the Treaty for the Establishment of the East African Community in 1999. The riparian countries of Lake Victoria agreed to cooperation in areas related to the conservation and sustainable utilization of Lake Victoria (Protocol for Sustainable Development of Lake Victoria Basin 2003). The Protocol “recognizes that water is a finite and vulnerable resources essential to sustain life and the environment must be managed in an integrated and holistic manner, linking social and economic development with protection and conservation of natural ecosystems” (Protocol for Sustainable Development of Lake Victoria Basin 2003). Furthermore, the Protocol promotes the polluter pays principle where “the person that causes the pollution shall as far as possible bear any costs associated with it” (Protocol

for Sustainable Development of Lake Victoria Basin 2003). Riparian countries are responsible for implementing procedures on existing facilities or constructing new facilities to avoid, reduce, minimize, and control pollution from facilities. It is encouraged to take “necessary legal, social, and economic measures to ensure that a polluter pays as near as possible the cost of the pollution resulting from their activities” (Protocol for Sustainable Development of Lake Victoria Basin 2003).

While, the Protocol for Sustainable Development of Lake Victoria Basin of 2003 is centered on sustainability, it is comprised of a vast number of topics. For example, the Protocol mentions irrigation, water quality, alternative predictions, natural disasters, and technical support. However, the main weakness of the Protocol is the lack of enforcement mechanisms (Protocol for Sustainable Development of Lake Victoria Basin 2003). The Protocol created the Lake Victoria Basin Commission which promotes equitable growth, promotes measures aimed at eradicating poverty, promotes sustainable utilization and management of natural resources, and monitors and evaluates compliance with policies (Protocol for Sustainable Development of Lake Victoria Basin 2003). While all these are vital components of a treaty, enforcement mechanisms of the treaty are absent, potentially leading to conflicts focused on water quality between riparian countries of Lake Victoria. For example, in 2013 it was reported that 90 percent of industries around Lake Victoria do not comply with discharge standards (OOSKANews 2013c). Facilities surrounding Lake Victoria simply discharge directly in to the waterbody, resulting in countries to point fingers at each and vocal concerns to be raised; no one is willing to take responsibility for the excessive pollution in Lake Victoria. Even with the “polluters pay principle” in the 2003 Protocol for Lake Victoria, there is not an absence of reported

international water conflict focused on water quality. There are two reasons for the reported conflict; the first is the lack of enforcement of the Protocol leading to conflicts; the second is the riparian countries now have a legally binding document resulting in greater reporting of international water conflicts relating to water quality.

Uganda blamed the lack of data from each country on Lake Victoria, whether it is water quality or water quantity, as the major obstacle for effective basin wide management (Ooskanews 2010b). Monitoring is a component of the 2003 Protocol, however it is left to Kenya, Uganda, and Tanzania to “establish water quality and quantity monitoring and surveillance stations and water quality and quantity control laboratories” (Protocol for Sustainable Development of Lake Victoria Basin 2003). Leaving monitoring to the riparian countries may be successful, if once again there was enforcement mechanisms outlined in the treaty to require riparian countries to take such actions.

There is no treaty regarding Lake Victoria that is focused on the allocation of water or general water quantity. In 2011, Tanzania leaders accused Uganda of using excessive water from Lake Victoria (Ooskanews 2011). However, Tanzania changed its viewpoint in 2012, when Tanzania leaders wanted to push for an increase in water withdraw from Lake Victoria (Ooskanews 2012l). In order to avoid these water quantity conflicts, a treaty should be developed and implemented allocating the amount of water in Lake Victoria to each riparian country.

While it not clear whether the implementation of the treaties regarding Lake Victoria decreased conflict between the riparian countries, since there were no reported conflicts in the 1990s and no treaties past 2003 when the conflicts started, it can be

concluded that the components lacking from the treaties, enforcement and water allocation resulted in conflicts between riparian countries.

### *9.5 Lake Malawi*

Lake Malawi displays an interesting pattern for international water treaties and international water conflict. In the 1990s and early 2000s treaties, a variety of international water treaties were implemented. Then in 2012, a spike in conflict occurred with a recorded nine international water conflicts. Following similar trend, six reported international water conflicts occurred between the riparian countries, Malawi, Mozambique, and Tanzania of Lake Malawi. These conflicts focused primary on the border issues between Malawi and Tanzania. Besides verbal threats and protests, legal action was taken by Tanzania and Malawi, who both submitted their case to the SADC (Ooskanews 2013h and 2013j). An example of one of the border related conflicts occurred in July 2012 when Tanzania announced its plan to operate a tourist boat on Lake Malawi. Malawi believes Tanzania does not have a right to operate a boat on their property and therefore Malawi stated that Tanzania was not allowed to operate tourist boats (Meyer 2012).

Disagreements between Tanzania and Malawi have occurred since colonial times over the border of the lake. The lake boundary was publically disputed from May 1967 to September 1968, and then ceased even though no resolution of the border took place (Mayall 1973). Malawi claims the majority of the lake based on a colonial agreement between Britain and Germany, the 1890 Heligolnad Agreement. This agreement states that the border between Malawi and Tanzania lays on the Tanzania side of the lake; therefore, Malawi aligns its opinions with this treaty. Since the 1890 Heligolnad



Agreement was implemented when Malawi and Tanzania were not independent countries, there is question of legitimacy of the defined border of Tanzania and Malawi in Lake Malawi.

The international water border conflict between Malawi and Tanzania has been reignited by oil exploration and alleged encroachment of Tanzania fishing and tourist boats (Meyer 2012). As a result of the Heligoland Agreement, Malawi believes Tanzania does not have a right to operate tourist boats on Lake Malawi since they are the owners. Even with the high number of disputes between Tanzania and Malawi over Lake Malawi, President Jakaya Kikwere of Tanzania has stated war with Malawi is not a feasible option (Meyer 2012). Furthermore, Tanzania claims Lake Malawi belongs with all the riparian countries and it should be shared equally among them all.

Between 1990 and 2013 there have been no international water treaties focused on the delineation of Lake Malawi's border between Tanzania and Malawi. The four international water treaties which were implemented between 1990 and 2013 were general African treaties, which are described in an above section. Two Protocols on the Shared Watercourses in the SADC region were implemented in 1995. Furthermore, A Revised Protocol on Shared Water Courses in the SADC was implemented in 2000. Finally, The African Convention of the Conservation of Nature and Natural Resources was signed by numerous African countries in 2003. While these four general African treaties govern Lake Malawi, they do not contain articles defining the international borders in Lake Malawi. An international water treaty needs to be developed focused on the delineation of the border of Lake Malawi to decrease the reported conflict between Tanzania and Malawi.

### *9.6 Lake Tanganyika*

During the time period between 1990 and 2013 Lake Tanganyika experienced one international water conflict. This conflict occurred in 1998 at the end of a meeting of Zambia-Congo Joint Permanent Commission (International Water Event Database). Observations were made that there were no shared water agreements regarding Lake Tanganyika as well as Lake Mweru. Concerns were raised by members of the Zambia-Congo Joint Permanent Commission about the governance and sustainability of Lake Tanganyika (International Water Event Database).

Along with the four general African treaties implemented between 1990 and 2013, the riparian countries of Lake Tanganyika implemented international water treaties specific to the governance of Lake Tanganyika. In 2003, the Convention on the Sustainable Management of Lake Tanganyika was signed by the riparian countries, Burundi, Tanzania, Democratic Republic of Congo (DR Congo), and Zambia. The goal of the treaty is to “ensure the protection and conservation of the biological diversity and sustainable use of the natural resources of the lake and its basin on the basis of integrated and cooperative management” (Convention on the Sustainable Management of Lake Tanganyika 2003). The Convention encourages the development and implementation of harmonized laws and standards concerning the management of Lake Tanganyika. The treaty covers numerous areas regarding the joint management of Lake Tanganyika including, promoting sustainable fisheries management, prevention of pollution, prevention of sedimentation, navigation, and the conservation of biological diversity (Convention on the Sustainable Management of Lake Tanganyika 2003).

The four general African treaties encompass a vast amount of protocols on the natural resources in the Parties. While these treaties are important to consider when determining the effectiveness of international water treaties, when a lake specific treaty is present it should in theory dominate the governance of the lake regarding the treaty.

After the implementation of the Convention on the Sustainable Management of Lake Tanganyika in 2003, there have been no reported international water conflicts between the riparian countries. Additionally, after the Zambia-Congo Joint Permanent Commission expressed its concern with the lake of treaties regarding Lake Tanganyika, a treaty was implemented five years later regarding the sustainable use and management of Lake Tanganyika.

### *9.7 Aral Sea*

The Aral Sea has a variety of reported international water conflicts and international water treaties implemented between 1990 and 2013. The first international water conflict occurred in 1991. Komsomol activists mounted night raids along irrigation canals in border areas to combat water poaching by other nationality groups along the Uzbekistan and Kazakhstan border and the irrigation canals diverted water from the Aral Sea.

International water treaties were implemented in 1992, 1993, and 1995; the Agreement between the Republic of Kazakhstan, Republic of Kyrgyzstan, Republic of Uzbekistan, Republic of Tajikistan and Turkmenistan on Cooperation in the Area of Joint Management, Utilization, and Protection of Interstate Water Resources, Agreement on Joint Activities in Addressing the Aral Sea and the Zone around the Sea Crisis, and the Resolution of the Heads of States of Central Asia on work of the EC of ICAS on

Implementation of Action Plan on Improvement of Ecological Situation in the Aral Sea Basin respectively. These international water treaties were not able to be located in English; therefore, little information is known about the specific contents.

The Agreement on Joint Activities in addressing the Aral Sea and the Zone around the Sea Crisis was signed by Kazakhstan, Krygyzstan, Tajikistan, Turkmenistan, and Uzbekistan in 1993. The Agreement is focused on improving the environment, and ensuring the social and economic development of the Aral Sea region while taking into account the global character of the Aral Sea designation. The Agreement recognizes the extensive deterioration of the environment in the Aral Sea region. Furthermore, the Agreement promotes the rational use of the limited land and water resources, protects public health, and ensures water inflow to the Aral Sea. Inflow is required for sustaining the lower water levels which have been considered stable at the time of the Agreement. Through the Agreement, an Interstate Council was created and includes the riparian countries Kazakhstan and Uzbekistan and Russia as an observer in addressing the Aral Sea crisis. The Interstate Council provides the required financial and technical assistance in water treatment, which creates the domestic and drinking water supply system in the region, as well as fights against desertification.

In 1995, a Resolution of the Heads of States of Central Asia on work of the EC of ICAS on Implementation of Action Plan on Improvement of Ecological Situation in the Aral Sea Basin for the 3-5 years to come with consideration for social and economic development of the region was established. This Resolution's goal is to ensure efficient work of Commission for Social and Economic Development, Scientific, and Technical and Ecological cooperation and to take into consideration the information of the President

of the International Fund for the Aral Sea (IFAS). The Interstate Council of the Aral Sea (ICAS) promotes good neighborhood relations and mutual respect fundamental principles. Overall, ICAS wants cooperation among the riparian countries for the entire basin, including riparian countries of tributaries of the Aral Sea.

Following the implementation of the three treaties regarding the Aral Sea a dispute occurred in 1995. Turkmenistan President Niyazov informed his Kazakhstan and Uzbekistan counterparts, Nazarbayev and Karimov, by telephone that for objective reasons, he was not be able to visit Almaty for the session of the Commonwealth of Independent States (CIS) heads of state (International Water Event Database). The CIS session would be attended by all heads of state of Central Asia and representatives of the Russian Federation to discuss a variety of transboundary issues, including the Aral Sea. However, with the absence of Turkmenistan President Niyazov, it will be difficult to make decisions about the management of the Aral Sea.

In 1996, an Agreement between Uzbekistan and Turkmenistan on Water Management was implemented. This treaty focuses on all transboundary waterbodies between Turkmenistan and Uzbekistan (Agreement between Uzbekistan and Turkmenistan on Water Management 1996). Uzbekistan and Turkmenistan agree to prevent flooding and channel deformation, allocate part of their water resources to the Aral Sea, and implement measures on land reclamation.

In 1996 and 1998 international water treaties were implemented between Kazakhstan, Kyrgyzstan, and Uzbekistan on the management of water resources including use and energy resources; however, these treaties are only available in Russian resulting in a detailed analysis not feasible. Also implemented in 1998 was the

Agreement between the governments of the Republic of Kazakhstan, the Kyrgyzstan Republic, and the Republic of Uzbekistan on Joint and Complex Water Use and Energy Resources of the Naryn Syr Darya Cascade Reservoirs. This Agreement focuses on the irrigation schedule for all waters in the region, including those flowing into the Aral Sea. Energy allocations are given for the countries involved. Once again this treaty was only found in Russian.

Early in 1997, Uzbekistan threatened to cut the flow to Kazakhstan from the Aral Sea (Pacific Institute). In July 1997, Uzbekistan cut off 70 percent of flow downstream, threatening 100,000 hectares of farmland. Additionally, a Kazakhstan farmer rioted due to the decrease in available water diverted from the Aral Sea (International Water Event Database). Even though this reported transboundary conflict was focused on rivers in the region, the Aral Sea was impacted as a result of water cutoffs.

Another Agreement was signed in 1998, the Agreement between the government of the Republic of Kazakhstan, the government of the Kyrgyz Republic and the government of the Republic of Uzbekistan on Cooperation in the Area of Environment and Rational Nature Use. This agreement seeks to realistically estimate “potentialities of ecological dangers in the context of unfavorable natural climatic and hydrometeorological conditions” while also recognizing the essential need for protection and improvement of the Aral Sea degradation (Cooperation in the Area of Environment and Rational Nature Use 1998). Furthermore, the Agreement encourages Parties to develop cooperation regarding environmental protection and rational use of natural resources, focused on the Aral Sea. In order to achieve cooperation between riparian countries, the Agreement facilitates the development and implementation of joint

purpose-oriented programs and projects on environmental protection, soil conservation, pollution control as well as developing new environmental resource technologies which protect against degradation. Parties agree to perform joint research and exchange information, technologies, and specialists.

The Tashkent Declaration was signed in 1998 governing the Aral Sea. As stated above, the agreement focuses on economic development of the Central Asian States creating SPECA, intended to support cooperation between countries and provide incentives for economic development. The final international water treaty implemented in 1998 regarding the Aral Sea is the CIS Agreement on Rational Management and Protection of Transboundary Waterbodies. This Agreement focuses on the preventing of freshwater pollution, increasing purification for sewage, distributing adequate water supplies, and establishing a common water monitoring system. Furthermore, this Agreement between the riparian countries of the Aral Sea and other countries, agree to exchange information regarding water quality and water quantity of shared waterbodies including the Aral Sea.

The implementation of treaties continued in 1999, with three treaties were implemented governing the Aral Sea. First, the Agreement on the Status of the International Aral Sea Fund and its organizations was signed by Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. This Agreement established a variety of committees including Executive Committee, Interstate Coordination Water-economic Commission, and the Commission on Sustainable Development.

Additionally in 1999, the Protocol on Interesting Amendments and Addenda in the Agreement between the governments of the Republic of Kazakhstan, the Kyrgyz

Republic, and the Republic of Uzbekistan on the use of water and energy resources of the Syr Darya Basin was signed. The Protocol's goal is to establish an increase in cooperation regarding water and energy resources. Equal amounts of electric power generated on transboundary waterbodies shall be given to each country. The final international water treaty implemented in 1999, governing the Aral Sea is the Agreement between Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan in the Sphere of Hydrometeorology.

The Multilateral Agreement between Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan regarding the establishment of the Organization of Central Asian Cooperation was signed in 2002. The Parties agree to carry out coordinated and concerted actions in the sphere of rational and mutually advantageous management of waterbodies. The text of the treaty is in Russian resulting further analysis to be lacking.

Despite the numerous international water treaties implemented between 1998 and 2002, an international water conflict occurred in 2008 and 2009. In 2008, Kazakhstan and Uzbekistan raised concerns regarding the water use of the other country leading to a water-energy consortium between the two countries (OOSKAnews 2008). International water treaties implemented in 1998 and 1999 addressed use and allocation of water and energy between the riparian countries of the Aral Sea; however, these treaties appear they have not been completely successful in limiting international water conflict between riparian countries since concerns were raised regarding water and energy consortium.

In 2009, the continued decrease in water levels in the Aral Sea has led to an increase in tensions between Kazakhstan and Uzbekistan (OOSKAnews 2009a). It is no surprise a high number of international water treaties and international water conflict



since the Aral Sea is one of the best examples of poor natural resource management, where extreme loss of water has occurred from poor policies and agriculture needs. The international water treaties implemented regarding the Aral Sea have addressed pressing concerns including the inflow into the Aral Sea, water and energy allocation, and overall sustainable management. These focuses have potentially lead to a relatively small number of transboundary water conflicts occurring between Kazakhstan and Uzbekistan.

### *9.8 Lake Titicaca*

Lake Titicaca experienced no reported international water conflict between the riparian countries of Bolivia and Peru from 1990 to 2013. Only one international water treaty specific to Lake Titicaca implemented between 1990 and 2013. In 1993, Notes Reversals related to the Creation of the Autonomous Binational Authority of the Basins of Lake Titicaca, Desaguadera River, Lake Poopo, and Coispsasa Salt Pant System was signed by Bolivia and Peru (International Water Treaty Database). The treaty sets out to detail the responsibilities of the Binational Authority which oversees the development in the basin of the Titicaca-Poopo system. Some of these responsibilities include maintaining and developing the technical instrument and promoting, managing, and providing over-site on national and bi-national projects (Notas Reversals related to the Creation of the Autonomous Binational Authority 1993). Furthermore, the treaty has an element of conflict resolution and promotes joint management of Lake Titicaca between Bolivia and Peru (Notas Reversals related to the Creation of the Autonomous Binational Authority 1993).

The international water treaty of 1993 may be the main reason for no reported international water conflict since 1990 regarding Lake Titicaca, but there may be other

factors which play a more significant role such as governmental stability or location of the lake.

### *9.9 Lake Turkana*

The African Convention of the Conservation of Nature and Natural Resources is the only international water treaty, besides the three general international water treaties, implemented between 1990 and 2013 governing Lake Turkana.

Lake Turkana had one reported international water conflict 1990 and 2013 which occurred in 2012. A Kenyan environmental group, Friends of Lake Turkana, asked China not to provide the promised \$500 million USD loan to Ethiopia for Gibe III Hydroelectric dam (Ooskanews 2012a). The dam is under construction on the Omo River, which flows into Lake Turkana. It cannot be concluded that the controversial construction of this dam stems from the lack of treaty regarding Lake Turkana since the actual construction is on the Omo River, but Lake Turkana is impacted. Furthermore, the African Convention of the Conservation of Nature and Natural Resources does not address specific hydropower construction projects on rivers in Africa.

### *9.10 Lake Albert and Lake Edward*

Lake Albert and Lake Edward are located between Uganda and the DR of Congo. These two lakes have no treaties specific to the lake implemented between 1990 and 2013. The African Convention of the Conservation of Nature and Natural Resources in 2003 governs both of these lakes as well as the three general transboundary water treaties.

It is hypothesized, since there are no international water conflicts between Uganda and the DR of Congo, international water treaties specific to the lake have not

been developed. There is no sense of urgency between these Uganda and the DR of Congo to develop a legally binding treaty since there does not appear to be any conflicts.

### *9.11 Lake Nasser*

More international water conflicts occurred between Egypt and Sudan than the implementation of international water treaties between 1990 and 2013. In 1992, a border dispute occurred between Egypt and Sudan in the Hala'ib triangle (International Water Event Database). Sudan has stated it plans to build water projects both in the Nile River and Lake Nasser, west of the Hala'ib triangle. In 1995, another conflict occurred regarding the Hala'ib triangle. Sudan Interior Minister Brigadier General Khayr stated that any attack by Egyptian forces on the Sudanese police force in the Hala'ib triangle will be considered a clear violation of border agreements. Furthermore, if an attack takes place, Sudan has stated it will be free of its obligations to other agreements, including those regarding transboundary water bodies. Also in 1995, Sudan Secretary General of the National Islamic Front, Al-Turabi, threatened that Sudan would use water, potentially from Lake Nasser, as a weapon in its ongoing dispute with Egypt (International Water Event Database). While Lake Nasser could be used as a weapon in the conflict between Sudan and Egypt, the conflict regarding the Hala'ib triangle stem from more than concerns with Lake Nasser. This territory has been disputed for a number of years on who the legitimate owner is (International Water Event Database).

The African Convention of the Conservation of Nature and Natural Resources was implemented in 2003 and is the governing treaty of Lake Nasser between 1990 and 2013. As stated above, the goals of the Convention are to enhance environmental protection, foster the conservation and sustainable use of natural resources, and to

harmonize and coordinate policies in natural resources, including water (African Convention of the Conservation of Nature and Natural Resources 2003).

Even after the 2003 African Convention of the Conservation of Nature and Natural Resources, a conflict occurred in 2007 between Sudan and Egypt. Experts in Sudan and Egypt have raised concerns about the lack of a clear-cut plan to handle the extensive amount of Nile River water accumulating in Lake Nasser behind the Aswan High Dam (OOSKANews 2007a). There have been no implemented international water treaties relating to the water accumulation behind the Aswan High Dam. The lack of international water treaties governing Lake Turkana, specifically hydropower, has led to conflicts between Sudan and Egypt. Additionally, the disputed Hala'ib triangle between Egypt and Sudan has led to an increase in water from Lake Nasser to be used as a weapon. The conflict between Egypt and Sudan around the Hala'ib triangle needs to be addressed to decrease the likelihood of impacts to Lake Nasser.

#### *9.12 Lake Kariba and Lake Cahora Bassa*

In 2003, the Agreement on the Establishment of the Zambezi Watercourse Commission was signed by riparian countries of Lake Kariba and Lake Cahora Bassa; Zambia, Zimbabwe, and Mozambique. The agreement encompasses the entire Zambezi watershed including Lake Kariba and Lake Cahora Bassa (Agreement on the Establishment of the Zambezi Watercourse Commission 2003). The Zambezi Commission was created from the Agreement and is an international organization that collects, evaluates, and disseminates all data and information on the Zambezi watercourse (Agreement on the Establishment of the Zambezi Watercourse Commission 2003). ZAMCOM, as the Zambezi Watercourse Commission is known was also created to

advise Member States on measures necessary for dispute avoidance including in assisting in conflict resolution (Agreement on the Establishment of the Zambezi Watercourse Commission 2003). Furthermore, ZAMCOM promotes, supports, coordinates, and harmonizes the management and development of water resources within the Zambezi Watercourse, including Lake Kariba and Lake Cahora Bassa. Overall, ZAMCOM's goal is to assist the Member States in achieving regional cooperation and integration through sharing the Zambezi Watercourse. The Member States, including Zambia, Zimbabwe, and Mozambique, commit to "sustainable development, sustainable utilization, prevention of harm, precaution, inter-generational equality, cooperation, equitable and reasonable utilization (Agreement on the Establishment of the Zambezi Watercourse Commission 2003).

There are four general African treaties governing Lake Kariba and Lake Cahora Bassa: two protocols on shared watercourses in the Southern African Development Community in 1995, The Revised Protocol on Shared Water Courses in the Southern African Development Community in 2000, and The African Convention of the Conservation of Nature and Natural Resources in 2003.

Since the implementation of the Agreement on the Establishment of the Zambezi Watercourse Commission treaty there is no experienced conflict between 1990 and 2013. While ZAMCOM was an important component of the Agreement, there is not enforcement mechanisms outlined in the treaty. Nonetheless, Lake Kariba and Lake Cahora Bassa have not had any reported international water conflict between 1990 and 2013; therefore, international water conflict between the riparian countries of Lake Cahora Bassa and Lake Kiriba was the not the driver of the implementation of the

international water treaty. The Agreement may be one reason there is still an absence in conflict between riparian countries, Zambezi, Zimbabwe, and Mozambique after implementation.

#### *9.13 Lake Mweru*

A conflict occurred in 1998 at the end of a meeting of Zambia-Congo Joint Permanent Commission (International Water Event Database). Observations were made that there were no shared water agreements regarding Lake Mweru as well as Lake Tanganyika. Concerns were raised by members of the Zambia-Congo Joint Permanent Commission. Unlike the riparian countries of Lake Tanganyika implementing the Convention on the Sustainable Management of Lake Tanganyika in 2003, there has not been an international water treaty implemented regarding Lake Mweru concerns were raised about the lack of a shared water agreement. Despite the lack of treaty, no international water conflicts have occurred between Zambia and the DR of Congo regarding the management and sustainability of Lake Mweru.

#### *9.14 Lake Xingkai*

In 1997, the Agreement between the Government of the Russia Federation and the Government of the People's Republic of China on Guiding Principles of the Joint Economic Activity was signed by Russia and China. The primary focus of this agreement is economic development resulting in Russia and China agreeing on joint economic activity along the border. Overall, the agreement calls for coordination between both Parties relating to economic development within transboundary water regions. Even though the treaty focuses on economic cooperation in transboundary waters, the treaty does not specifically mention water quality, water quantity, monitoring, enforcement, or conflict resolution. Furthermore, there is no establishment of an institutional mechanism.

In 2008, the Agreement between the Government of the Russian Federation and the Government of People's Republic of China on Rational Management and Protection of Transboundary Waters was signed. Overall, Russia and China agree to prevent any negative transboundary effects due to the discharge of pollutants. This treaty specifically focuses on transboundary rivers, lakes, streams, and wetlands located. Furthermore, the Agreement established a joint commission where Russia and China agreed to exchange information and promote scientific research specifically related to transboundary water management (Agreement between the Government of the Russian Federation and the Government of People's Republic of China 2008).

The two international water treaties appear to be effective in governing Lake Xingkai since no international water conflicts were reported between Russia and China regarding Lake Xingkai between 1990 and 2013.

#### *9.15 Lake Merin*

Lake Merin had no reported international water conflicts occur between its riparian countries, Uruguay and Brazil between 1990 and 2013. In 1991, the Complementary Agreement to the Basic Scientific and Technical Cooperation Agreement between the Government of the Eastern Republic of Uruguay and the Federal Republic of Brazil on the Cooperation in the Area of Water Resources was signed. Uruguay and Brazil agreed to create mechanisms to facilitate joint development of mutual interests (International Water Treaties Database). While this treaty has no enforcement, no monitoring, and no conflict resolution it seems to have prevented water related conflict occurring between Uruguay and Brazil over Lake Merin since there have been no reported international water conflicts.

### *9.16 Lake Sargamysh*

In 1996, an Agreement between Uzbekistan and Turkmenistan on Water Management was implemented, focused on all transboundary waterbodies between Turkmenistan and Uzbekistan (Agreement between Uzbekistan and Turkmenistan on Water Management 1996). Uzbekistan and Turkmenistan, the riparian countries of Lake Sargamysh, agree to prevent flooding, prevent channel deformation, allocate part of their water resources to the Aral Sea, and implement measures on land reclamation.

In 1998, the Tashkent Declaration was signed by Central Asian States, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan (International Water Treaties Database). This international treaty focuses on the economic development of the Central Asian States governing Lake Sargamysh, the Aral Sea, and the Caspian Sea. SPECA was adopted with the intention to support the countries developing their cooperation and provide incentives for economic development (UNECE 2014). While Turkmenistan is not a Party of this treaty, it is still governs Lake Sargamysh because it provides support for Uzbekistan to develop cooperation efforts between bordering countries. In 1998, the CIS Agreement on Rational Management and Protection of Transboundary Waterbodies was signed governing Lake Sargamysh. The signatures of the treaty included Uzbekistan and Turkmenistan, who agree to cooperate to prevent freshwater pollution, exchange information, increase water quality by increase water purification, and establish basic principles for water management (CIS Agreement on Rational Management and Protection of Transboundary Waterbodies 1998).

No international water conflicts was reported between 1990 and 2013 regarding Lake Sargamysh. One reason for the lack of conflict may be the focus in the region being on the Aral Sea. As previously stated, the Aral Sea is an extreme example of



environmental degradation caused by humans; therefore, the attention in the region has potentially been on the Aral Sea for the last decades, shifting focus away from Lake Sargamysh. There is still the potential for the treaty implemented regarding Lake Sargamysh between 1990 and 2013 to be the main mechanism for no international water conflict.

#### *9.17 Lake Uvs*

Between 1990 and 2013, there are no international water treaties implemented specifically regarding Lake Uvs. Furthermore, there are no international water conflicts over Lake Uvs between 1990 and 2013 between Russia and Mongolia.

#### *9.18 Lake Peipsi*

Between 1990 and 2013 there were no international water treaties implemented specifically regarding Lake Peipsi. Additionally, there were no international water conflicts over Lake Peipsi between 1990 and 2013 between Estonia and Russia.

#### *9.19 Lake of the Woods*

An Act to amend the International Boundary Waters Treaty was signed by the United States and Canada in 2002. The International Boundary Waters Treaty was originally signed on January 11, 1909 to address all transboundary waterbodies between the United States and Canada. The International Boundary Waters Treaty Act was created to increase implementation of the Treaty as well as increase clarification of Treaty elements (International Boundary Waters Treaty Act 2002). The Act prohibits bulk removal of boundary waters from the basin which they are located in, requires obtaining licenses for water-related projects that will affect water quantity, and provides clear sanctions and penalties for violation (International Boundary Waters Treaty Act 2002).

Following the implementation of the Act in 2002, tensions rose between the United States and Canada regarding Lake of the Woods. Two incidents in 2005 focused on the transfer of water from Lake of the Woods to Fargo, North Dakota raised concerns in Canada (International Water Event Database). Fargo had a plan to construct a pipeline originating at Lake of the Woods. This pipeline was to be used in the event of a drought, which is predicted to occur within the next 25 years (International Water Event Database). Furthermore, Fargo claimed their population would double to more than 200,000 by 2050 as well as being a center for water-intensive food processing industries (Fallding and Rabson 2005). The pipeline from Lake of the Woods to Fargo has not been constructed, partly due from the recommendation of IJC.

Since no transport of water out of the Lake of the Woods basin occurred, it appears the International Boundary Waters Treaty Act in 2002 along with the original International Boundary Waters Treaty has been successful in preventing bulk water transfer. However, the Act did not eliminate concerns being raised and tensions high between United States and Canada regarding Lake of the Woods.

#### *9.20 Lake Kivu*

There was only one international water treaty implemented between 1990 and 2013 which governs Lake Kivu. The African Convention of the Conservation of Nature and Natural Resources was implemented in 2003. There were no reported international water conflicts between Rwanda and the Democratic Republic of Congo regarding Lake Kivu between 1990 and 2013.

#### *9.21 Lake Itaipu*

International water conflicts occurred between Brazil and Paraguay regarding Lake Itaipu in 1991 and 1993. Both of these conflicts focused on the hydroelectric dam,

Itaipu Dam. In 1991, the Brazil Integration Ministry said Brazil's opposed the Itaipu Hydroelectric Dam program for integrated electricity use (International Water Event Database). The hydroelectricity produced from the dam is used by Brazil and Paraguay based on a treaty signed by Brazil and Paraguay in 1973. While energy is being wasted in Brazil and Paraguay from an excess, Argentina and Uruguay are experiencing an energy shortage; but due to the treaty Argentina and Uruguay do not able to received hydroelectricity from the Itaipu dam. Differences in opinions between Paraguay and Brazil on the proper distribution of hydroelectricity from Itaipu Dam was the driver of this international water conflicts.

The River Transport Agreement of the Waterway Paraguay – Parana was signed into place in 1992. Lake Itaipu is located within the defined Paraguay – Parana waterway, comprised of over 3,000 kilometers of riverways. This treaty focuses on navigation and trade including promoting the development, modernization, and efficiency of navigation. The Agreement created the Intergovernmental Committee to promote the rational use of waterbodies for navigation. This treaty did not address the hydropower focus of the prior conflict in 1991.

Another international water conflict between Brazil and Paraguay occurred in 1993 again focused on hydropower. Paraguay Foreign Minister, Dr. Yaeshken brought up the possibility of renegotiating the Itaipu Treaty, which would include Paraguay relinquishing its bilateral agreement with Brazil on the Itaipu Dam (International Water Treaty Database). Paraguay would surrender its “unfair” compensation for surrendering energy, which may cause a negative impact on Brazil and surrounding countries (International Water Event Database).

Along with the conflicts in 1991 and 1993 on hydropower, two international water conflicts occurred in 2012 focused the sale of hydroelectric power from the Itaipu dam (OOSKANews 2012j). First, tensions increased between Brazil and Paraguay over the negotiation of hydropower produced from the Itaipu Dam. Second, in 2012 Paraguay stopped distributing energy supplies to neighboring countries which raised concerns from the neighboring countries. Paraguay stated, “We are no longer going to hand over our energy” (OOSKANews 2012i). The four conflicts which occurred regarding Lake Itaipu focused on hydroelectricity from the Itaipu Dam. There were no international water treaties implemented between Brazil and Paraguay regarding the distribution of hydroelectricity produced from the Itaipu Dam.

#### *9.22 Lake Buenos Aires and Lake O’Higgins*

In 1991, the Treaty on the Environment between the Republic of Chile and the Republic of Argentina was signed. Argentina and Chile agreed to coordinate on the protection and rational utilization of water resources. Detailed information from this treaty was not able to be obtained due to language limitations – the treaty was in Spanish. However, due to the generalness of this treat it main contribute to the lack of reported international water conflicts between Chile and Argentina regarding Lake Buenos Aires and Lake O’Higgins. There were no reported international water conflicts between Chile and Argentina regarding Lake Buenos Aires or Lake O’Higgins between 1990 and 2013.

#### *9.23 Lake Chad*

Two treaties were implemented between 1990 and 2013 regarding Lake Chad. In 1990, the Agreement between the Federal Republic of Nigeria and the Republic of Niger Concerning the Equitable Sharing in the Development, Conservation, and Use of their Common Resources was implemented. The goal of the Agreement is to foster sustained

cooperation in the development, conservation, and use of the shared resources. Niger and Nigeria will collect, process, and provide data and information to the Nigeria-Niger Joint Commission for cooperation needed to arrive at equitable sharing determinations for Lake Chad. Furthermore, the Agreement creates a Permanent Technical Committee of Water Experts composed of an equal number of representatives from Niger and Nigeria. This Committee of Water Experts is required to meet every four years and when needed. According to the Agreement, if a dispute occurs it will be referred to the Nigeria-Niger Joint Commission for Cooperation (Agreement between the Federal Republic of Nigeria and the Republic of Niger Concerning the Equitable Sharing in the Development, Conservation, and Use of their Common Resources 1990). If a dispute is not resolved within six months, it will then be referred to the Commission of Mediation, Conciliation, and Arbitration of the Organization of African Unity for resolution. The African Convention of the Conservation of Nature and Natural Resources was also implemented in 2003 governing Lake Chad.

There were no reported international water conflicts between 1990 and 2013 regarding Lake Chad between Niger, Nigeria, Chad, and Cameroon.

#### *9.24 Rainy Lake, Lake Champlain, and Lake St. Clair*

In 2000, the International Boundary Waters Treaty Act was signed by the United States and Canada. The Act prohibits bulk removal of boundary waters from their original basin, requires obtaining licenses for impactful water-related projects, and provides clear sanctions and penalties for violation (International Boundary Waters Treaty Act 2002). The Boundary Treaty Waters Act governs Rainy Lake, Lake Champlain, and Lake St. Clair as well as the Laurentian Great Lakes.

There were no reported international water conflicts that occurred between the United States and Canada regarding Rainy Lake, Lake Champlain, and Lake St. Clair between 1990 and 2013.

#### *9.25 Lago de Yacyreta*

International water treaties were implemented during the 1990s while international water conflict between the riparian countries of Lago de Yacyreta occurred in 2012 and 2013. The first international water treaty was implemented in 1992; the River Transport Agreement for the Waterway Paraguay – Parana was signed in 1992. Along with Lake Itaipu, Lago de Yacyreta is in the defined watershed. The Agreement focuses on navigation and trade including promoting the development, modernization, and efficiency of navigation.

The Agreement Constituting the Trilateral Commission for the Development of the Pilcomayo River Basin was signed by Argentina, Paraguay, and Bolivia in 1995. Through this Agreement the Trilateral Commission was established with the responsibility to study and execute joint projects between the riparian countries. Additionally, the Trilateral Commission promotes the rational exploration of natural resources, including the rational exploration of hydroelectric energy. Furthermore, the Trilateral Commission regulates the discharge of any hazardous material into the basins, including Lago de Yacyreta (Agreement Constituting the Trilateral Commission for the Development of the Pilcomayo River Basin 1995).

The Agreement on Conservation and Development of the Fishery Resources in the Border Stretches of the Parana and Paraguay Rivers authorizes Argentina and Paraguay was implemented in 1996. Furthermore, the Agreement defines fishing rights in

border regions and promotes the implementation of an action plan for the conservation of fishing, including the migration patterns of fishes. Between 1990 and 2013 there have been no reported international water conflict between Argentina and Paraguay with a focus of fishing.

Finally, in 2000 the Agreement of the Exchange of Notes on Created a Security Zone thousand meters Downstream and Upstream for the Entirety of the Yacyreta Hydroelectric Dam was implemented by Paraguay and Argentina. The majority of the treaties regarding Lago de Yacyreta are written in Spanish and English translations were not located; therefore, it is difficult determine if the components contained in the treaty are effective at preventing international water conflict.

Despite treaties on navigation, fishing, and hydropower two international water conflicts occurred between 1990 and 2013 regarding Lago de Yacyreta. The two conflicts were focused on hydropower occurring after the implementation of all international water treaties for the defined time frame. In 2012, Paraguay stopped supplying hydropower to the neighboring countries were sparked a variety of verbal concerns by Argentina and other neighboring countries (OOSKAnews 2012j). Additionally, in 2013 Paraguayans and Argentinians protested the Yacyreta Hydroelectric Dam by blocking the access to the dam (OOSKAnews 2013i). As stated above a treaty between Argentina and Paraguay was signed in 2000 regarding hydroelectricity; however, it appears this treaty has not been completely effective in the preventing conflict between Argentina and Paraguay focused on hydropower. There were no reported international water conflicts with the primary or secondary focus of fisheries, navigation, or water quality between 1990 and

2013. The lack of conflict on these topics may be due to the implementation of treaties regarding fisheries, navigation, and water quality.

#### *9.26 Lake Chilwa*

Four African treaties described earlier govern Lake Chilwa between 1990 and 2013. The Protocol on Shared Watercourses in the SADC region in May 1995, the Protocol on Shared Watercourses in the SADC region in August 1995, the Revised Protocol on Shared Watercourses in the SADC Region in 2000, and the African Convention on the Conservation of Nature and Natural Resources govern Lake Chilwa.

Even with the implementation of four treaties focused on transboundary waters, there was one reported international water conflict in 2012 regarding Lake Chilwa. Citizens of Malawi and Mozambique expressed concerns about Lake Chilwa becoming a dry lakebed from environmental degradation and climate change (OOSKANews 2012f). The four general African treaties are intended to promote sustainability and conservation while also decreasing environmental degradation. Due to the fact the riparian countries have not implemented an international water treaty specific to Lake Chilwa between 1990 and 2013, citizens are concerned with the sustainable future of this essential resource.

#### *9.27 Szczecin Lagoon*

Three international water treaties were implemented and there was one reported international water conflict between the riparian countries of Szczecin Lagoon between 1990 and 2013. International water treaties between Poland and Germany were implemented in 1992, 1996, and 1997 regarding Szczecin Lagoon. The Agreement between the Federal Republic of Germany and the Republic of Poland on Cooperation in the Field of Water Management at Border Waters was implemented in 1992. This Agreement focused on the joint management between Poland and Germany regarding



transboundary waterbodies, including Szczecin Lagoon. Through the Agreement, a permanent Commission on Boundary Waters was created, focused on the protection of surface water and groundwater quality and quantity (1992).

In 1996, the Agreement between the Federal Republic of Germany, the Czech Republic and the Republic of Poland on the Protection of the Oder River from Pollution was implemented. While this agreement has a main focus on the Oder River, the scope includes the protection of drainage areas, including Szczecin Lagoon, since the Oder River empties into the Szczecin Lagoon. Parties of the agreement created a commission to determine water quality measurements. The overall goal of the agreement is to prevent pollution into the Oder River and drainage area. Germany, Poland, and the Czech Republic are required to exchange information regarding the protection of the Oder River and Szczecin Lagoon, including protection of drinking water.

In 1997, the Convention on Environmental Impact Assessment in a Transboundary Context was implemented. Originally signed in 1991, various European countries are governed by this treaty, including Poland and Germany. The goal of the Convention is to “ensure environmentally sound and sustainable development” in transboundary areas (Convention on Environmental Impact Assessment in a Transboundary Context 1997). All Parties will, individually or jointly, take all appropriate measures to prevent, reduce, and control significant adverse transboundary impacts. The Convention does not prevent Parties from entering bilateral or multilateral treaties regarding transboundary issues. Furthermore, Parties will exchange information as well as analyzing and monitoring the efficient implementation of proposed activities. Appendix I of the Convention includes a list of 17 potential actions (crude oil refineries,

thermal power stations, waste disposal, large dam construction, major mining, and deforestation) which require an environmental impact statement, notification to parties of potential adverse impacts, and exchange of information (Convention on Environmental Impact Assessment in a Transboundary Context 1997). Furthermore, the Convention of 1997 states that if a dispute occurs between Parties about the interpretation or application of the Convention a solution should be reached by negotiation or by another method of dispute settlement (Convention on Environmental Impact Assessment in a Transboundary Context 1997). If the dispute is not resolved to the satisfaction of the Parties through negotiation, Parties may submit the dispute to the International Court of Justice.

Despite three specific treaties to Szczecin Lagoon in the 1900s, an international water conflict occurred in 2005 regarding the high levels of pollution the in Oder River and Szczecin Lagoon. Greenpeace activists from Poland, the Czech Republic, Slovakia, Austria, and Germany protested against the high levels of pollution in the Szczecin Lagoon and Oder River. The protests were staged at Brzeg Dolny near Wroclaw, Poland, where a chemical plant discharges its waste directly into the Oder River causing significant degradation of the Szczecin Lagoon (International Water Event Database). Recall, in 1996 a treaty was implemented for the protection against pollution to the Oder River and Szczecin. Since concerns were raised in 2005 about the level of pollution in these waterbodies, it does not appear the Treaty of 1996 has been successful in preventing concerns about water quality.

#### *9.28 Lake Zun-Torey*

Lake Zun-Torey had one international water treaty implemented between 1990 and 2013 and no reported international water conflict. The Agreement between the

Government of Mongolia and the Government of the Russia Federation on the Protection and Use of Transboundary Waters was signed in 1995. This Agreement defines transboundary waters as rivers, watercourses, lakes and other surface waters and groundwater intersected by the State frontier. The goal of the Agreement is to develop “good-neighborly relations and cooperation in the protection and rational utilization of transboundary waters”. Additionally, the treaty promotes the rational management and protection of transboundary water resources against pollution and building joint water monitoring programs. The Treaty incorporates information exchange and heavily promotes cooperation between riparian countries over transboundary waterbodies, which may be the reason for the lack of reported conflict between 1990 and 2013.

## 10.0 Results

### *10.1 Key Findings*

Between 1990 and 2013, 52 international water treaties governing large transboundary lakes were implemented. Joint management was the main primary focus of the international water treaties, 24 of 52. Asia had 19 international water treaties implemented between 1990 and 2013, making it the continent with the most international water treaties implemented. Only four percent of the 52 treaties governing large transboundary lakes included a mechanism of enforcement. Additionally, international water treaties lack information exchanging, monitoring, and conflict resolution mechanisms.

Between 1990 and 2013, 53 international water conflicts were reported regarding the 35 largest transboundary lakes. Most of these conflicts focused on water quantity and border delineation. There were no reported violent conflicts, instead the majority of reported conflicts were verbal threats and legal action between riparian countries. More

than half of the large transboundary lakes, 18 of the 35, experienced no reported transboundary conflict between 1990 and 2013. Of the 17 large transboundary lakes reporting conflict, six experienced no related conflicts to the implemented treaties.

The majority of the reported water conflicts, 28 of the 53, were not related to content of a treaty implemented prior to the occurrence of conflict. Africa had the most international water conflict between 1990 and 2013 with 30 reported transboundary water conflicts. Lake Malawi had the most reported transboundary conflict with 15 conflicts between Malawi and Tanzania.

### *10.2 Primary Focus and Secondary Focus*

The primary and secondary focuses are vital to understand the relationship between the contents of the treaty and of the conflict. It is important to note that not all international water treaties and conflicts had a secondary focus; some conflicts were specifically about water quantity, while others had elements of irrigation and water quantity. For example, in 1997 when Uzbekistan cut off 70 percent of flow the primary issues was water quantity, but the secondary issue was irrigation since 100,000 hectares of farmland were threatened.

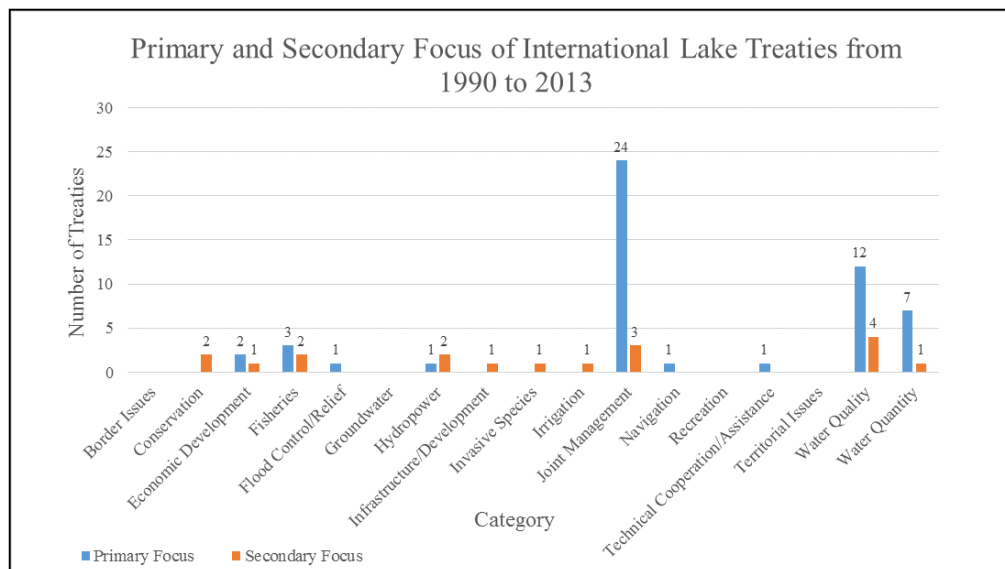


Figure 11: The primary and secondary focus of international water treaties from 1990 to 2013 governing large transboundary lakes.

The majority of international water treaties governing large transboundary lakes have a primary focus of joint management; 24 of the 52 treaties (46 percent) have a primary focus of joint management (Figure 11). Treaties with a primary focus of joint management were defined as “documents involving joint management of the basin or water resources, especially where the management concerns cover a range of issue areas” (International Water Event Database). The second and third highest primary focuses of international water treaties governing large transboundary lakes are water quality and water quantity. There are no international water treaties implemented between 1990 and 2013 with a primary or secondary focus of border issues, territorial issues, groundwater, or recreation (Figure 11).

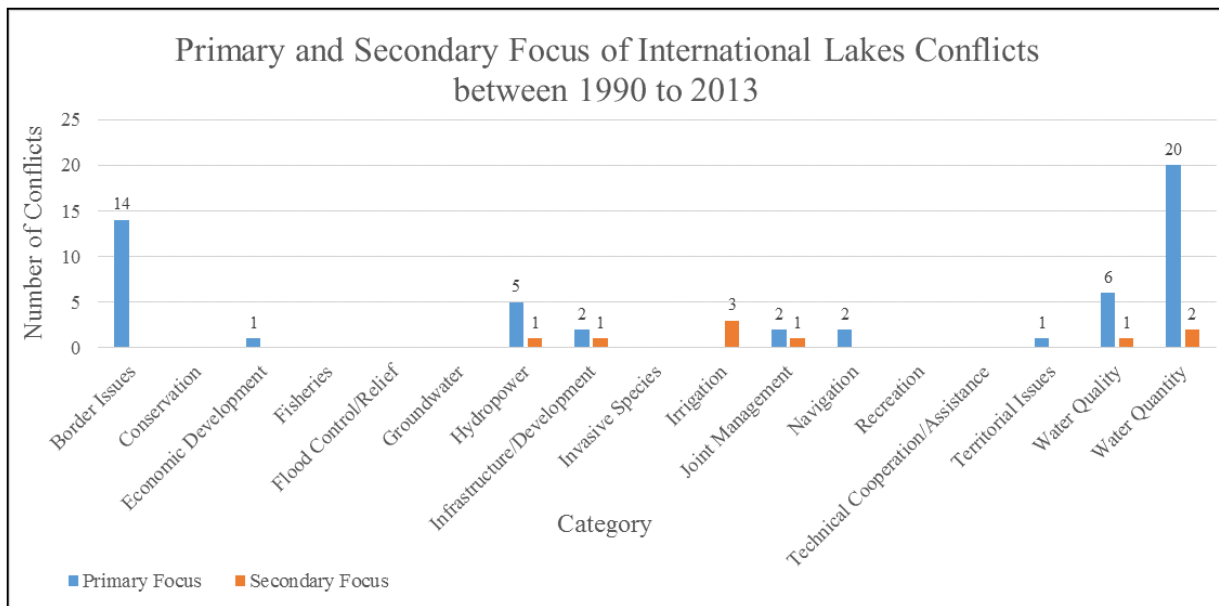


Figure 12: The primary and secondary focus of international water conflicts between 1990 and 2013.

Twenty of the 53 international water conflicts between 1990 and 2013 had a primary focus of water quantity (Figure 12). The second highest primary focus of international water conflicts was border issues with 14 of the 53 conflicts. These

conflicts occurred between Tanzania and Malawi regarding the border of Lake Malawi between 1990 and 2013. International water conflicts centered on water quantity were concentrated between the riparian countries of the Aral Sea and Lake Victoria. The riparian countries of Lake Victoria experienced conflict over the appropriate withdrawal amount by each riparian country from Lake Victoria. Irrigation was the dominant secondary focus for international water conflicts.

### *10.3 International Water Treaty and International Water Conflict*

Between 1990 and 2013 there were 52 international water treaties implemented. There were more international water treaties implemented regarding large transboundary lakes during the 1990s than during the 2000s (Figure 13). A total of 13 treaties were implemented during the 2000s, while 39 treaties were implemented during the 1990s. The two years that experienced the greatest number of international treaty implementation are 1992 and 1999 with six treaties.

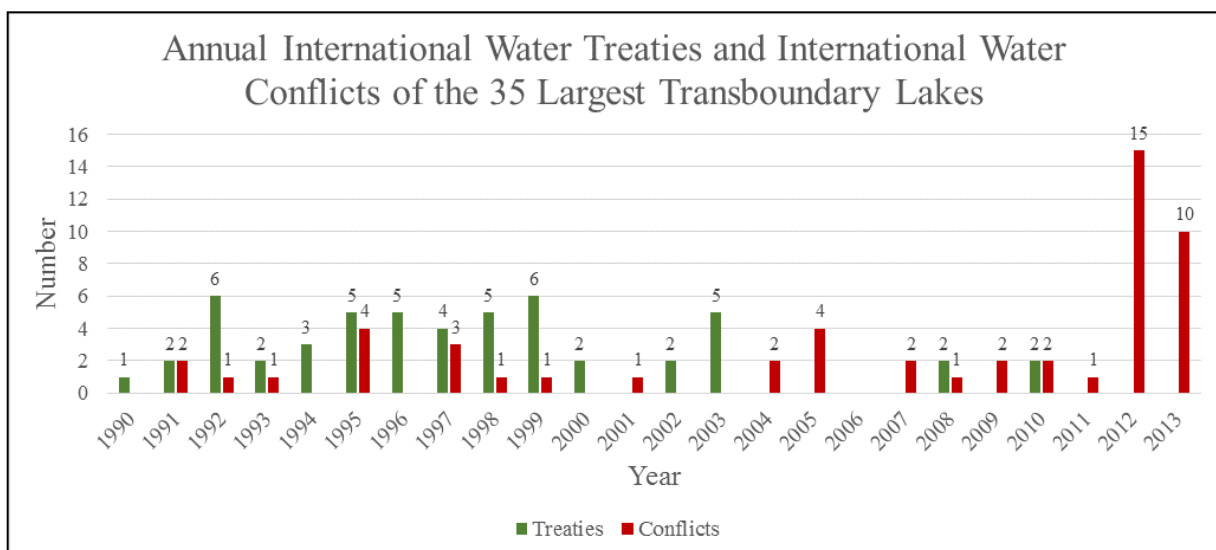


Figure 13: The number of international water conflicts that occurred and international water treaties implemented between 1990 and 2013 for large transboundary lakes.

Between 1990 and 2013 there were 53 reported international water conflicts. The number of international water conflicts is greater in the 2000s as compared to the 1990s (Figure 13). There were 13 reported conflicts regarding large transboundary lakes in the 1990s, while there were 40 reported international water conflicts in the 2000s.

Annually, more international water treaties were implemented than reported international water conflict between 1990 and 2003, except in 1991 and 2001. In 1991, there were two international water treaties implemented and two reported international water conflict, and one conflict reported in 2001. After 2003, the number of annual reported international water conflict is greater than the number of international water treaties, except in 2006 and 2010. In 2006, there were no reported treaties or conflicts, and in 2010 where there were two reported conflicts and two treaties implemented. There was not an observed decrease in international water conflict in the 2000s after the 39 international water treaties were implemented in the 1990s.

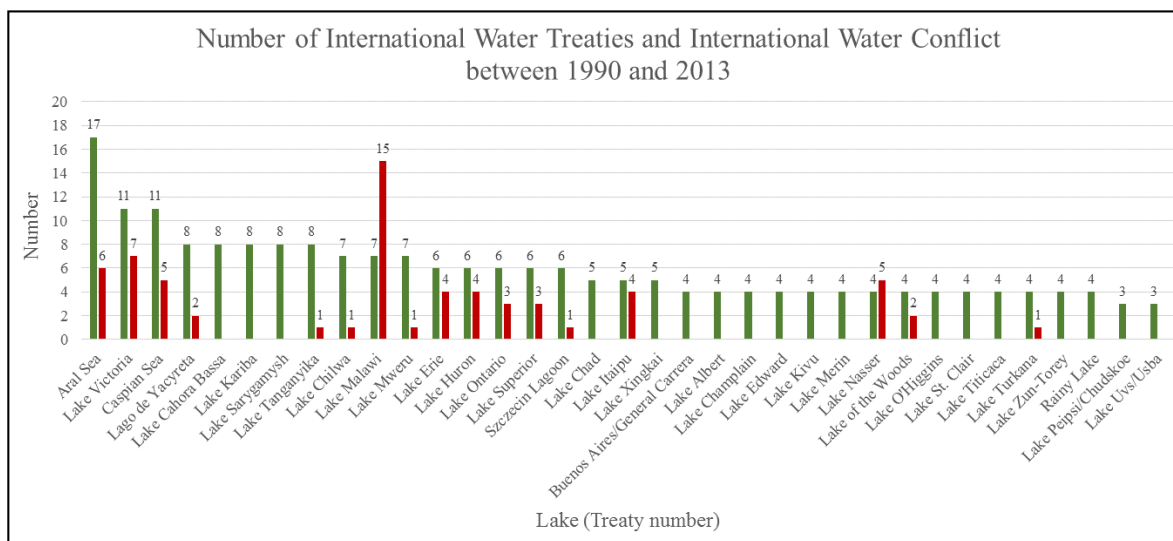


Figure 14: The number of international water treaties and international water conflict from the lake with the highest number of treaties to the lowest.

Between 1990 and 2013, the Aral Sea experienced the highest number of international water treaties implemented with 17 (Figure 14). The Caspian Sea and Lake

Victoria each had 11 treaties implemented between 1990 and 2013 (Figure 14). Two lakes, Lake Uvs between Mongolia and Russia, and Lake Peipsi between Russia and Estonia, had no international water treaties implemented between 1990 and 2013 specifically regarding the lake. These lakes are governed by three international water treaties which govern all large transboundary lakes. One international water treaty in 1992 and two in 1999 were implemented which govern all transboundary waterbodies, including large transboundary lakes. The Convention on the Protection and Use of Transboundary Watercourses and International Lakes was implemented in 1992. The Agreement on Transboundary Cooperation and the UN Protocol on Water and Health of the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes were implemented in 1999. These treaties are not specific to one large transboundary lake rather they govern general transboundary waters.

The following large transboundary lakes experienced no reported international water conflict between 1990 and 2013: Lake Titicaca, Lake Albert, Lake Kariba, Lake Cahora Bassa, Lake Xingkai, Lake Merin, Lake Sarygamysh, Lake Uvs, Lake Peipsi, Lake Kivu, Lake Edward, Lake Buenos Aires, Lake Chad, Lake St. Clair, Lake Champlain, Lake O'Higgins, and Rainy Lake (Figure 14). Lake Malawi had the most reported international water conflict between 1990 and 2013, having 15 international water conflicts reported in 2012 and 2013. Lake Victoria had seven international water conflicts between 1990 and 2013, focused on water quality and water quantity.

Lakes displaying a relatively high number of international water treaties do not indicate a low number of reported international water conflict between riparian countries. For example, 11 international water treaties were implemented between 1990 and 2013



governing Lake Victoria, but Lake Victoria still experienced seven international water conflicts. On the other hand, Lago de Yacyreta had eight international water treaties implemented between 1990 and 2013, and Lago de Yactreta only experienced two international water conflicts. Only two large transboundary lakes experienced more international water conflict between 1990 and 2013 than implementation of international water treaties: Lake Malawi and Lake Nasser.

As shown with examples above, there is no apparent pattern between the number of international treaties and the number of international water conflicts that occur between 1990 and 2013 on a lake basis. While the number of international water treaties decreases by lake, the number of international water conflicts does not increase. There is potential for external variables, economic, political, and environment to impact the amount of international water conflict that occurs between the riparian countries of large transboundary lakes.

The dominant primary focus of the international water treaties implemented between 1990 and 2013 was joint management; 24 of the 52 international water treaties had a primary focus of joint management (Figure 15). There were only two-reported international water conflicts with the primary focus of joint management. Water quantity was the focus of the majority of transboundary water conflicts (Figure 15). Between 1990 and 2013, 14 international water conflicts were reported between Tanzania and Malawi with the primary focus of border issues. There were no international water treaties focused on border delineation of large transboundary lakes implemented between 1990 and 2013. Twenty international water conflicts occurred between 1990 and 2013 focused on water quantity, while seven international water treaties were implemented.

Water quantity encompasses two main categories: first, is the volume of water that is present in the lake; and second is the amount of water each riparian country is allowed to use or withdraw from the lake.

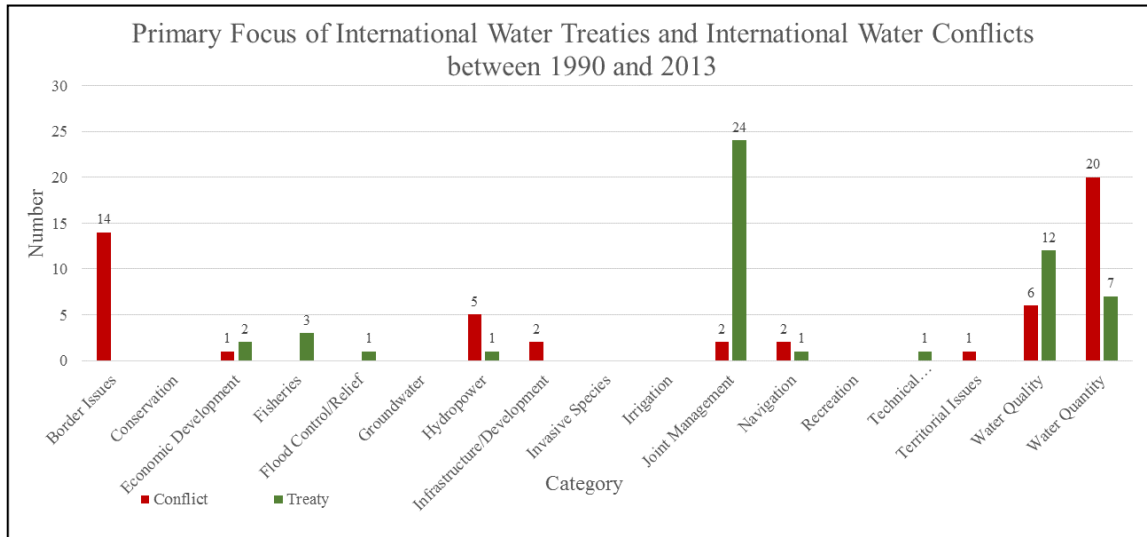


Figure 15: A comparison of primary focus of international water treaties and international water conflict between 1990 and 2013.

#### 10.4 Regional Results

Africa experienced the most transboundary lake conflict and Asia had the most international water treaties implemented between 1990 and 2013 (Figure 16). Asia experienced the highest number of international water treaties; 19 treaties were implemented in Asia between 1990 and 2013. The high number of international water treaties implemented in Asia was primary due to the high number of treaties implemented regarding the Aral Sea. Africa and the United States had more reported international water conflict than international water treaties implemented between 1990 and 2013. Africa experienced the most international water conflicts between 1990 and 2013 with 30 reported international water conflicts. Africa has had the second most international water treaties implemented between 1990 and 2013 with 11. North America, United States and

Canada, had three international water treaties implemented between 1990 and 2013, but six reported international water conflicts; these conflicts were mainly focused on the bulk transfer of water out of the basin of origin.

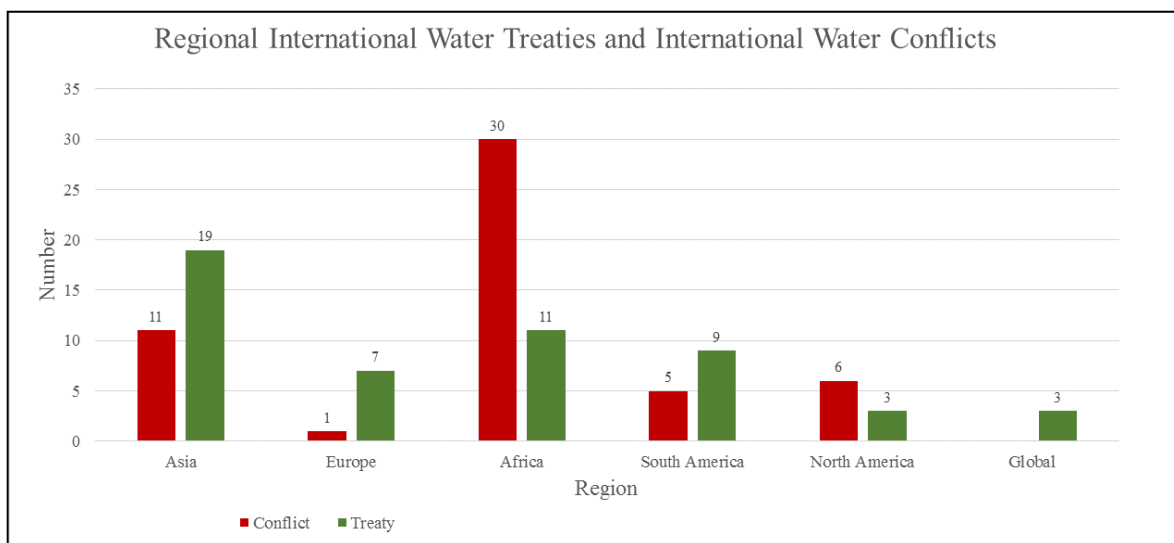


Figure 16: Number of international water treaties and number of international water conflicts by continent for large transboundary lakes between 1990 and 2013.

### *10.5 Strengths and Weaknesses of International Water Treaties*

The following four components were used to evaluate the strengths and weaknesses of the international water treaties governing large transboundary lakes: information exchange, monitoring, conflict resolution, and enforcement (Wolf 1998). Over half, 53 percent of the large lake treaties between 1990 and 2013 include information exchange (Figure 17). Less than half, 46 percent of the treaties included monitoring. This monitoring includes extent of pollution, status construction projects, and allocation amounts.

There were less international water treaties that contained an element of conflict resolution; only 38 percent mentioned a mechanism to resolve disputes when they arise. These mechanisms ranged from Parties given the responsibility to resolve the dispute

themselves to taking the dispute to international court to a third party acting as a mediator or negotiator. Less than four percent of the 52 international water treaties governing large transboundary have a mechanism of enforcement.

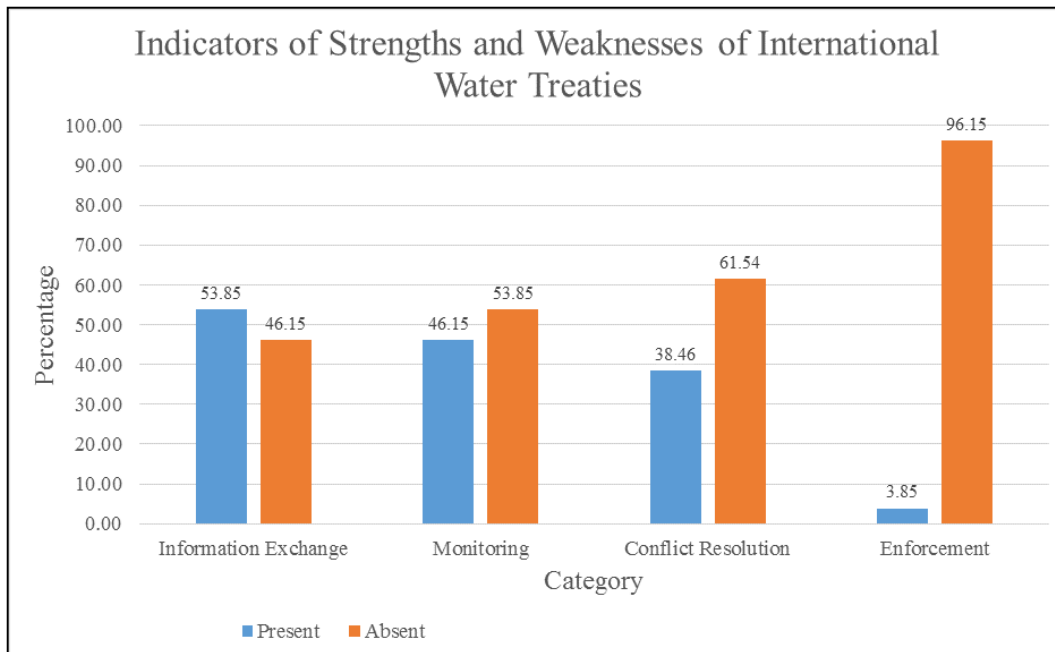


Figure 17: Various strengths and weaknesses of international water treaties implemented between 1990 and 2013 regarding the 35 largest transboundary lakes.

The TFDD project compiled 145 international water treaties from 1870 until 2000. While there is treaty overlap between the TFDD and this study, new information is presented in this study including incorporating data focused on transboundary lakes and data collected until 2013. The observed pattern of the strengths and weaknesses indicators with is similar between this study and the TFDD project. Over half, 54 percent, of the treaties contained a mechanism of monitoring, while 54 percent of the treaties did not include an element of conflict resolution (Wolf 1998). While 116 of the 145 treaties contained no enforcement mechanism, over half of the treaties had an element of information exchange (Wolf 1998). The percentages of the 145 treaties compiled by

TFDD containing the various indicators are comparable with this study focused on large transboundary lakes. Overall, treaties lacked information exchange, monitoring, conflict resolution, and enforcement in both studies.

### *10.6 Conflict Categories*

The majority of the reported international water conflicts between 1990 and 2013 regarding large transboundary lakes were not related to the content of the treaty. Almost 53 percent of the international water conflicts fell into the third category (Figure 18). Over 33 percent of international water conflicts between 1990 and 2013 that were related to the content of an international water treaty implemented in a prior year. Only 15 percent of the reported international water conflicts occurred before the implementation of a treaty. When the international water conflicts that occurred before the implementation of a treaty in this study are removed, almost 61 percent of the conflicts are unrelated to the content of the treaty implemented in a prior year

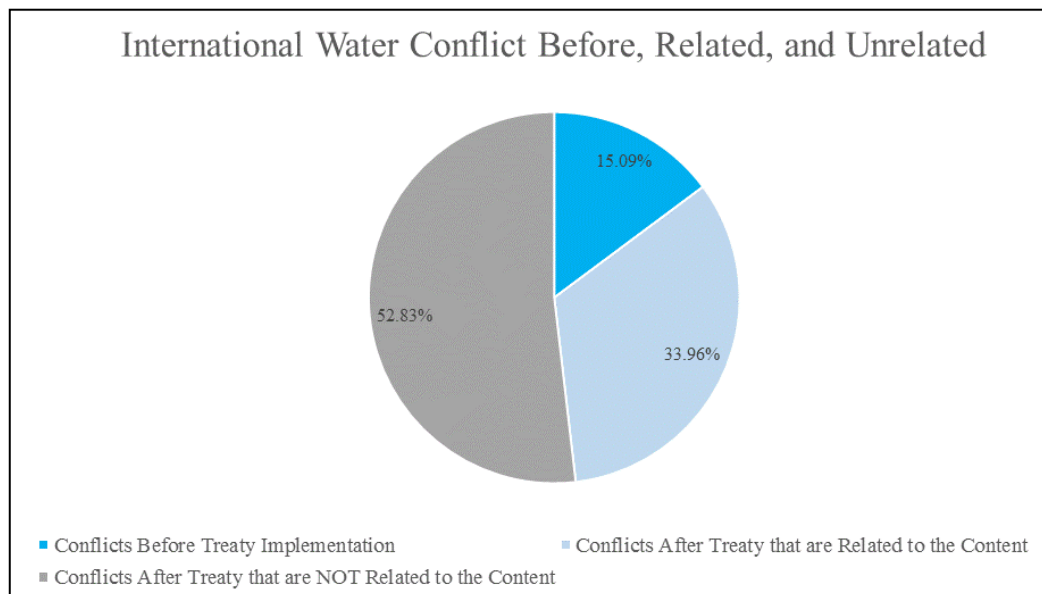


Figure 18: Percentage of international water conflicts that occurred before an international water treaty was implemented, occurred after a treaty and are related to the content of the treaty, or occurred after a treaty and are NOT related to the treaty.

After 1998, no large transboundary lakes that experienced transboundary conflict without the presence of an international water treaty implemented prior to the occurrence of the conflict in the time frame of the study. Recall that there were more international water treaties implemented in the 1990s than the 2000s; resulting in the majority of large transboundary lakes of interest being governed by an international water treaty.

Next, conflicts which were not related to the content of the treaty implemented prior were removed. Of the 17 large transboundary lakes that had reported international water conflict, six lakes had no reported international water conflict that was related to the content of a treaty implemented between 1990 and 2013 (Appendix 1). This results in 24 of the 35 large transboundary lakes having no reported conflict related to the content of a treaty. The following six lakes experienced conflict that was not related to the content of the treaty implemented prior: Lake Tanganyika, Lake Malawi, Lake Turkana, Lake Nasser, Lake Mweru, and Lake Itaipu. Almost 65 percent, 11 of the 17 large transboundary lakes with reported conflict, experienced conflict related to the content of a prior implemented international treaty (Appendix 1). The following 11 lakes experienced conflict related to a treaty implemented prior: Caspian Sea, Lake Superior, Lake Victoria, Lake Huron, Lake Erie, Aral Sea, Lake Ontario, Lake of the Woods, Lago de Yacyreta, Lake Chilwa, and Szczecin Lagoon.

### *10.7 Logistic Regression*

A logistic regression was completed with the data collected on the presence of conflict, the presence of a treaty, as well as economic, political, and environmental variables. After data imputation was completed, there were a total of 840 observations for each variable, resulting in a full dataset. The likelihood ratio (LR) chi-square test is 21.43

meaning that the null hypothesis is rejected since the model at the 95 percent significance level, 21.34 is greater than 16.92, the critical value at nine degrees of freedom.

Furthermore, the probability of obtaining the chi-square statistic given that the null hypothesis is true is 0.0109, resulting in the rejection of the null hypothesis, of the contextual variables and the presence of a water treaty having no effect on the occurrence of international water conflict between riparian countries of large transboundary lakes.

The following contextual variables displayed a p-value from the two-tailed z-test that is less or close to 0.05: average population growth, average GINI index, average precipitation, and average external water dependence. However, further analysis of the calculated odds ratios explained how each variable assists in the prediction of the occurrence of an international water conflict.

The p-value for average population growth is 0.067 resulting in the average population growth of all riparian countries to be almost significant at the 95 percent confidence interval. The odds ratio of average population growth is 1.581 meaning that with every one unit change in population growth the chance conflict will occur is 58.1 percent. A one percent increase in population growth increases the chances of conflict occurring between the riparian countries of large transboundary lakes by almost 60 percent.

The p-value for average GINI index is 0.055 resulting in the GINI coefficient being a significant independent variable to predict international water conflict. The odds ratio for the GINI index is 0.927 meaning that with every unit increase in the GINI index there is a 7.3% decrease in the chance of transboundary conflict to occur. In other words as the level of inequality increases in the riparian countries of a large transboundary lake

there is less of a chance for international water conflict to occur. This is opposite to prior studies, which concluded the greater level of inequality in a country the more likely they are to experience conflict (Hauge and Ellingsen 1998). One would predict as the GINI Index increases and the amount of inequality in a country increases the chance of conflict would increase.

Average external water dependence has a p-value of 0.016 resulting in external water dependence being a significant predictor of conflict at the 95 percent confidence interval. However, the odds ratio of external water dependence is 0.999. An odds ratio of one means that the odds do not change of international water conflict occurring as the external water dependence increases (Pollock 2014). As a riparian country's dependence on other countries increases the chance of an international water conflict does not change. Previous studies have shown that the higher dependency a country has on external water resources the changes for cooperation in the form of treaties increases (Zawahri and Mitchell 2011). The results of this study suggest that the amount of external water dependence of the riparian countries of a large transboundary lake does not increase or decrease the chance of conflict between those riparian countries.

While the p-value of average precipitation of 0.098 is not significant at the 95 percent confidence interval, the odds ratio displays a similar pattern to the average external water dependence. As the average precipitation increases there is no change in the odds of international water conflict occurring.

At least one environmental, political, and economic variable resulted in a significant impact on the predication of international water conflict. Despite the presence of a treaty having odds ratio of 1.224 meaning that when an international water treaty is



present there is a 22.4 percent chance of an international water conflict occurring, the p-value was well above 0.05 resulting in the presence of international water treaties not being significant. Future studies should take into account a time lag variable to further understand this relationship.

## 12.0 Discussion

Addressing a large gap in current research, this study explored the relationship between treaties and conflict focused on large transboundary lakes, by researching the 35 largest transboundary lakes by surface area and volume. Between 1990 and 2013, 52 international water treaties were implemented and 53 international water conflicts occurred between the riparian countries of the 35 largest transboundary lakes. External factors such as location, political regime, population, and environmental variables play a role in determining whether riparian countries will experience transboundary conflict regarding a large lake.

A simple relationship, where conflict decreased after a treaty was implemented was not observed in this study. An increase in water conflicts was observed in the 2000's. One reason for the observed increase in conflicts is an increase in reporting by various organizations. While, OOSKAnews, one of the main data sources for conflict, is considered one of the most comprehensive databases of water events, it did not start reporting water events until 2006 (OOSKAnews 2014). The fairly recent reporting of OOSKAnews, may be one reason for the observed increase in international water conflict during the 2000s. Furthermore, as water scarcity increases and countries further understand the potential consequences for mismanagement and governance, reporting conflicts may increase.

Even with the implementation of treaties, conflicts occurred. For the large transboundary lakes experiencing transboundary conflict after a treaty was implemented, there were less reported conflicts related to the content of a treaty than conflicts not related to the content of a treaty. It was concluded that 28 of the 53 reported international water conflicts were not related to the content of the international water treaty implemented prior. Since more conflicts were unrelated to the content of a treaty implemented prior, there is potential for the treaty to be a mechanism to prevent conflict. However, after an international water treaty is implemented, there may be a greater incentive for a riparian country to raise concerns with a legally binding document. Prior to the treaty there might have been no legal standards or protocols; therefore, a riparian country did not have authority to initiate conflict between another riparian country. Over time, the behavior of country interaction may change, including their expectations of one another in terms of the treaty (Brochmann 2012). Riparian countries may feel empowered to take action regarding the governance, border, water quantity, water quality and borders. Treaties governing a transboundary lake may result in an increase in water conflict between riparian countries due to the new mechanism.

There was a notable difference between the dominating primary focuses of the treaties implemented and the conflicts that occurred between 1990 and 2013. Joint management was the dominant primary focus of international water treaties with 24 treaties, while there were only two reported conflicts with the primary focus of joint management. Water conflicts are reported primary with a focus of one issue, where international water treaties encompass a large number of components. Treaties that had a primary focus on joint management concentrated on sustainable management and

conservation of the national resource. Generally, water conflicts revolve around more discrete issues such as water allocation or water quality, instead of joint management. This resulted in the large differences in the number of treaties and conflicts with a primary focus of joint management in this study.

Between 1990 and 2013 there were no international water treaties implemented with a focus on border issues, territorial issues, groundwater, or recreation. During the study's time span, 14 conflicts were reported focused on the border of Lake Malawi. It is alarming that 14 conflicts occurred between Malawi and Tanzania focused the border of Lake Malawi and no international water treaties implemented. Since the conflicts happened in 2012 and 2013, there is hope that an international water treaty will be implemented to address the conflict between these riparian countries. Understanding the reasons why the transboundary conflict occurred needs to be taken into consideration when developing an international water treaty.

External factors need to be understood to develop a comprehensive knowledge of the relationship between treaties and conflict. Annual precipitation varied by lake basin (Aquastat). The results of previous studies on the impact of precipitation on conflict have varied. For example, Zawahri and Mitchell concluded that as precipitation increases the amount of available water increases resulting in less conflict (2001). However, Hsiang et al. (2013) found that extreme rain events resulting in a higher likelihood of international violence. Since previous results have varied, it is not surprising that this study did not conclude a distinct relationship between conflict and precipitation. The geographic and climatic area may influence the amount of precipitation and its impact on conflict. If a region is prone to extreme rain events, a decrease in rain may result in an increase in

conflict. However, in a dry region, an increase in rain, even though it brings an increase in available freshwater, would lead to an increase in conflict potentially due to inadequate infrastructure or governance and an increase in flooding.

Of the 35 large transboundary lakes, the Aral Sea had the most international water treaties implemented with 17. The Aral Sea is a prime example of the mismanagement of natural resources. The Aral Sea has lost more than 75 percent of its surface area since the 1960s and roughly 90 percent of its volume (Micklin 2007). Water from the Amu Darya and Syr Darya rivers, the two main inflows to the Aral Sea were diverted in the early 1960s for irrigation for cotton production, which greatly reduced the flow into the Aral Sea (Micklin 2007). In the summer of 2014, the Eastern half of the southern portion of the Aral Sea completely dried up for the first time in modern time (NASA 2014). The extreme change in the Aral Sea over the last decades has been a driver for the implementation of international water treaties governing the Aral Sea to ensure effective water management. Furthermore, the Aral Sea receives the third least amount of annual precipitation in comparison to the 35 large transboundary lakes, potentially increases the need for treaties due to the fact there is less available freshwater. External factors need to be understood and evaluated to fully comprehend the impact treaties have on conflict.

Overall, the 52 treaties implemented lack vital components to ensure successful compliance: information exchange, monitoring, conflict resolution, and enforcement mechanisms. As the indicator requires more funding, time, and personal, the less likely it will be included in the treaty. For example, information exchange and monitoring require additional personal and funding, but enforcement requires more intricate steps and

continued work; it was observed more treaties included monitoring and information exchange than conflict resolution and enforcement mechanisms. To increase the successful compliance of a treaty there first needs to be mechanisms in place to determine whether countries' actions are inline with the treaty elements. If it is determined that a riparian country is not in compliance with the treaty, detailed steps must be developed to determine appropriate actions which will be taken to ensure compliance with the treaty. While essential for compliance, these enforcement mechanisms encompass numerous steps and have the potential to take extended periods of time, more personal, and additional funding. Furthermore, including enforcement in an international water treaty requires increased work for the composers of treaty, potentially resulting in the observed minimal amount of treaties with enforcement. Nonetheless, these components need to be included in treaties to ensure compliance and the potential for the elimination in water conflict between riparian countries of large transboundary lakes. An example of a treaty lacking vital components is the Protocol for Sustainable Development of Lake Victoria Basin. The Protocol includes the "polluter pays principle" where "the person that causes the pollution shall as far as possible bear any costs associated with it" (2003). In order for the riparian countries of Lake Victoria to comply with the 'polluter pays principle', new monitoring mechanisms have to be established to accurately determine which riparian country is discharging pollution into Lake Victoria. Conflicts between the riparian countries of Lake Victoria have occurred regarding the water quality since the implementation of the Protocol, potentially due to the lack of monitoring and enforcement mechanisms in the Protocol.

Furthermore, between 1990 and 2013, no international water treaties were implemented regarding water allocation in Lake Victoria. During the mid to late 2000's conflicts between Lake Victoria's riparian countries focused on water quantity, especially, allocation of the resource. The lack of treaties focused on water quantity may be a reason why Lake Victoria experienced conflicts over water allocation. The Lake Victoria Fisheries Organization was created in 1994, which may be the driver there were no reported international water conflicts regarding fisheries in Lake Victoria. Furthermore, it is vital to understand the components of existing treaties to understand the components that are lacking to assist in the development of appropriate, successful, and accurate treaties.

Conflict and cooperation as they relates to transboundary water do not display a linear relationship; instead cooperation and conflict co-exist and should not be treated separately in analyses (Zeitoun and Mirumachi 2008). While, previous studies have shown that the implementation of a treaty will lead to an increase in cooperation, this study only included conflictive events (Wolf 1997; Wolf et al. 2003). It cannot be concluded whether treaties lead to an increase in cooperation between riparian countries of large transboundary lakes. Future studies should focus on a broader range of cooperative events, and how treaties play a role in decreasing conflict and increasing cooperative events. Studies should include other cooperative events, based on the TFDD BAR Scale, which may assist in understanding if international water treaties lead to an increase in cooperation between riparian countries. Additionally, future studies need to further understand how economic, political, and environmental factors play a role in impacting the likelihood of conflict in large transboundary lakes.

There have been international water conflicts between riparian countries of large transboundary lakes in the past 23 years. When an international water treaty has been implemented there is less conflicts related to the content of the treaty than not related to the content of the treaty. It is essential to understand that it was concluded that institutions, treaties, did not eliminate or decrease conflict between riparian countries of large transboundary lakes. There is not a simple or direct relationship between treaties and conflict.

This research study opens numerous opportunities for further researched focused on large transboundary lakes. For example, other studies should evaluate the effect of a time-lag, focused on when an international water treaty is implemented and when an international water conflict occurs. Furthermore, understanding if there is a time-lag between the contextual variables and international water conflict. For example, if the GINI Index increases dramatically from one year to the next, will there be a greater chance of conflict in the year directly following or in two, three, or more years after the increase. Additionally, a greater focused shall be placed on determining the impact of population growth on international water conflict for large transboundary lakes.

As climate change continues and population growth accelerates available freshwater will become more scare. The world population growth is expected to increase to 7.7 billion over the next decade (WEF 2011). The population growth will be unevenly distributed with the greatest increase in sub-Saharan Africa and the Middle East (DCDC 2010). Water quality will decrease from increased urban growth and increase in industrial growth. Furthermore, The United Nations projects a 50 percent increase in demand for food by 2030 (United Nations 2012). Preparation by countries, states,

communities, and people is vital. One form of preparation is international water treaties focused on water quantity and water quality. It is essential to have outlined legally binding cooperation between countries focused on the largest freshwater reservoirs, lakes. The ratification of the Convention on the Non-Navigation of International Water Sources in August 2014, is a step in the right direction to ensure effective and comprehensive management of transboundary waters. Furthermore, organizations or institutions focused on the governance of waterbodies containing mechanisms of enforcement of rules, policies, and regulations are ideal. It is the specific content of the treaties, and the correlation of the content to the foundational causes of conflicts, that determines the relevance and effectiveness of the treaties.



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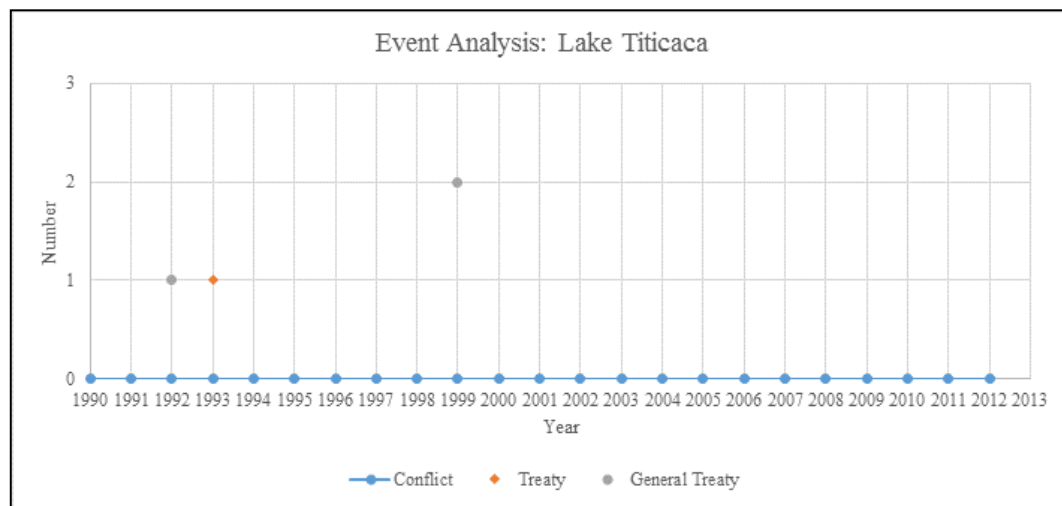
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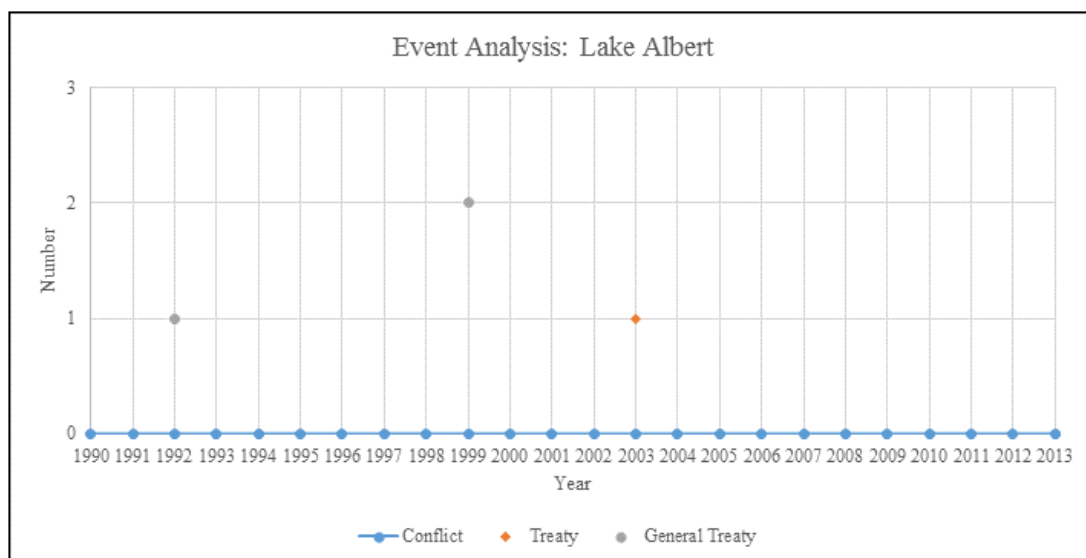
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## Appendix A: Event Analysis Figures – All Conflict

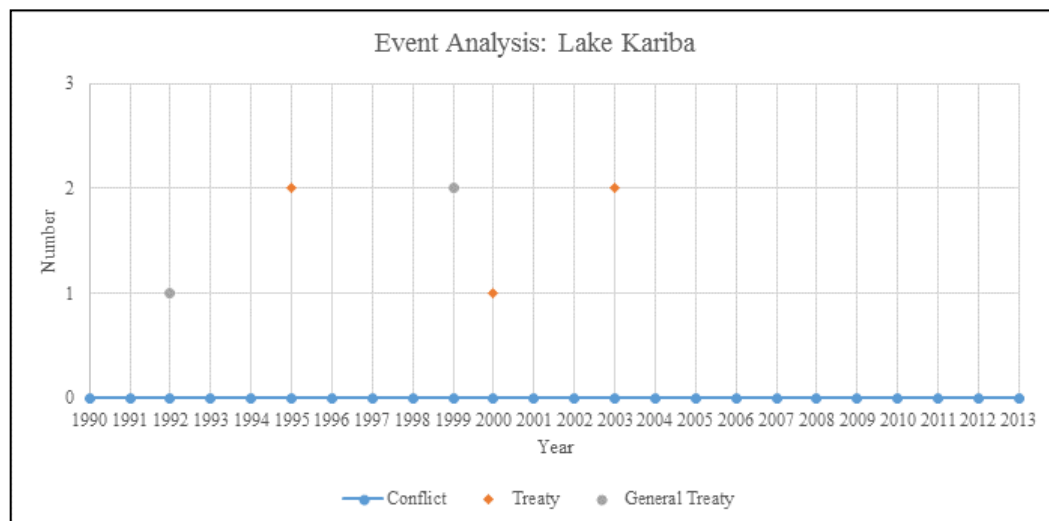
Eighteen of the 35 large transboundary lakes in this study had no reported international water conflict between the riparian countries between 1990 and 2013 Lake Titicaca, Lake Albert, Lake Kariba, Lake Cahora Bassa, Lake Xingkai, Lake Merin, Lake Sargamysh, Lake Uvs, Lake Peipsi, Lake Kivu, Lake Edward, Lake Buenos Aires, Lake Chad, Lake St. Clair, Lake Champlain, Lake O’Higgins, Rainy Lake, and Lake Zun-Torey.



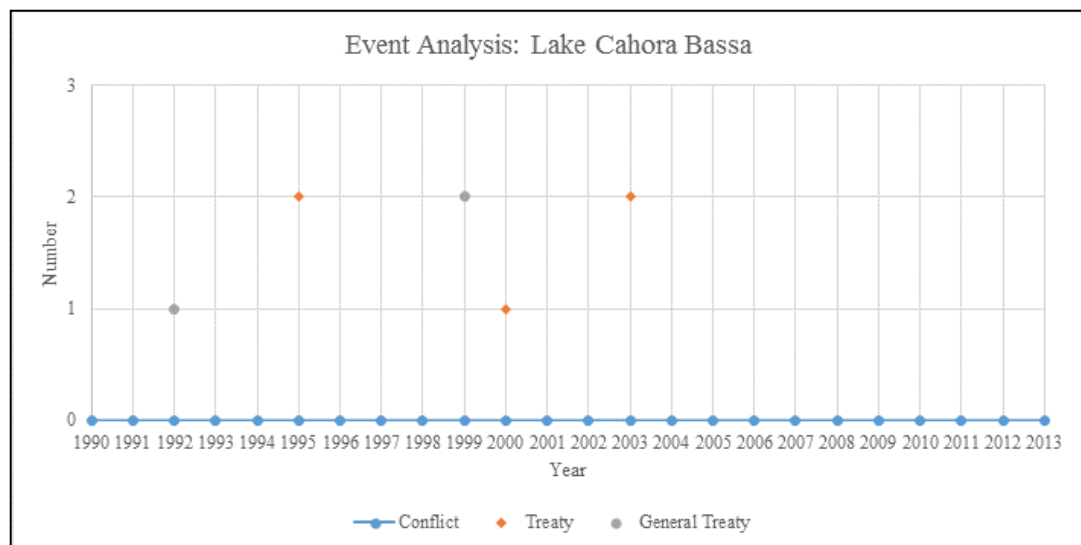
Appendix Figure A1: Annual international water treaties and international water conflicts for Lake Titicaca.



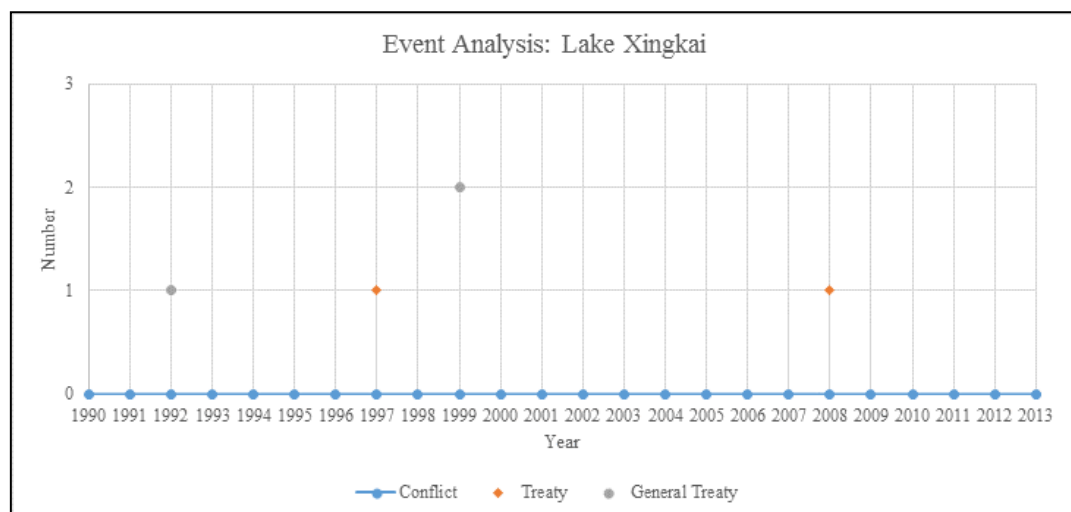
Appendix Figure A2: Annual international water treaties and international water conflicts for Lake Albert.



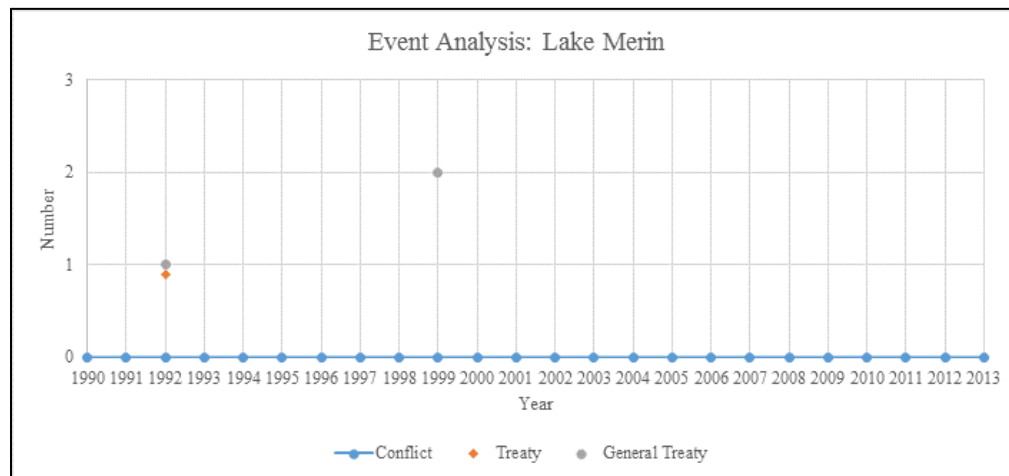
Appendix Figure A3: Annual international water treaties and international water conflicts for Lake Kariba.



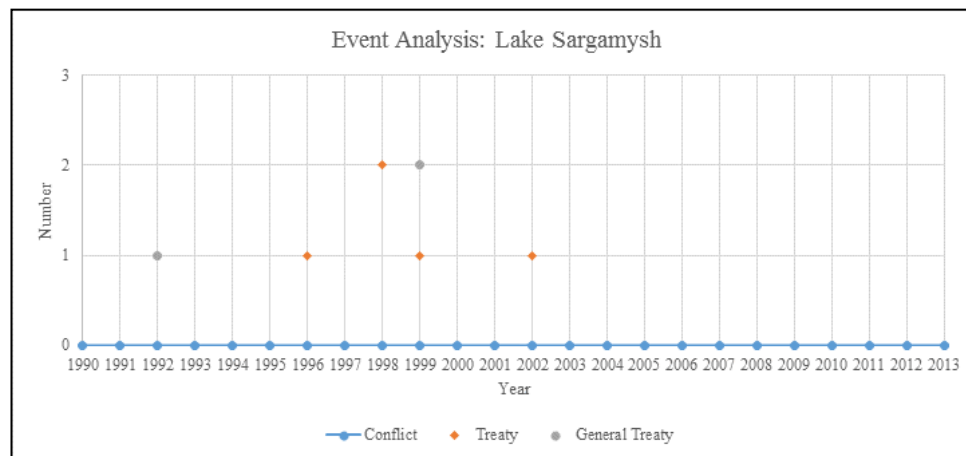
Appendix Figure A5: Annual international water treaties and international water conflicts for Lake Cahora Bassa.



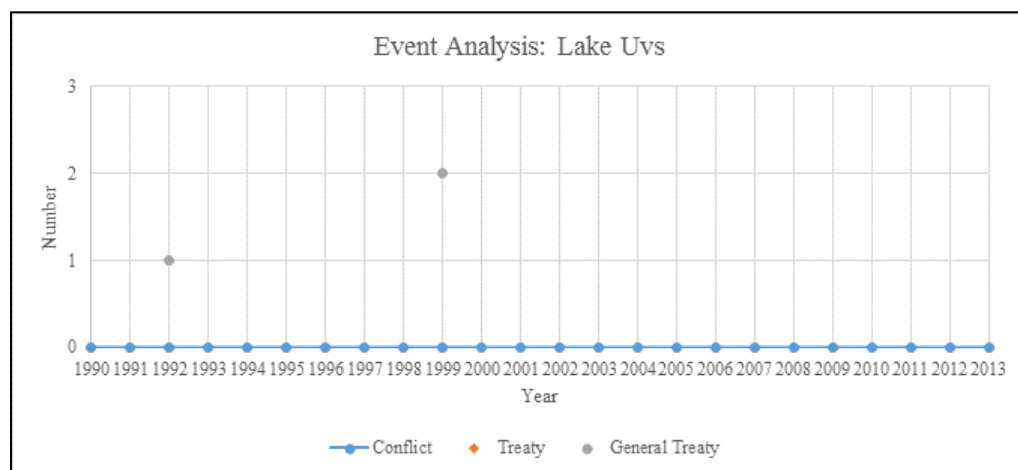
Appendix Figure A4: Annual international water treaties and international water conflicts for Lake Xingkai.



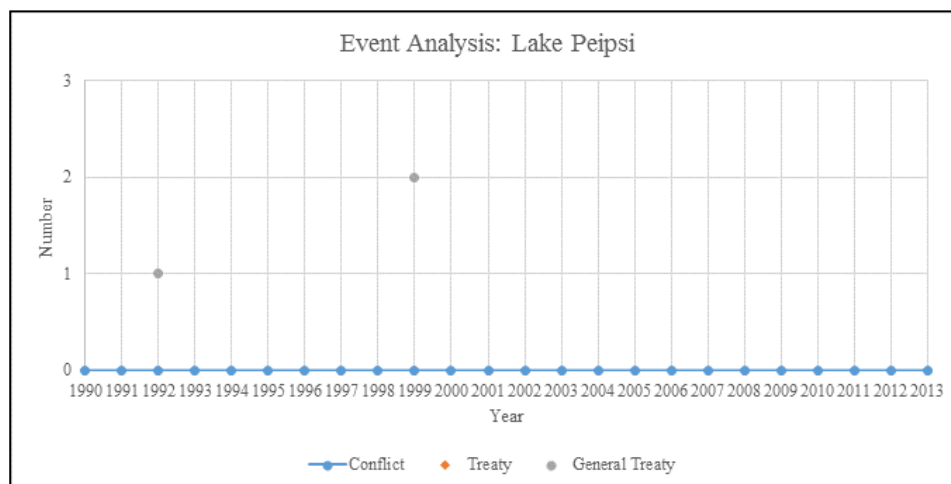
Appendix Figure A6: Annual international water treaties and international water conflicts for Lake Merin.



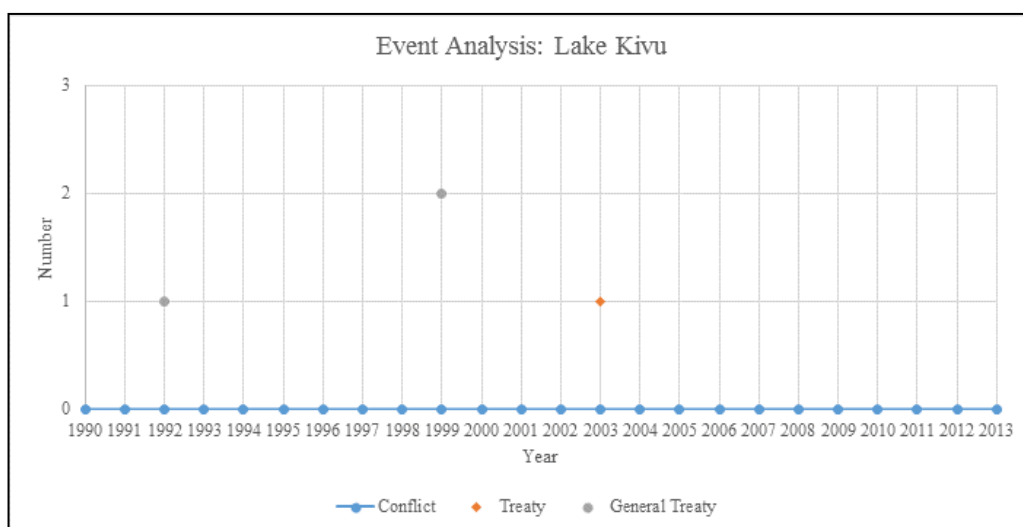
Appendix Figure A7: Annual international water treaties and international water conflicts for Lake Sargamysh.



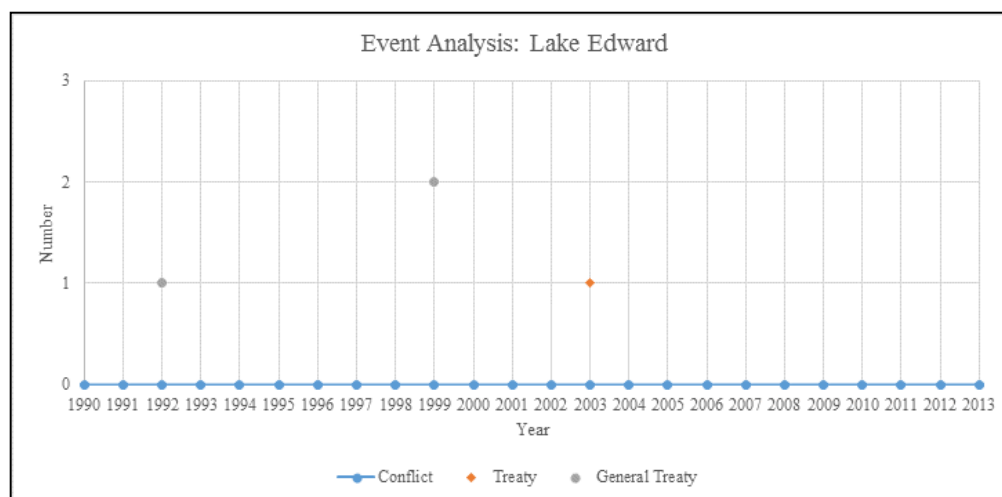
Appendix Figure A8: Annual international water treaties and international water conflicts for Lake Uvs.



Appendix Figure A9: Annual international water treaties and international water conflicts for Lake Peipsi.

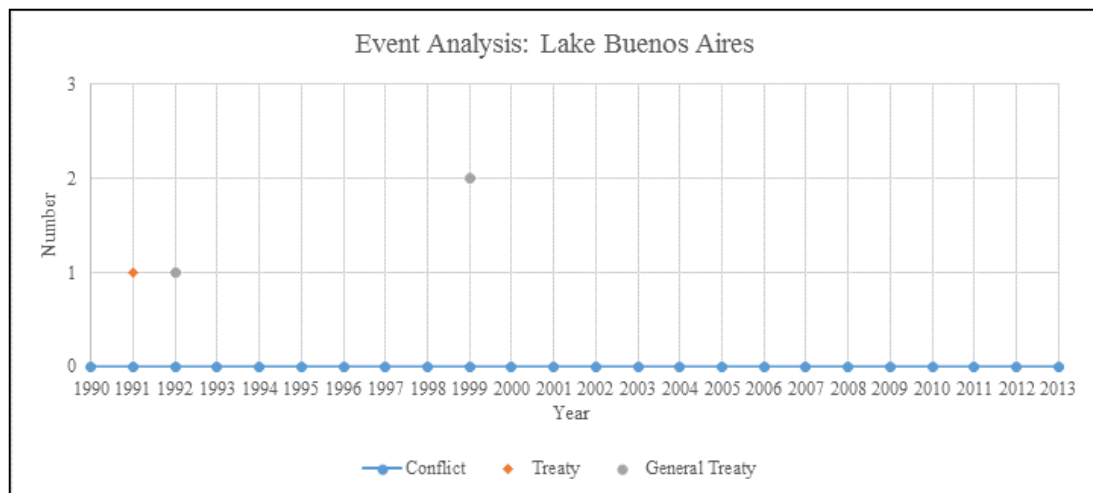


Appendix Figure A10: Annual international water treaties and international water conflicts for Lake Kivu.

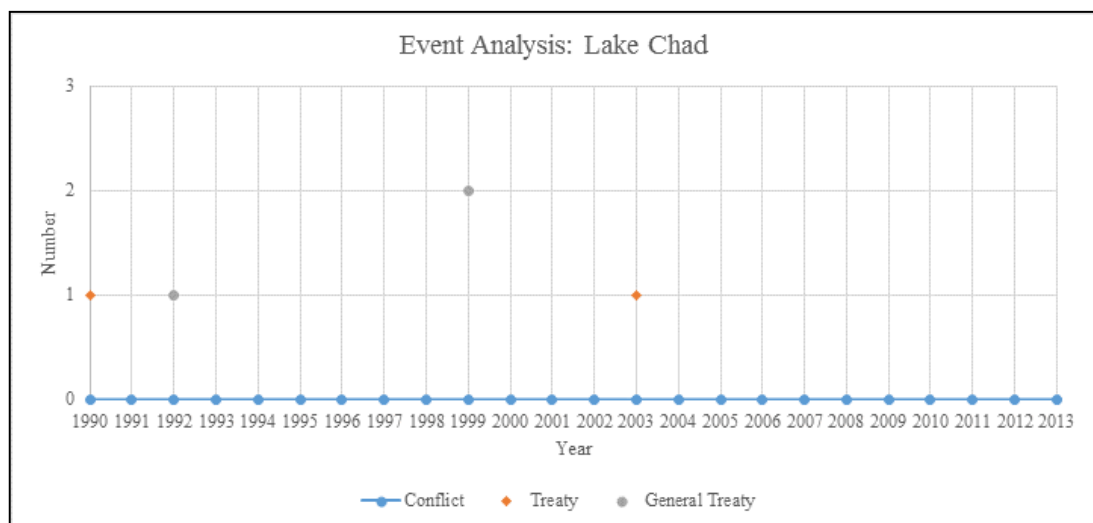


Appendix Figure A11: Annual international water treaties and international water conflicts for Lake Edward.

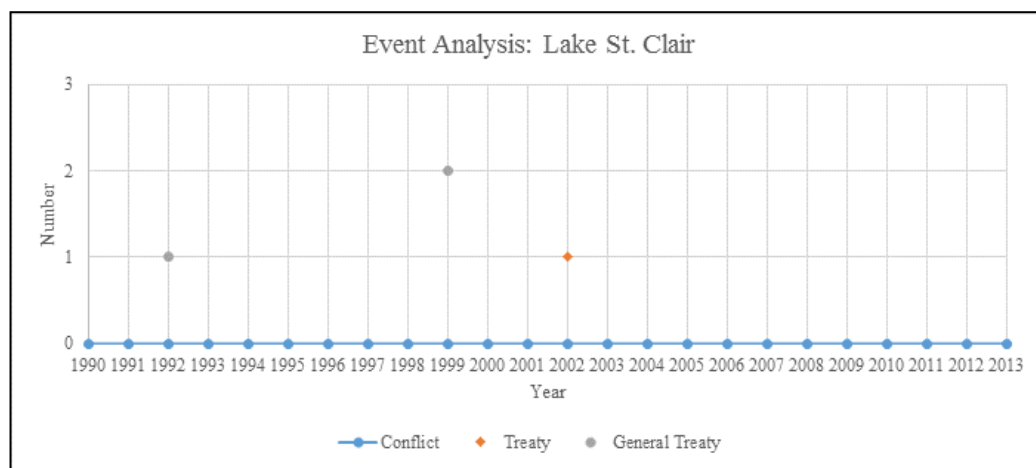




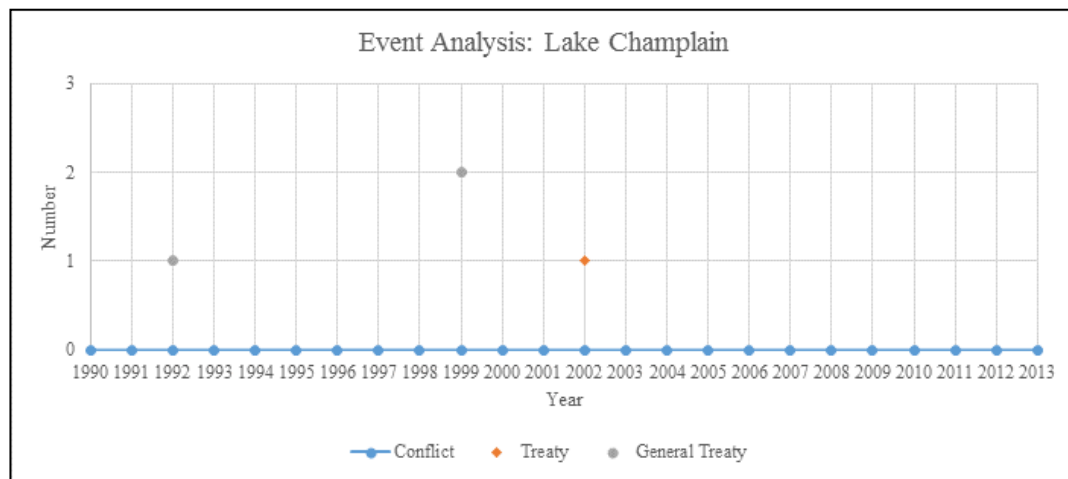
Appendix Figure A12: Annual international water treaties and international water conflicts for Lake Buenos Aires.



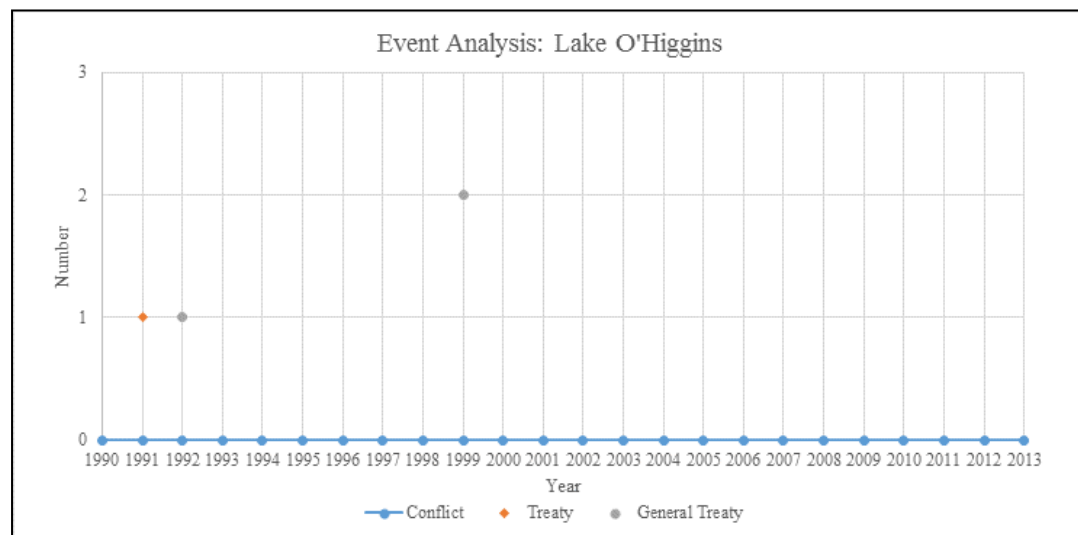
Appendix Figure A13: Annual international water treaties and international water conflicts for Lake Chad.



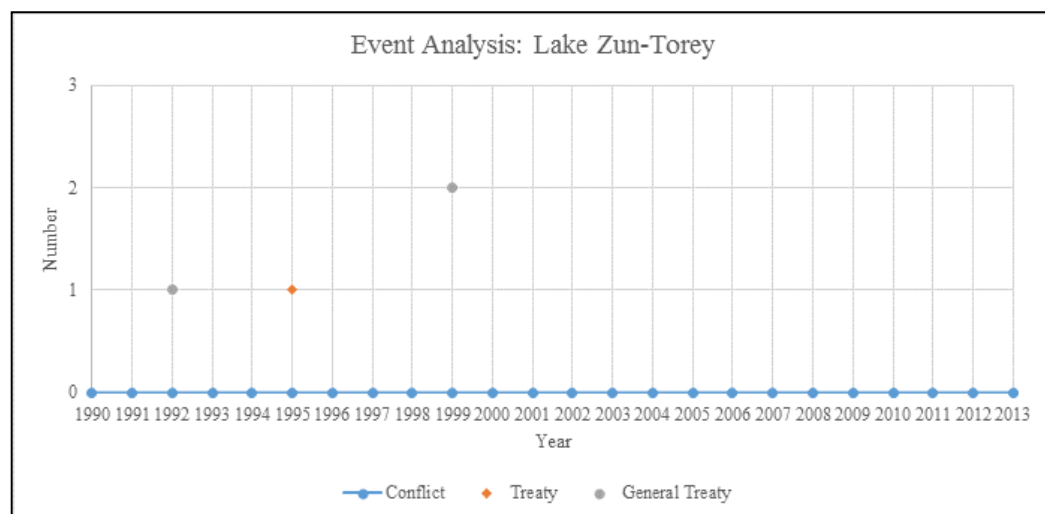
Appendix Figure A14: Annual international water treaties and international water conflicts for Lake St. Clair.



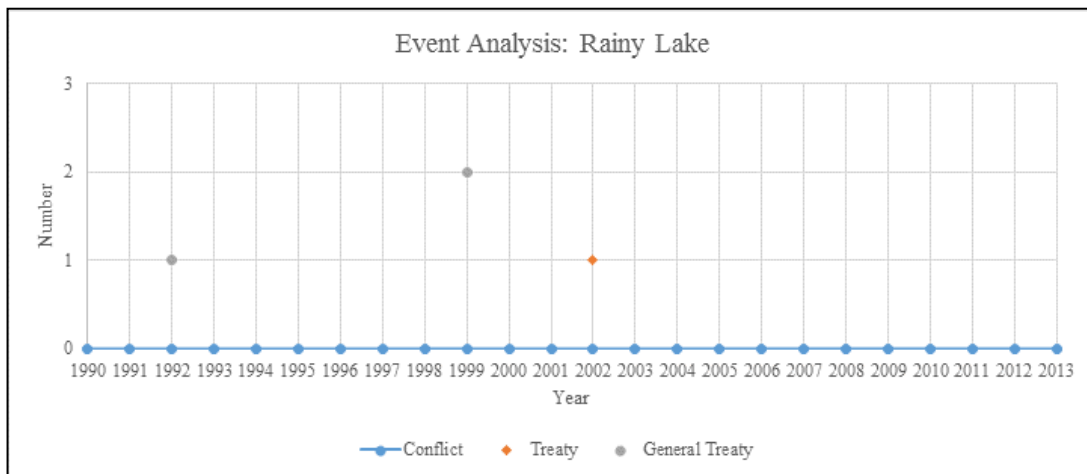
Appendix Figure A15: Annual international water treaties and international water conflicts for Lake Champlain.



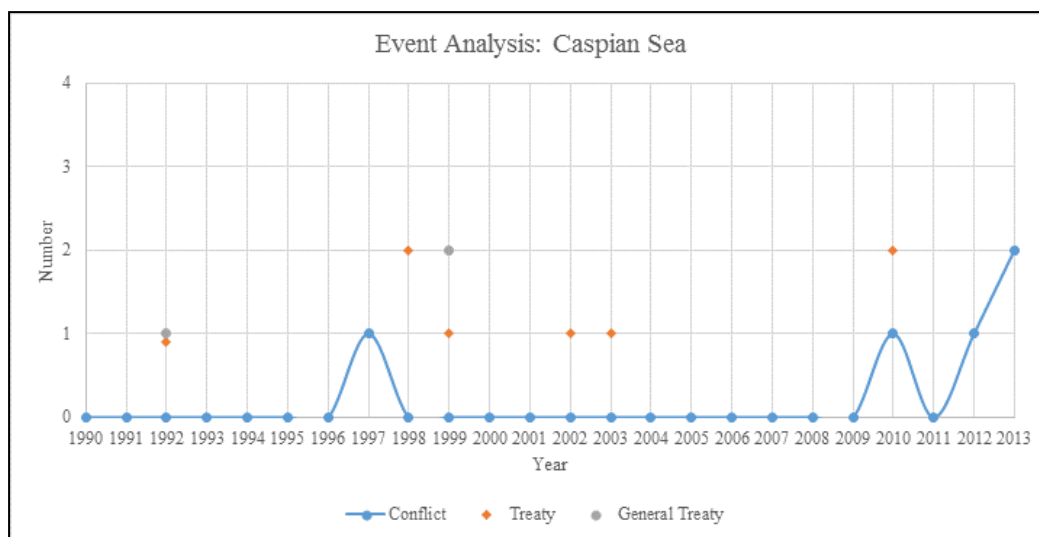
Appendix Figure A 16: Annual international water treaties and international water conflicts for Lake O'Higgins.



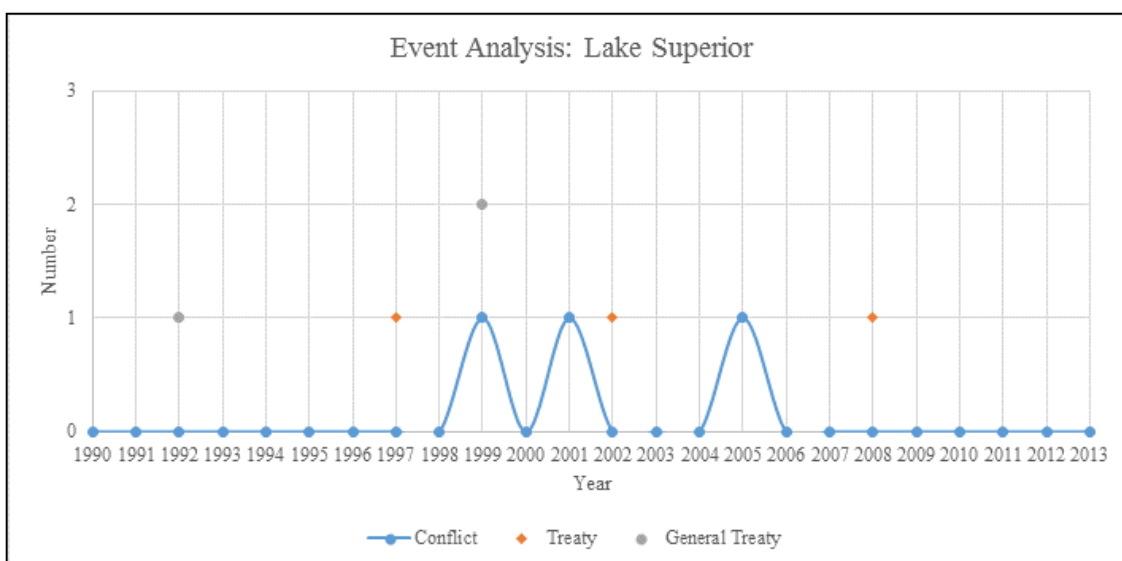
Appendix Figure A 17: Annual international water treaties and international water conflicts for Lake Zun-Torey.



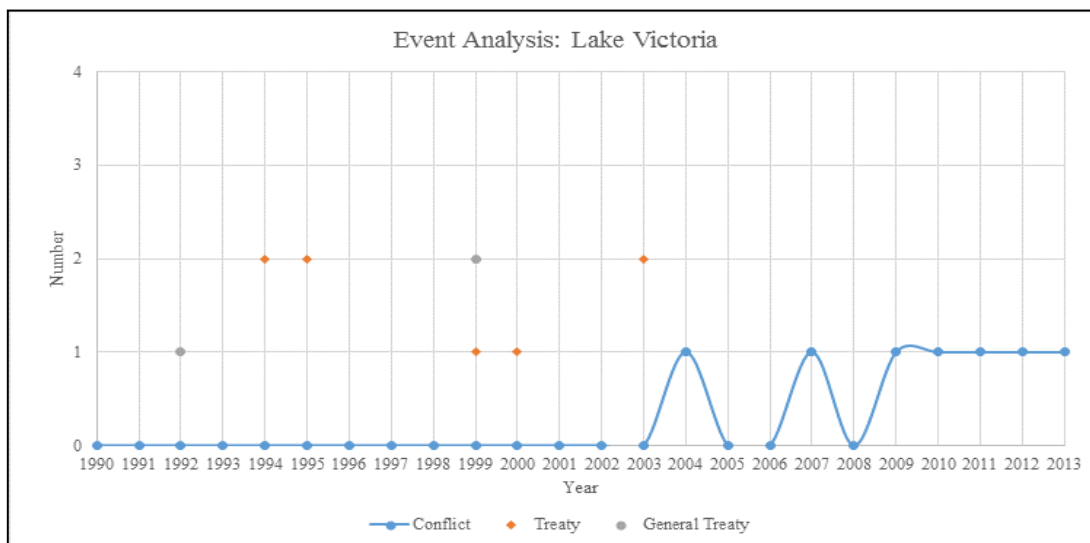
Appendix Figure A 18: Annual international water treaties and international water conflicts for Rainy Lake.



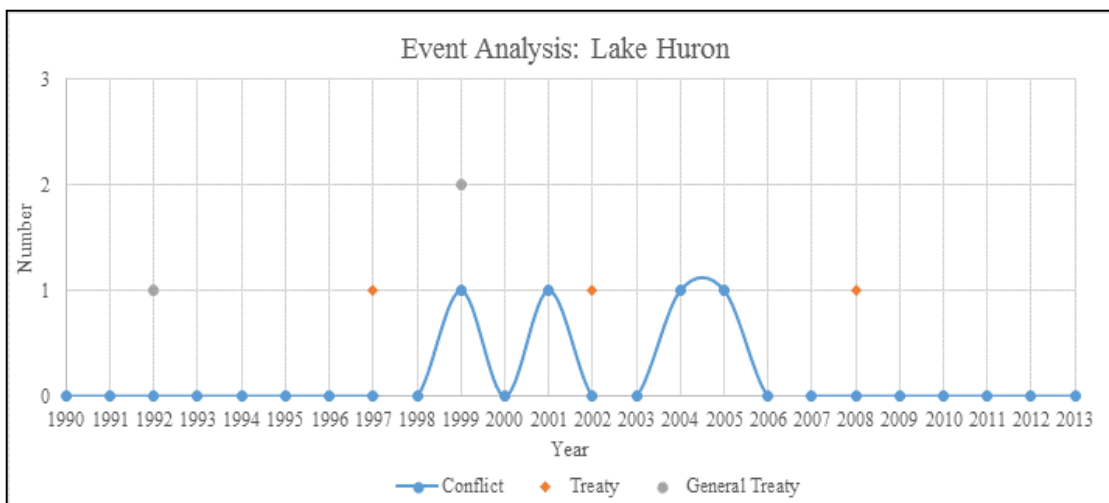
Appendix Figure A 20: Annual international water treaties and international water conflicts for the Caspian Sea.



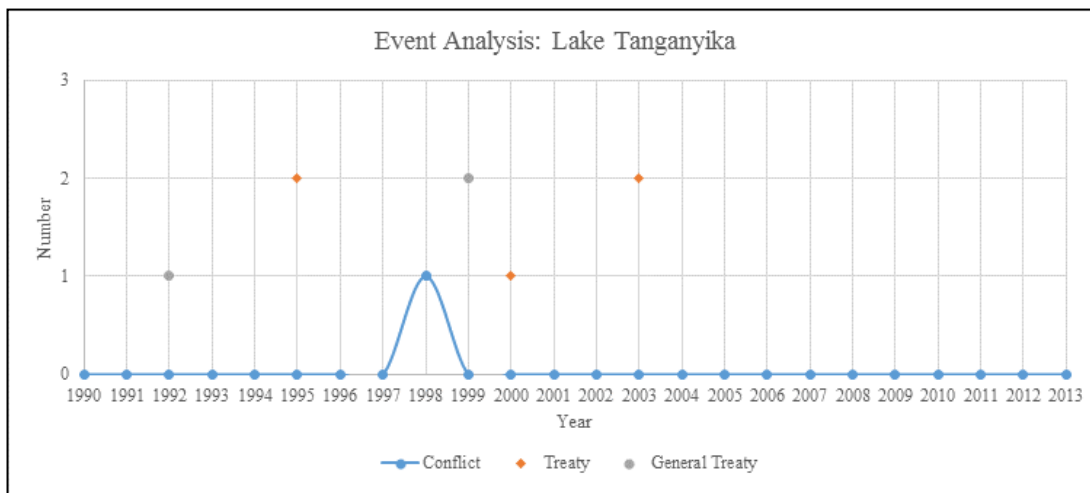
Appendix Figure A 19: Annual international water treaties and international water conflicts for Lake Superior.



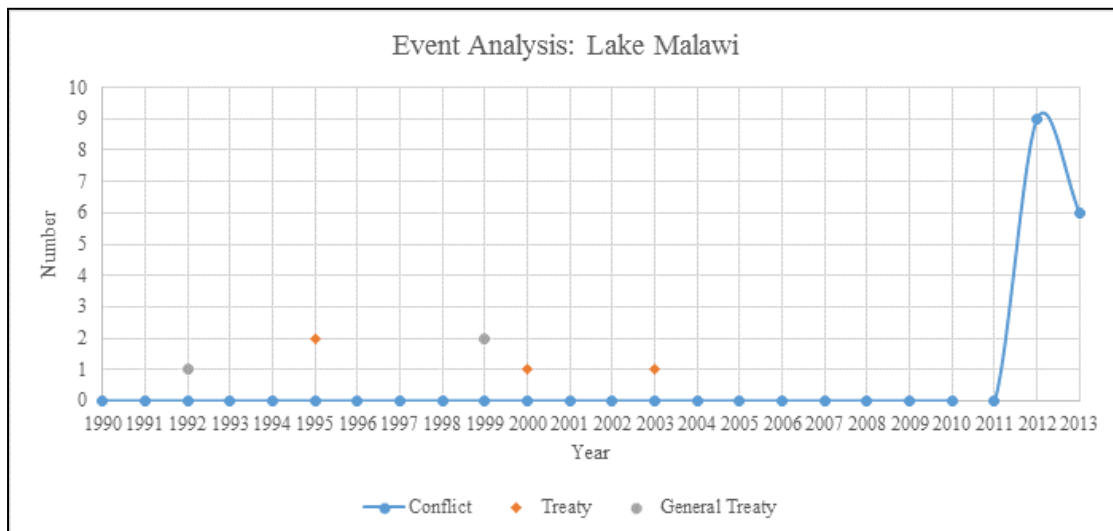
Appendix Figure A21: Annual international water treaties and international water conflicts for Lake Victoria.



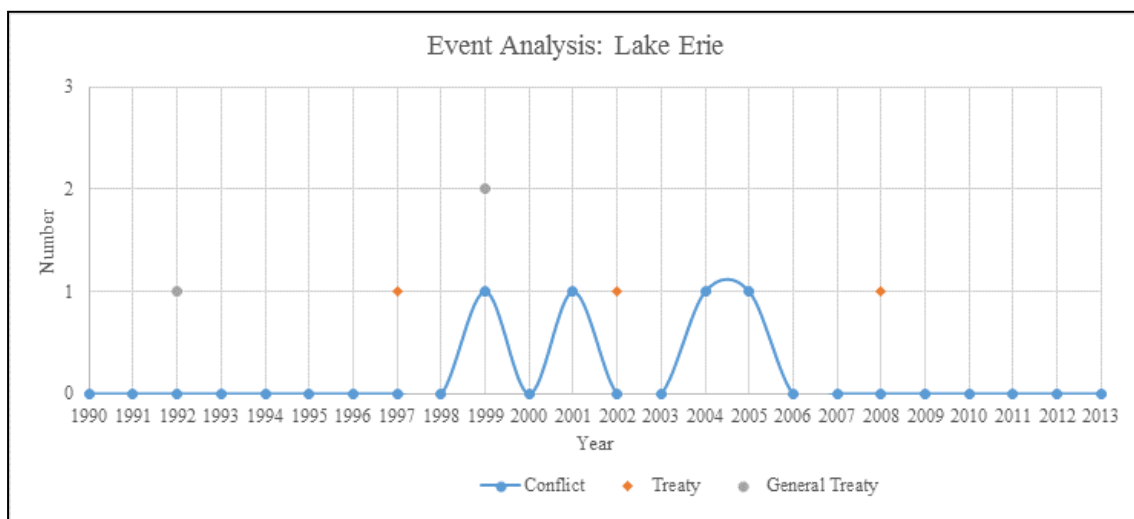
Appendix Figure A22: Annual international water treaties and international water conflicts for Lake Huron.



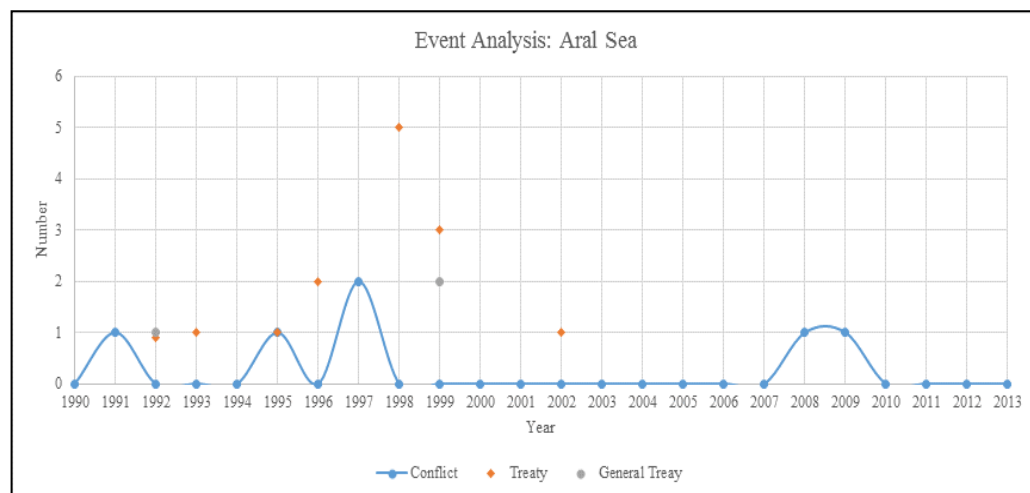
Appendix Figure A23: Annual international water treaties and international water conflicts for Lake Tanganyika.



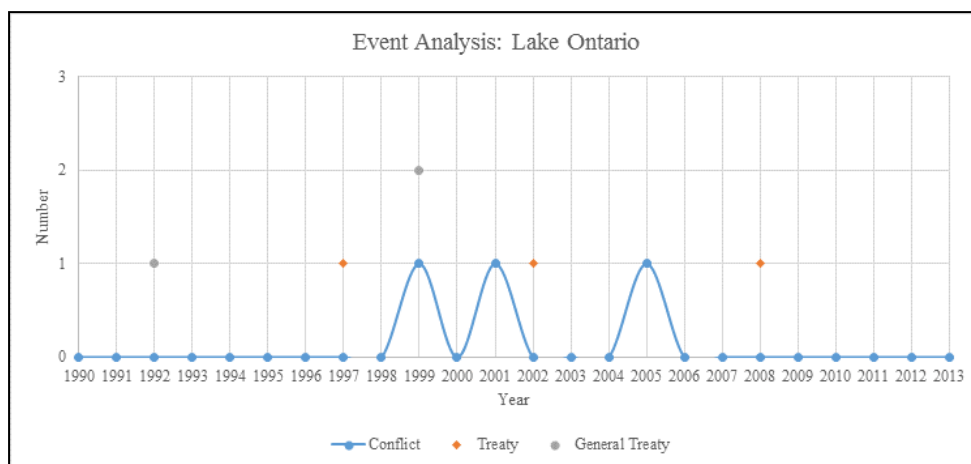
Appendix Figure A24: Annual international water treaties and international water conflicts for Lake Malawi.



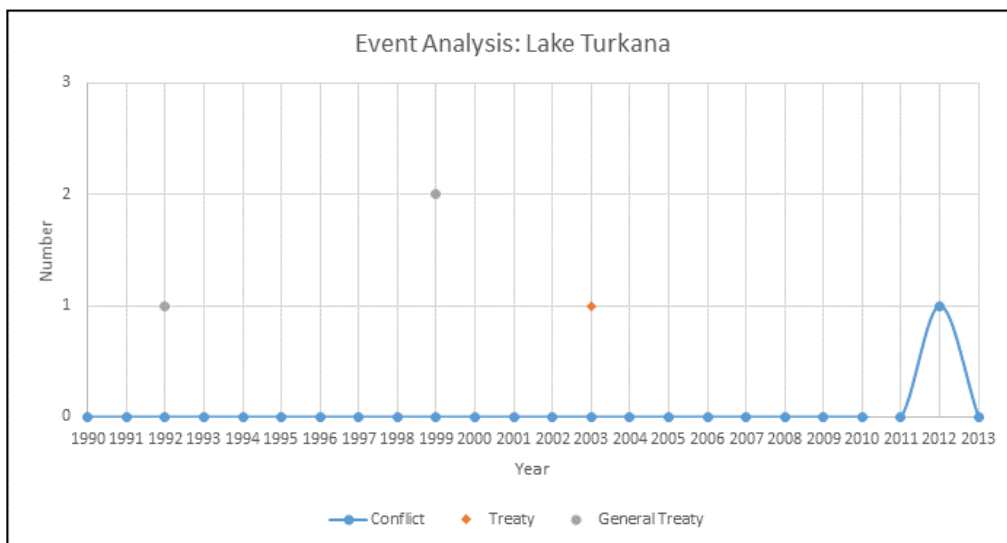
Appendix Figure A25: Annual international water treaties and international water conflicts for Lake Erie.



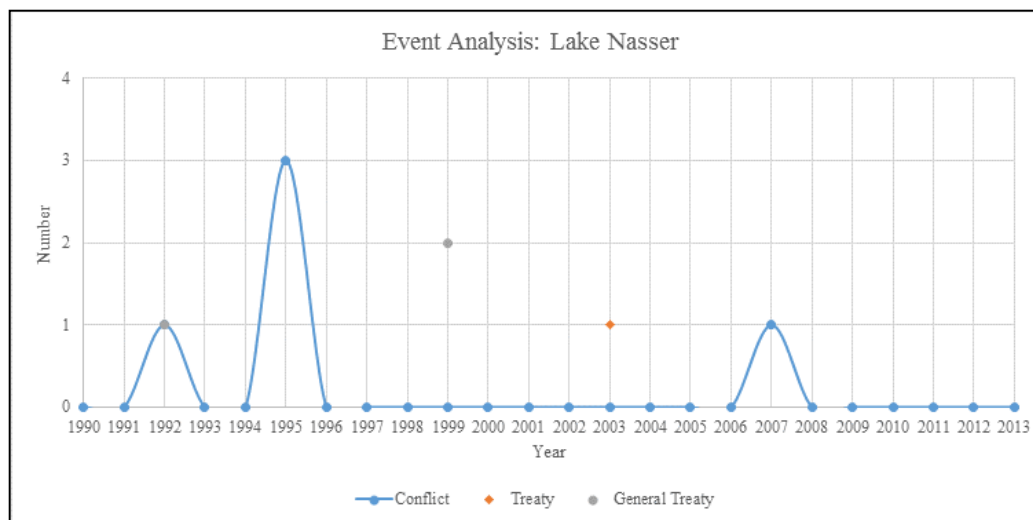
Appendix Figure A26: Annual international water treaties and international water conflicts for the Aral Sea.



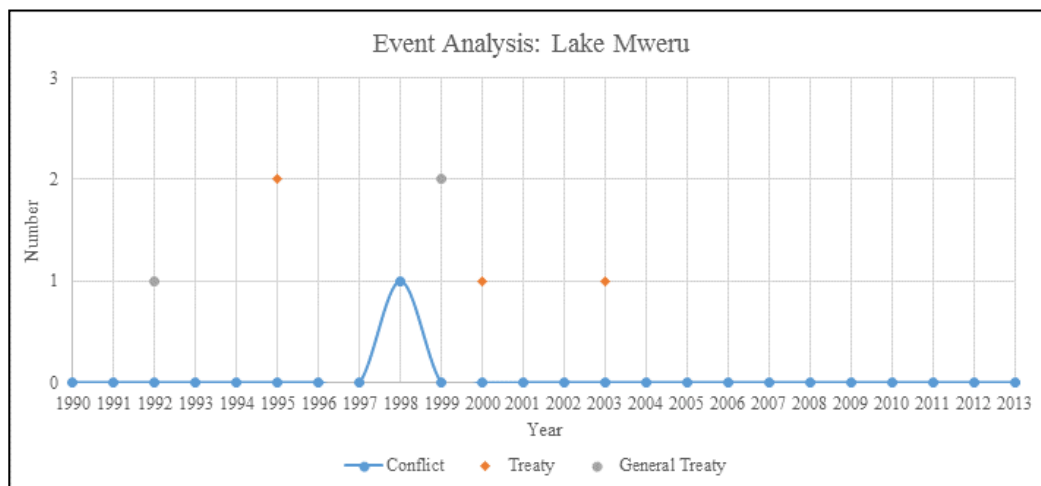
Appendix Figure A 27: Annual international water treaties and international water conflicts for Lake Ontario.



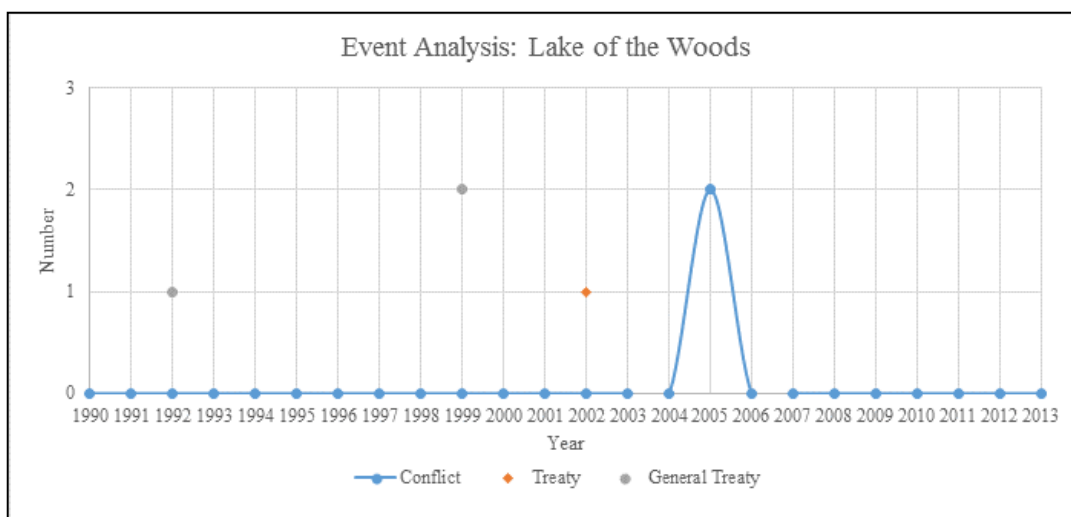
Appendix Figure A28: Annual international water treaties and international water conflicts for Lake Turkana.



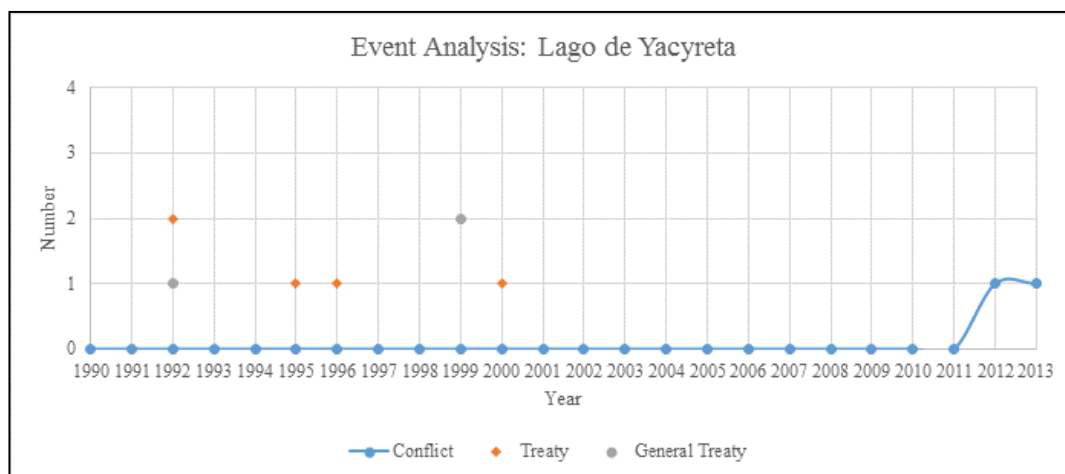
Appendix Figure A29: Annual international water treaties and international water conflicts for Lake Nasser.



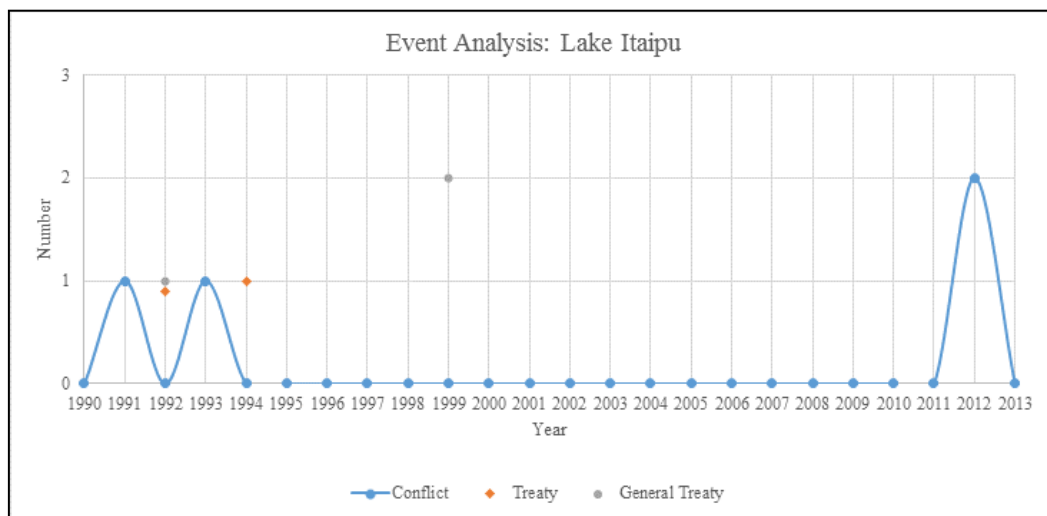
Appendix Figure A30: Annual international water treaties and international water conflicts for Lake Mweru.



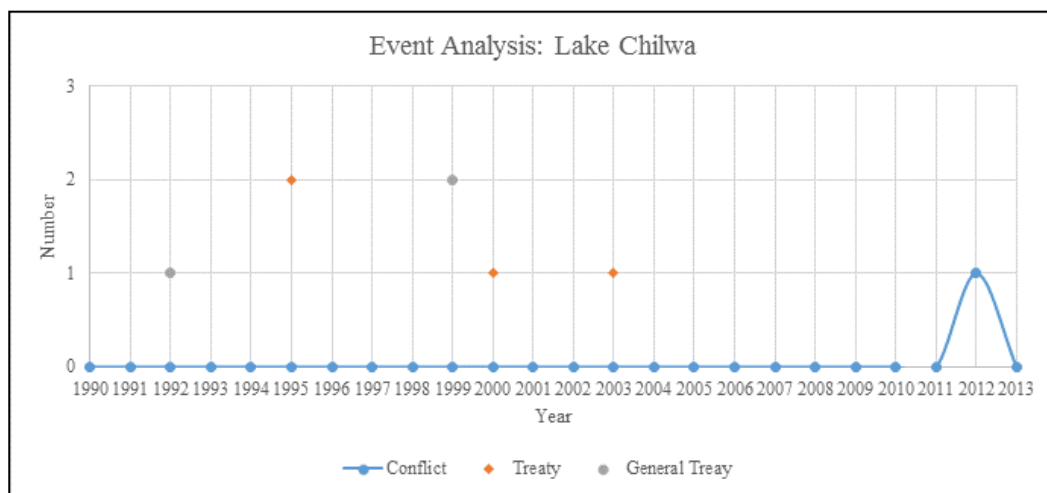
Appendix Figure A31: Annual international water treaties and international water conflicts for Lake of the Woods.



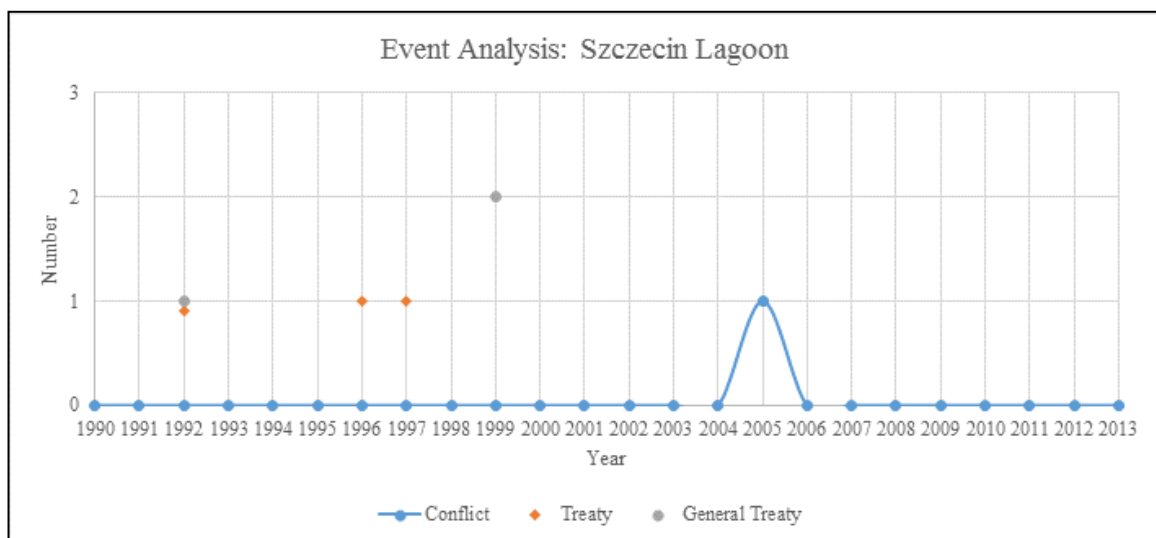
Appendix Figure A32: Annual international water treaties and international water conflicts for Lago de Yacyreta.



Appendix Figure A33: Annual international water treaties and international water conflicts for Lake Itaipu.



Appendix Figure A22: Annual international water treaties and international water conflicts for Lake Chilwa.

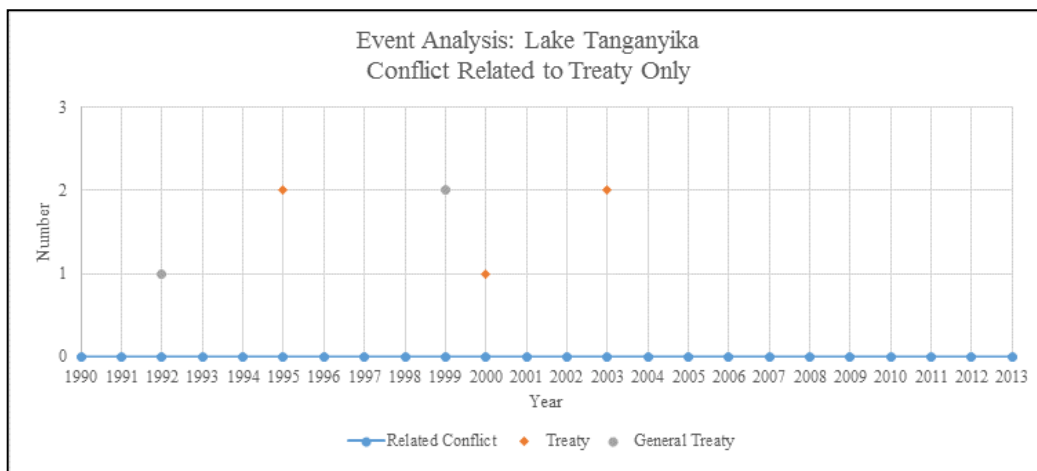


Appendix Figure A23: Annual international water treaties and international water conflicts for Szczecin Lagoon.

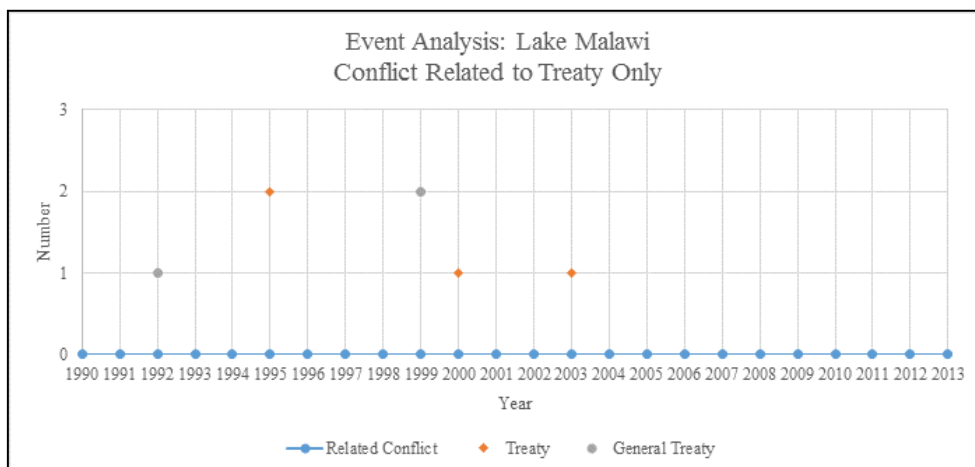


## Appendix B: Event Analysis Figures – Related Conflict

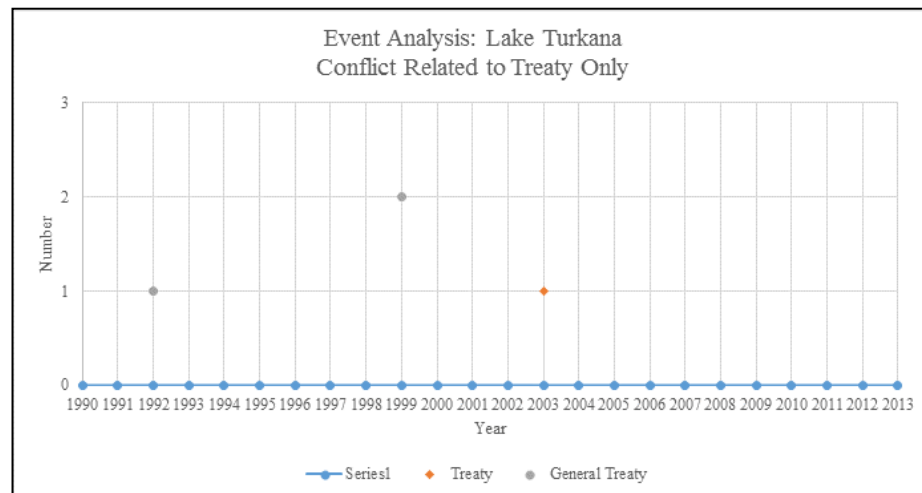
Six of the 35 large transboundary lakes experienced no reported international water conflict that was related to the content of a prior implemented international water treaty. The following lakes have no reported international water conflict that is related to the content of the implemented international water treaties between 1990 and 2013: Lake Tanganyika, Lake Malawi, Lake Turkana, Lake Nasser, Lake Mweru, and Lake Itaipu.



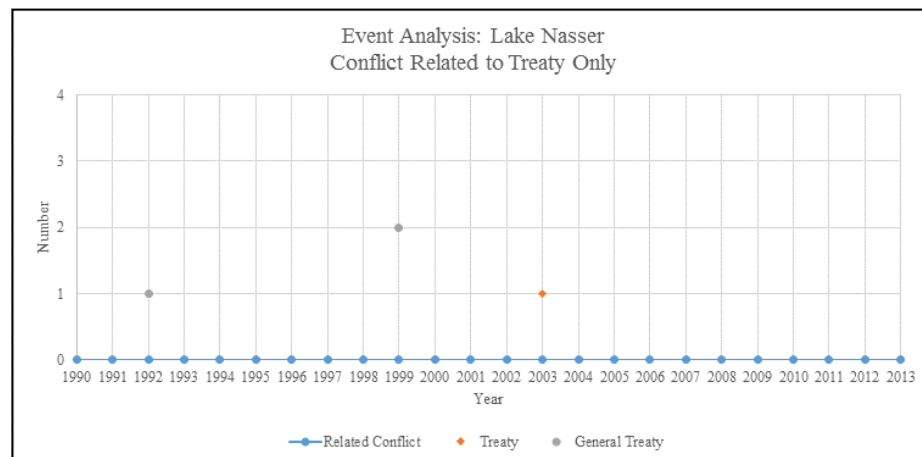
Appendix Figure B1: Annual international water treaties and international water conflicts for Lake Tanganyika.



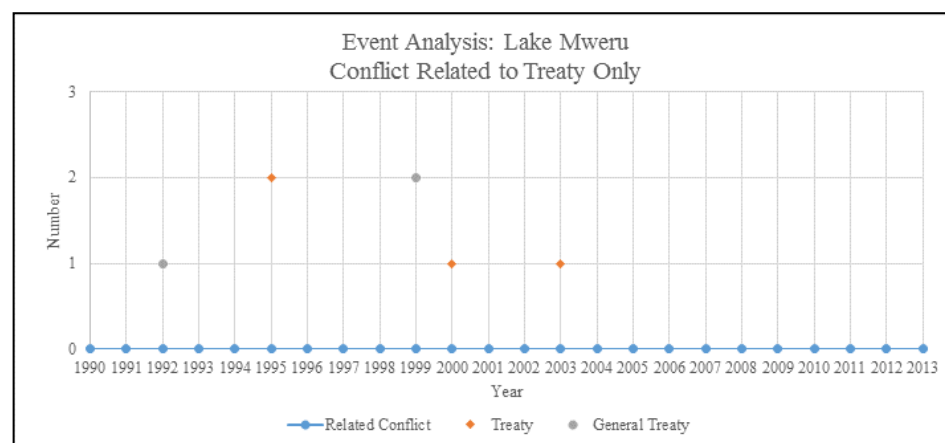
Appendix Figure B2: Annual international water treaties and international water conflicts for Lake Malawi.



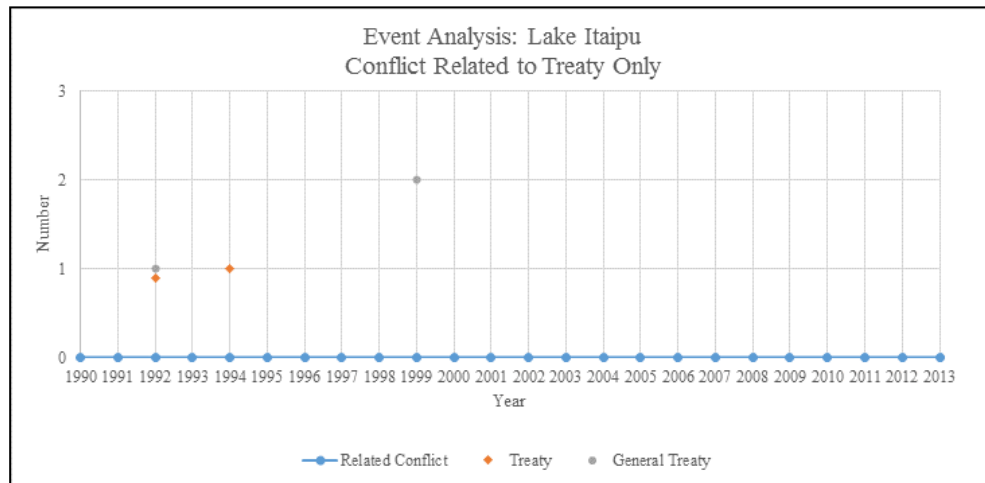
Appendix Figure B3: Annual international water treaties and international water conflicts for Lake Turkana.



Appendix Figure B4: Annual international water treaties and international water conflicts for Lake Nasser.

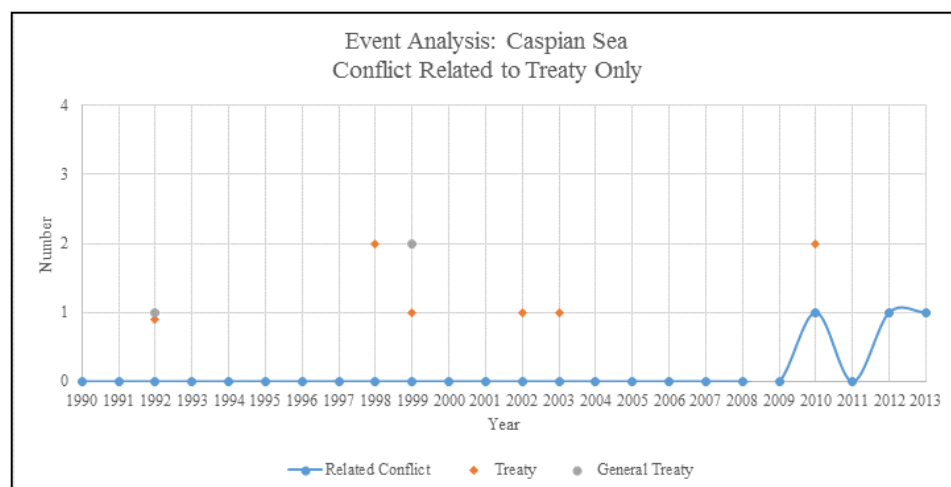


Appendix Figure B5: Annual international water treaties and international water conflicts for Lake Mweru.

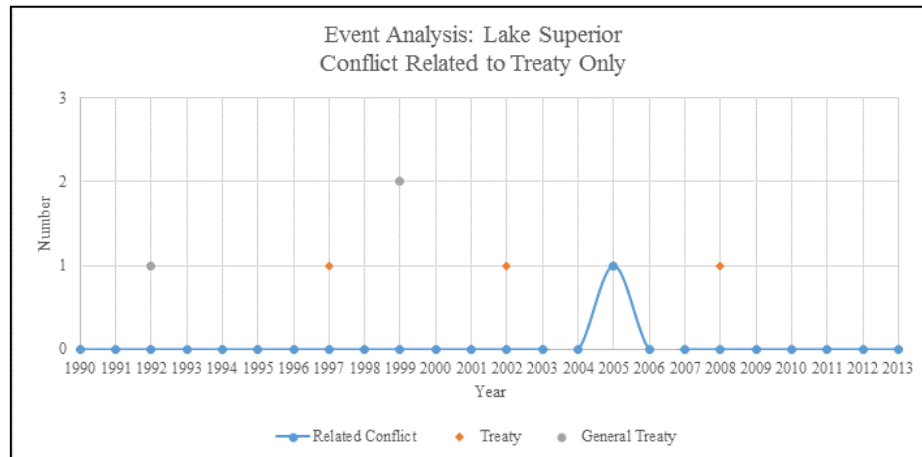


Appendix Figure B6: Annual international water treaties and international water conflicts for Lake Itaipu.

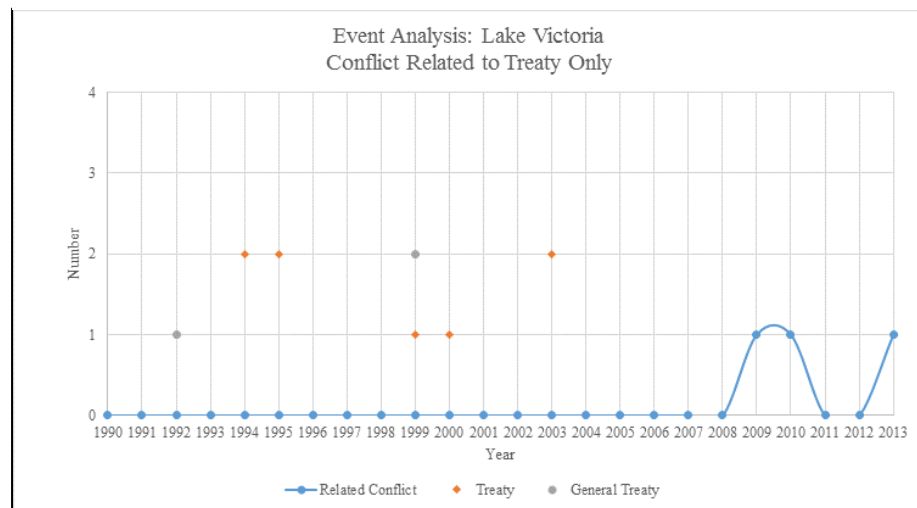
Eleven of the 35 large transboundary lakes in this study had reported international water conflict that was related to the content of a prior implemented international water treaty. The following large transboundary lakes have reported international water conflict that is related to an implemented international water treaty: Caspian Sea, Lake Superior, Lake Victoria, Lake Huron, Lake Erie, Aral Sea, Lake Ontario, Lake of the Woods, Lago de Yacyreta, Lake Chilwa, and Szczecin Lagoon.



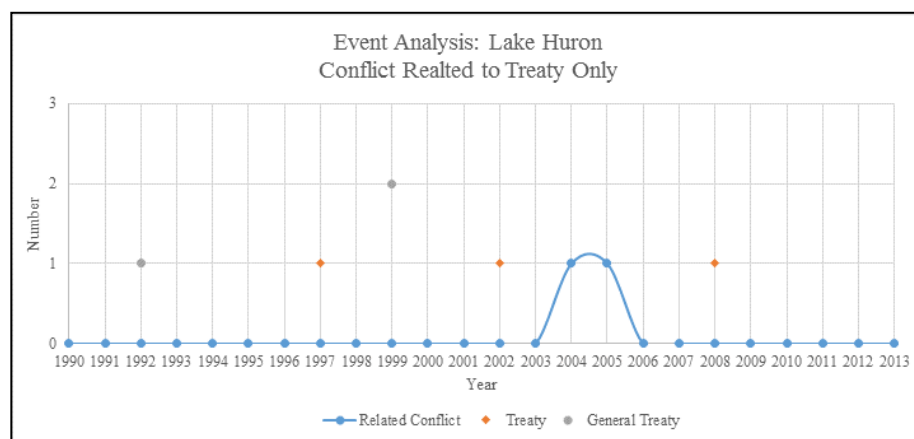
Appendix Figure B7: Annual international water treaties and international water conflicts for the Caspian Sea.



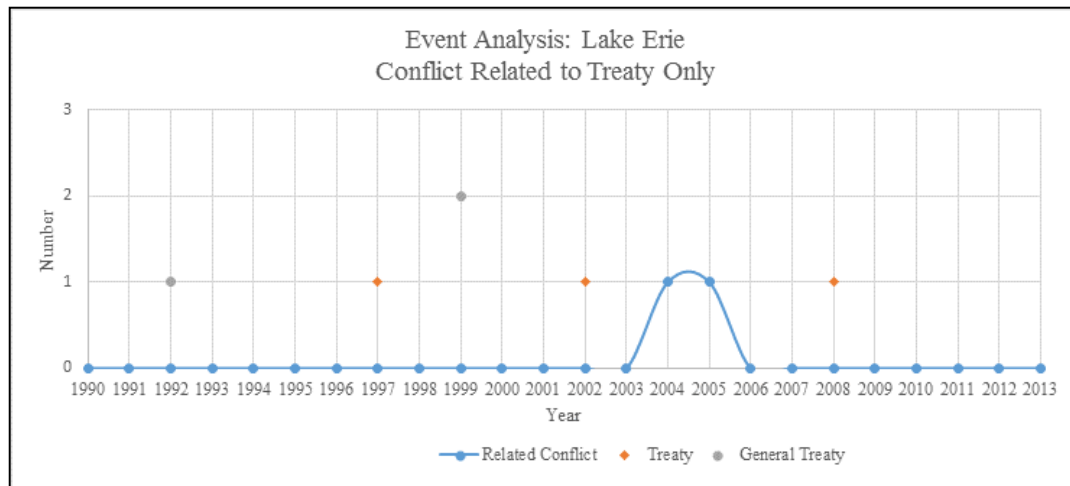
Appendix Figure B8: Annual international water treaties and international water conflicts for Lake Superior.



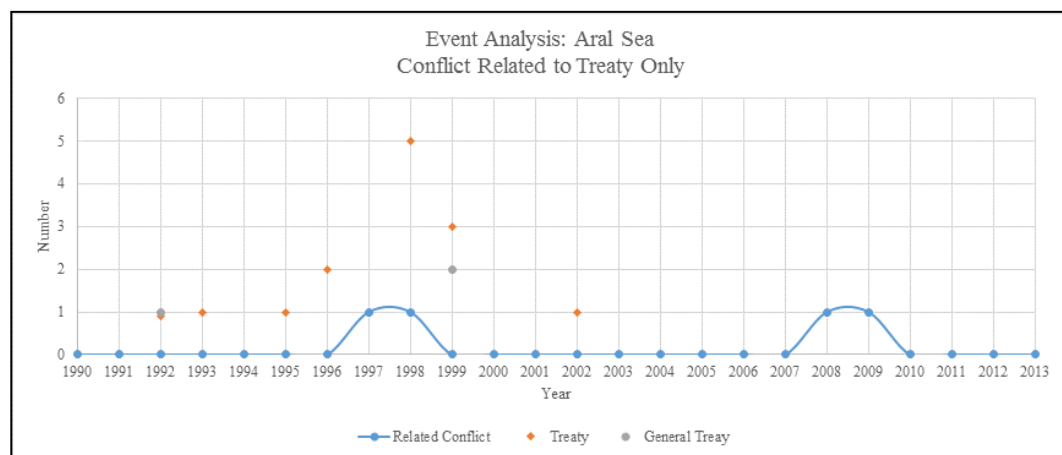
Appendix Figure B9: Annual international water treaties and international water conflicts for Lake Victoria.



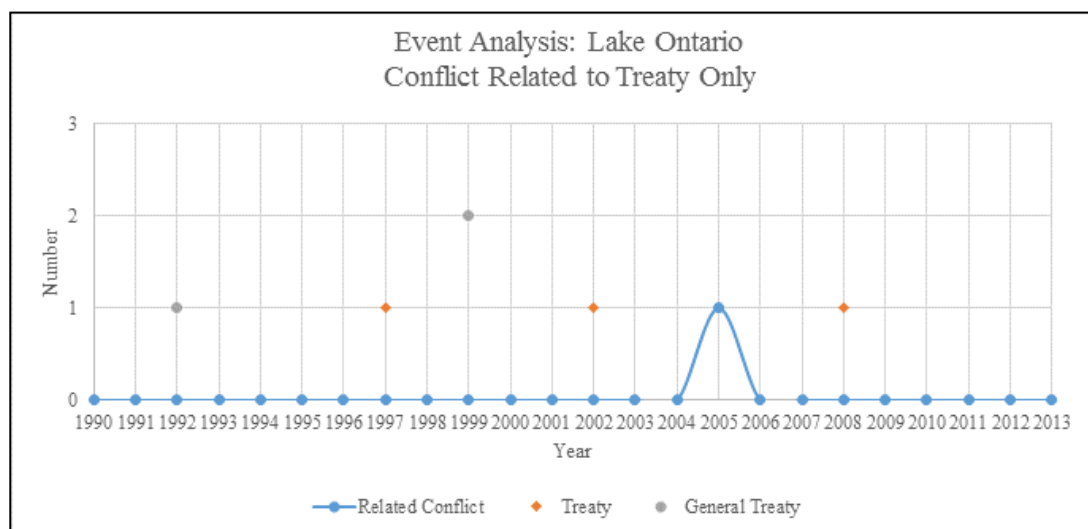
Appendix Figure B10: Annual international water treaties and international water conflicts for Lake Huron.



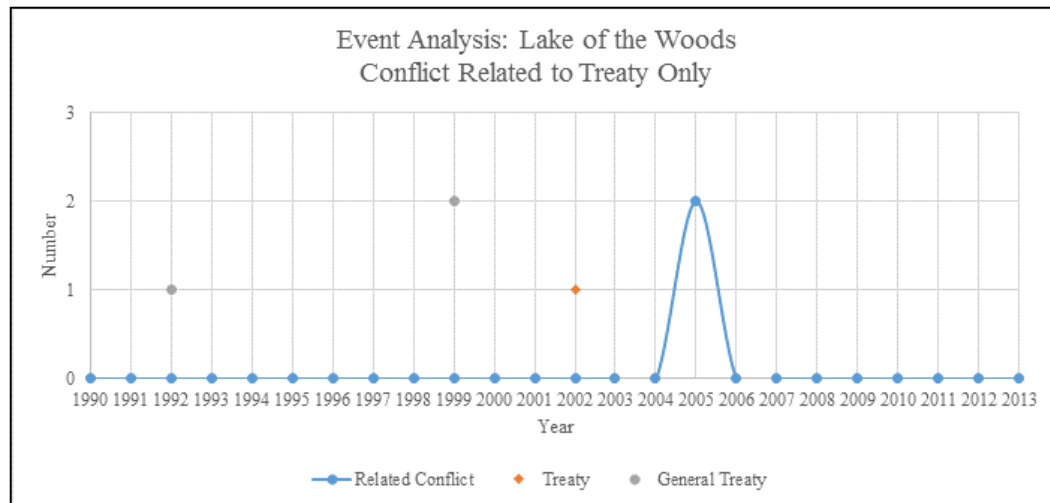
Appendix Figure B11: Annual international water treaties and international water conflicts for Lake Erie.



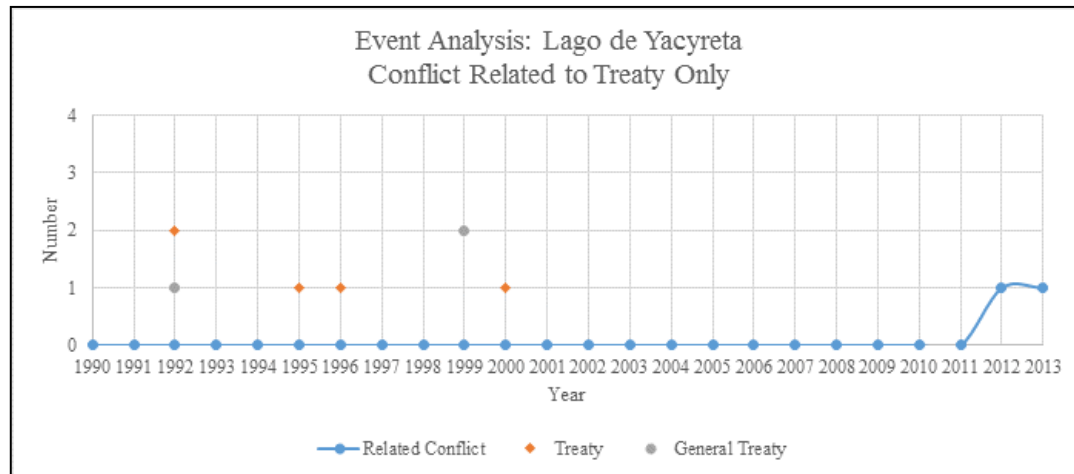
Appendix Figure B12: Annual international water treaties and international water conflicts for the Aral Sea.



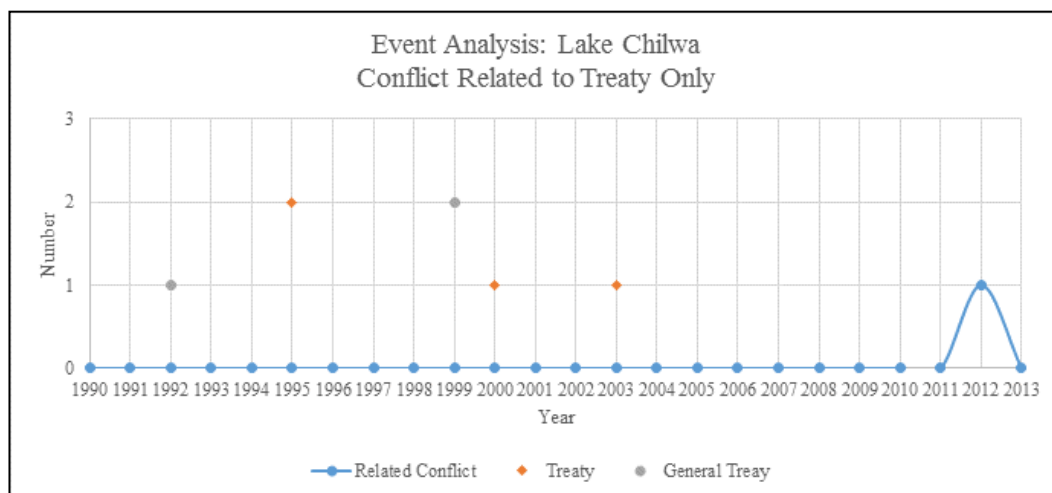
Appendix Figure B13: Annual international water treaties and international water conflicts for Lake Ontario.



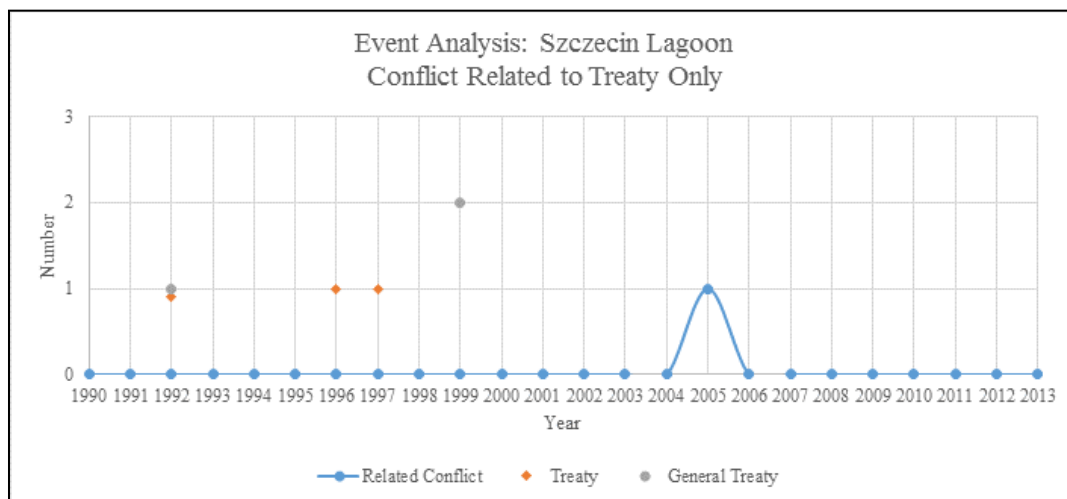
Appendix Figure B14: Annual international water treaties and international water conflicts for Lake of the Woods.



Appendix Figure B15: Annual international water treaties and international water conflicts for Lago de Yacyreta.



Appendix Figure B16: Annual international water treaties and international water conflicts for Lake Chilwa.



Appendix Figure B17: Annual international water treaties and international water conflicts for Szczecin Lagoon.



## Appendix C: Data Imputation: Variable Summaries

Appendix Table C1: Variable summaries from Stata before data imputation.

<b>Variable</b>	<b>Number of Observations</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b>Minimal</b>	<b>Maximum</b>
Population Growth	840	1.597	1.047	-1.816	6.128
GDP per capita	840	10341.67	14781.67	129.956	52550.64
GINI Index	784	40.223	7.195	22.558	61.922
Political Stability	525	-0.287	0.831	-2.575	1.058
Voice and Accountability	525	-0.087	1.034	-2.11	1.493
Water per capita	175	26896.71	21714.83	785.4	82102
Precipitation	175	824.501	391.235	150.5	1530.5
External Dependence	175	281.6	349.424	10	1628.4

Appendix Table C2: Variable summaries from Stata after data imputation. Note all contextual variables now have 840 observations.

<b>Variable</b>	<b>Number of Observations</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b>Minimal</b>	<b>Maximum</b>
Population Growth	840	1.597	1.047	-1.816	6.128
GDP per capita	840	10341.67	14781.67	129.956	52550.64
GINI Index	840	40.267	7.112	22.558	61.922
Political Stability	840	-0.293	0.89	-2.575	1.058
Voice and Accountability	840	-0.083	1.046	-2.11	1.493
Water per capita	840	27032.71	21732.57	785.4	82102
Precipitation	840	827.399	385.866	150.5	1530.5
External Dependence	840	218.223	348.817	10	1628.4

## Appendix D: Logistic Regression Stata Output

<pre>. logistic PresenceofConflict PresenceofTreaty AveragePopulationGrowth AverageGDPpercapita AverageGINI AveragePol &gt; iticalStability AverageVoiceandAccountability AverageWaterperCapita AveragePrecipitation AverageExternalDepend &gt; ence</pre>						
Logistic regression			Number of obs	=	840	
			LR chi2(9)	=	21.43	
			Prob > chi2	=	0.0109	
Log likelihood = -167.62236			Pseudo R2	=	0.0601	
PresenceofConflict	Odds Ratio	Std. Err.	z	P> z	[95% Conf. Interval]	
PresenceofTreaty	1.224342	.5058347	0.49	0.624	.5447915	2.751535
AveragePopulationGrowth	1.58135	.3949807	1.83	0.067	.9692136	2.580098
AverageGDPpercapita	1.00002	.0000184	1.10	0.271	.9999842	1.000056
AverageGINI	.9271587	.0364801	-1.92	0.055	.8583464	1.001487
AveragePoliticalStability	.7455596	.2747754	-0.80	0.426	.3620535	1.535296
AverageVoiceandAccountability	1.434199	.6255047	0.83	0.408	.6100571	3.371696
AverageWaterperCapita	.9999801	.0000156	-1.27	0.202	.9999495	1.000011
AveragePrecipitation	.9987282	.0007673	-1.66	0.098	.9972254	1.000233
AverageExternalDependence	1.001781	.0007402	2.41	0.016	1.000331	1.003232
_cons	1.118214	1.378145	0.09	0.928	.0998756	12.51959

Appendix Figure D1: Logistic regression output from Stata.